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

Final Report. Volume 3. Tasks 4-6

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MASTER

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Toledo Edison Company
Toledo, Ohio

U. S. DEPARTMENT OF ENERGY

Division of Buildings and Community Systems

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

Task 4

Technical Review and Assessment

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May, 1979
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3.4 TASK 4 - TECHNICAL REVIEW AND ASSESSMENT

ABSTRACT

Stone & Webster Engineering Corporation is a member of the Demonstration Team employed by Toledo Edison to review and assess the technical aspects of cogeneration for district heating. While the Task 4 report goes into considerable detail on different retrofit schemes, only the most practical will be presented in this summary.

Task 4 is tailored to the service areas identified in Task 3 - Energy Market Analysis, and will address those alternative expansion plans only, as opposed to the broad approach employed in Task 2 - Identify Sources and Service Areas. At this point it would be helpful to again show the gross peak heat loads by retrofit scheme, or expansion plan, determined in Task 3.

Gross Heat Load (10^6 BTU/Hr.)

Expansion Plan	1	2	3	4
Retrofit Scheme	A3(f1)	A3(f2)	A3(g1)	A3(g2)
Gross Heat Load (10^6 BTU/Hr.)	278.6	325.8	723.0	786.9

The task deliverables are listed along with the responses for the reader's convenience. Again, only the recommended schemes are reported in this summary. See Appendix A of the complete Task 4 report for a detailed explanation of retrofit schemes.

3.4.1 Task Deliverables

Supply detailed explanation of each scheme investigated together with an explanation of its advantages and disadvantages.

3.4.1 Schemes Investigated

Acme Station, a coal-fired station, is situated close enough to potential customers to provide reasonable capital costs for the transmission system. The station dates back to 1918 and is the oldest plant of the three electric generating stations operated by Toledo Edison Company. In addition, Acme Station is an intermediate-loaded plant, and its operating equipment and modes make it an appropriate choice for retrofitting and expansion.

Of the cogeneration schemes studied, a back-pressure turbine is considered the best source of steam for district heating. Using extraction steam from the present condensing turbines was considered but rejected because of physical and capacity limitations.

Figure 8-1 shows schematically the sources of steam at Acme and emphasizes the amount of backup available for heating system steam. Steam in the 235 psig system is presently furnished through the existing topping turbine, directly through Boiler Nos. 9, 10, 11, and 12, or through the pressure reducing valves from the 825 psig and 1450 psig boilers.

FIGURE 8-1
SCHEMATIC ARRANGEMENT
OF ACME STATION

Figure 8-2 shows the recommended retrofit in more detail. It also indicates the four steam flows necessary to serve the four potential expansion plans. The first plan, A3(f1), is the system which supplies the present steam customers plus nine potential customers within the area of the present downtown distribution system. Alternate A3(f2) is an expansion of alternative A3(f1) to include customer #7.

Alternate A3(g1) more than doubles the thermal requirements by the addition of customer #15, and customer #1 which needs both process and heating steam. In this alternate, distribution requires two branch lines, one to the downtown area and one to customer #1.

Alternate A3(g2) is a further expansion by the addition of customer #6 which is an extension of the route to customer #1.

The potential expansion plans served by their respective retrofit schemes are shown below:

<u>Total Steam Flow by Expansion Plan*</u>				
Expansion Plan	1	2	3	4
Retrofit Scheme	A3(f1)	A3(f2)	A3(f1)	A3(g2)
Gross heat load 10^6 BTU/hr.	278.6	325.8	723.0	786.9
Steam flow from new back pressure turbine lbs/hr.	212,000	248,000	418,000	418,000
Steam flow from existing topping turbine-lbs/hr.	---	---	<u>133,000</u>	<u>182,000</u>
Lbs./hr. total steam flow	212,000	248,000	551,000	600,000

* Enthalpy of the 235 psig steam is 1,314 BTU/lb.

RETROFIT AT ACME STATION

ESTIMATED STEAM FLOWS AT PEAK DEMAND (LB/HR)

ALTERNATE	W1	W2	W3
A3(f1)	319,000	212,000	0
A3(f2)	373,000	248,000	0
A3(g1)	630,000	418,000	133,000
A3(g2)	630,000	418,000	182,000

ENERGY REQUIREMENTS SHOWN ARE PROJECTED PEAK DEMANDS

FIGURE 8-2
DIAGRAM OF SELECTED
DISTRICT HEATING SYSTEMS

The basic retrofit scheme is described in detail on the following pages. For data on all retrofit schemes considered, see Appendix A of the Task 4 report.

ACME STATION RETROFIT - ALTERNATE A3(f1)

Steam for District Heating

Steam Flow: 212,000 lb/hr. for heating

Heat output: 278.6×10^6 BTU/hr.

Source: Steam is taken from No. 16 boiler at 1,450 PSIG.

Retrofit: This scheme provides for installation of a new noncondensing turbine generator. The exhaust steam at 235 psig pressure is piped to the vicinity of Water Street Station for district heating in the downtown area. With a throttle flow of 319,000 lb/hr. at 1,450 psig, the new back-pressure turbine generator produces 15.9 MW of electric power. Of this flow, 212,000 lb/hr. is available for district heating. The balance is utilized in the deaerator and feedwater heating. Total heat exported would be 278.6×10^6 BTU/hr. Consideration was given to return of the condensate and rejected because of first costs and because the present users waste condensate to the drain, making recovery difficult.

In addition to the turbine generator, which would be installed in parallel with No. 2 Turbine, the retrofit includes deaeration equipment, feedwater heaters, water treatment, instrumentation and controls, and the distribution system. Backup for the export steam is the existing 235 psig header, which can be fed from any of the boilers at the station.

Advantages:

- . Multiple backup steam sources, which result in a very reliable heating source.
- . Extracting steam for feedwater heating provides additional electrical power generation.
- . The relatively high throttle pressure is adequate to provide high turbine efficiency.
- . Capital cost per million BTU is low.
- . Heat exported meets projected maximum demand.
- . Relatively low capital cost for the transmission system.

Disadvantages:

- . No condensate is returned, thus requiring water treatment of the full flow. The high pressure boiler requires a higher degree of treatment than lower pressure systems.
- . Loss of electric power caused by not using No. 2 Turbine must be made up within the system, possibly at a higher heat rate. (Common to all schemes.)

3.4.2 Task Deliverables

Examine alternative operating modes for each scheme evaluating efficiency of heat capture by each and the thermal demand each can serve. Explain how different energy allocations interact with each scheme and the consequences of choosing different energy allocation strategies.

3.4.2 Alternate Operating Modes

The effectiveness of steam-turbine cogeneration can be expressed as the ratio between the theoretical work of expansion to the extraction pressure and the theoretical work of expansion to a reference condenser pressure.

This ratio, referred to as the available energy ratio (AER), is obtained by dividing the theoretical steam rate for expansion to the condenser pressure (TSR1) by the theoretical steam rate for expansion to the extraction pressure (TSR2). The AER is zero for throttle steam and is one (unity) for heat at the condenser pressure. The AER is calculated for each of the proposed retrofits.

Studies show that the fuel chargeable to the steam (FCS) may be approximated by reducing the fuel needed in a steam-only boiler by a fraction equal to the AER. The FCS for the proposed back-pressure turbine and the existing topping turbine are plotted for comparison against the approximation of Figure 2-1. The AER is 0.375 for the anticipated retrofit. Fuel chargeable to steam would be reduced by 0.375. However, with regenerative feedwater heating, the actual value falls below the extraction factor line. The fuel chargeable to steam turns out to be 58% of the fuel required for a steam-only boiler.

The thermal demands each retrofit scheme can serve are reproduced below:

	<u>Gross Heat Load (10^6 BTU/Hr.)</u>			
Expansion Plan.	1	2	3	4
Retrofit Scheme	A3(f1)	A3(f2)	A3(g1)	A3(g2)
Heat Load (10^6 BTU/Hr.)	278.6	325.8	723.0	786.9

3.4.3 Task Deliverables

Explain the effect each retrofit scheme has on each plant's electric generating capacity and the consequences of each scheme on the utility's current and future capacity requirements.

3.4.3 Effect on Generating Capacity

Utilizing steam from No. 16 Boiler in a new back-pressure turbine will mean reducing the load on existing No. 2 Turbine. The reduction in capacity at peak district heating demands for each expansion plan is indicated in the table below:

Effect on Electric Generation At Maximum Steam Sendout				
	Megawatts			
Expansion Plan	1	2	3	4
Retrofit Scheme	A3(f1)	A3(f2)	A3(g1)	A3(g2)
Capacity Reduction	18 MW	23 MW	54 MW	58 MW

The consequences of this capacity reduction are impossible to predict at this time due to uncertainties in load and peak forecasting, environmental requirements, and anti-nuclear sentiment. It is felt that the effect will be minimal, however. The peak steam sendout occurs about 7 a.m. in the winter and drops considerably by the time the electric loads peak at around 11 a.m..

In addition, Toledo Edison Company is predicted to retain a summer peak electric load which is the time the district heating load is at its minimum.

There is a possibility that the plant generating capacity would not be decreased as a result of cogeneration. Back-up for the steam system could be provided either from Water Street Station, a back-up boiler at a "substation", or from a customer source. Under expansion plan number 2, it may be possible to provide district heating backup from customer

#7. Usually, as the electric load increases, the load dispatcher has sufficient warning to divert the cogenerated district heating load to another available source. Phase 2 will evaluate the economic and technical advantages of various back-up systems designed to shift district heating load to another source in the event of an electrical capacity shortfall.

The addition of more steaming capacity at Acme Station to take advantage of the increased generation facilities will also be considered in Phase 2. Since the capacity of No. 2 Turbine is limited only by steaming capacity, this aspect deserves attention.

Toledo Edison Company is a part of the Central Area Power Coordinating Group (CAPCO). Exploration will be required as to whether a decrease in the Company's generating capacity will require contract revisions. This is a complex issue and will be explored only after possibilities of district steam back-up are exhausted.

Another alternative exists. That is the purchase of emergency replacement power from other utilities during critical periods to compensate for the capacity reduction.

The plan at this point is to treat the reduction in capacity as a smaller reserve margin, and to provide some back-up steaming capacity for the district heating system so that all boilers and turbines at Acme may be utilized for the generation of electricity during critical periods. The parallel operation of the new back pressure turbine with No. 2 Turbine

does not diminish the electrical capacity of Acme Station when load conditions warrant full power production. Under this condition there will be no steam flow in the back pressure turbine and No. 2 Turbine is capable of the same capacity that it is today.

3.4.4 Task Deliverables

Explain how different thermal distribution networks affect the ability of each project to serve End-Users; how each affects decisions on which services to supply thermal energy to, and the efficiency of each alternative in transporting thermal energy.

3.4.4 Distribution Network

In district heating, thermal energy can be delivered to the end user by either a steam or hot water distribution system.

A steam system is the recommended transfer medium for this demonstration project. Although water is generally preferred if long distances are involved, distance is not a factor here. In addition, the existing downtown system and most of the potential load is steam. Those in-building systems that utilize hot water can be easily retrofitted to accept steam, where the opposite is more difficult.

Since the condensate will not be returned, treatment of make-up water becomes an economic factor. Retrofit scheme A3(f2r) is the same as A3(f2) except that a reboiler was added so that the condensate could be returned directly to the boiler. It was found that the differential capital costs for the reboiler and other related equipment could not be

justified by the savings resulting from lesser water treatment requirements. The additional fixed charges of \$116,000 were three times greater than the estimated \$39,000 in annual savings for reduced water treatment.

The curves in Figure 5-2 illustrate the installed cost comparison between a steam and high temperature water system. The steam piping cost does not include condensate return.

3.4.5 Task Deliverables

Compute the scarce fuel conservation potential of each alternative for a typical annual operating cycle.

3.4.5 Scarce Fuel Savings

The displacement of scarce fuel is accomplished with the proposed district heating system by utilizing coal to provide the energy in place of the fuel oil presently being used at Water Street Station and the oil and natural gas presently being used by certain potential customers.

The following table illustrates the annual displacement of scarce fuels by the proposed district heating systems:

Potential Annual Displacement of Scarce Fuels

<u>Expansion Plan</u>	<u>Retrofit Scheme</u>	<u>Cumulative Total 10⁶ BTU/Yr.</u>	<u>Equivalent Gallons #6 Oil</u>
1	A3(f1)	784,341	5,236,000
2	A3(f2)	910,341	6,077,000
3	A3(g1)	1,097,601	7,327,000
4	A3(g2)	1,264,601	8,442,000

FIGURE 5-2
DOE / TEDCO DISTRICT HEATING & COOLING STUDY
COMPARATIVE TRANSMISSION / DISTRIBUTION COSTS
OF STEAM VERSUS HIGH TEMPERATURE WATER (HTW)

In addition to the scarce fuel savings as shown above, energy is saved by cogeneration itself, and by the use of the Acme Station boilers which are more efficient than the Water Street boilers. The next table shows total energy saved by the proposed district heating systems:

Total Annual Energy Saved with Cogeneration
(Cumulative Totals)

<u>Expansion Plan</u>	<u>Retrofit Scheme</u>	<u>Fuel Used By Presept Customers 10⁶ BTU/Yr.</u>	<u>Fuel Used By Proposed System 10⁶ BTU/Yr.</u>	<u>Total Energy Saved 10⁶ BTU/Yr.</u>
1	A3(f1)	900,196	488,564	411,632
2	A3(f2)	1,026,196	577,538	448,658
3	A3(g1)	2,133,456	1,472,196	661,260
4	A3(g2)	2,300,456	1,634,361	666,095

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DOE/TED

DISTRICT HEATING/COOLING STUDY

1.0 INTRODUCTION

This section of the report describes the technical and economic investigations and evaluations performed to determine the retrofit scheme best suited for the district heating system. Factors considered in the analyses were sources of energy, methods used to obtain the energy, effect on existing operations, distribution systems, required capacities, end-users' specific requirements, and capital costs.

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2.0 EFFICIENCY OF HEAT CAPTURE

The effectiveness of steam-turbine cogeneration can be expressed as the ratio between the theoretical work of expansion to the extraction pressure and the theoretical work of expansion to a reference condenser pressure. This ratio, referred to as the available energy ratio (AER), is obtained by dividing the theoretical steam rate for expansion to the condenser pressure (TSR₁) by the theoretical steam rate for expansion to the extraction pressure (TSR₂). The AER is zero for live steam and is one (unity) for heat at the condenser pressure. The AER for each of the proposed retrofits is included with the descriptions contained in Appendices A and B. For a condensing steam turbine with single automatic extraction at a controlled intermediate pressure, an extraction factor, E, can be defined as the portion of a pound of steam which must be added to the throttle flow for each pound of steam extracted at constant kW output. As an approximation,

$$E = 1 - \frac{TSR_1}{TSR_2} = 1 - (AER)$$

The extraction factor is a rough measure of the ratio of the fuel chargeable to steam (FCS) to the fuel required in a steam-only boiler. The approximate extraction factor is shown graphically on Figure 2-1. Without regenerative feedwater heating, actual values would fall above this line by the ratio of heat added per pound of throttle steam to the heat added per pound in a steam-only boiler. With regenerative feedwater heating, actual values may fall below the line.

The fuel chargeable to steam ratio (FCSR) has been calculated for the proposed new back-pressure turbine and the existing topper turbine at Acme Station. In each case, the fuel chargeable to steam has been taken as the thermal input to the boiler less a credit for power generated at a heat rate assumed to be equal to the station average, 13,600 Btu/kWh. Steam-only boiler efficiency was assumed to be equal to the station average, 77.8 percent. The new turbine includes an uncontrolled extraction for regenerative feedwater heating. The topper turbine calculation ignores feedwater heating. These two values are shown on Figure 2-1 and fall as expected. The new turbine, operating with a higher throttle pressure and temperature, saves an additional 25 percent of the steam-only fuel requirement.

The values on Figure 2-1 are for full-load operation of the turbines. The thermal credit for the electric power from cogeneration will be proportionally less as the throttle flow is reduced. This reduction will cause the FCSR to increase.

3.0 CANDIDATE RETROFIT SCHEMES

Five broad categories of retrofit schemes have been considered for obtaining heat from the candidate plants. They are referred to as Categories 1, 2, 3, 4, and 5 and are briefly discussed below.

3.1 CATEGORY 1

Steam can be extracted from the turbine flowpath at an uncontrolled pressure and used directly as steam or indirectly to generate high temperature water (HTW). Extraction points include the cold reheat line, the feedwater heater extraction points, and the crossover from the intermediate to the low-pressure turbine.

Retrofit schemes in this category have the advantage of simplicity and low investment cost. A major disadvantage is the variation of extraction pressure with turbine-generator load. In addition, the boiler and turbine manufacturers impose constraints on the amount of cold reheat or extraction steam that can be safely withdrawn.

3.2 CATEGORY 2

The turbine-generator operation may be modified to provide controlled-pressure extraction or exhaust steam. At a minimum, this requires new controls, and could involve extensive modification of the turbine flowpath.

The advantage of this type of retrofit is that the operation can be tailored to suit the district thermal energy demand. Substantial investment cost and outage time can be expected. The noncogenerating operation of the plant may be impaired.

3.3 CATEGORY 3

A back-pressure turbine generator can be connected to the boiler or high-pressure turbine exhaust. The new turbine will operate in parallel with some of the stages of the existing turbine.

The equipment needed for this scheme is basically standard. If space is available in the plant, installation can proceed without an outage of the existing unit except when connecting into the steam supply. This outage could also be eliminated by coordinating the tie-in with a scheduled

outage. The noncogenerating operation of the unit is not impaired. During cogeneration, the load on the existing turbine is reduced and efficiency drops. A relatively large, new turbine connected directly to the boiler would necessitate shutting down the existing unit during maximum cogeneration.

3.4 CATEGORY 4

Under this category, steam for district heating would be provided by the exhaust from one or more back-pressure turbines used to drive power plant auxiliary equipment, primarily the boiler feed pump and/or the fans which provide the boiler draft.

There are some economic and operating advantages of using steam turbines to drive auxiliary equipment. Tying these turbines into a district heating/cooling system makes the operation more complex. The primary function of auxiliaries is to provide for the safe and efficient operation of the unit, not to produce a prescribed amount of exhaust steam.

3.5 CATEGORY 5

Heat for district heating can be taken from heated feedwater or the heater drains. The ultimate source of this heat is the extraction steam used for feedwater heating.

This scheme uses water-to-water heat exchangers to produce water for distribution. A thorough thermodynamic analysis is necessary to determine the extent of cogeneration. Reducing the final feedwater temperature and making up this heat in the boiler is not cogeneration. (This assumes that the boiler could be fired to produce the same turbine-throttle steam flow.)

4.0 RETROFITS FOR THE CANDIDATE PLANTS

Toledo Edison's three steam power plants (Acme, Bay Shore, and Davis-Besse Stations) are potential candidates for retrofit to provide thermal energy for district heating and commercial and industrial processes in downtown Toledo and the surrounding communities.

Descriptions of the various alternate retrofit schemes for Acme and Bay Shore, including the transmission pipelines, budgetary capital costs, the related fixed charges per million Btu, the available energy ratios, the scarce fuel conservation potential, and lists of the apparent advantages and disadvantages are contained in the appendices.

Table 4-1 summarizes all of the alternates studied for the stations. The retrofit schemes are designated, first, by a letter (A for Acme, B for Bay Shore, and D for Davis-Besse) followed by the category number and one, two, or three letters and numbers to indicate the alternate. The fixed charges per million Btu are based on the maximum output and a 0.3 annual load factor.

4.1 CANDIDATE PLANT - ACME STATION

Of the three candidate plants, Acme Station is the closest to the downtown district. From the transmission standpoint, it is the most logical choice for retrofit.

The 20 alternate schemes studied for the retrofit at Acme are based on Categories 1 and 3 which are considered the most feasible. Figures 4-1 through 4-8 are schematic diagrams of these alternates. Alternates A1(a) through A3(e2) were developed before the market survey analysis was completed and are considered preliminary. The capital cost estimates for these are conceptual and do not include engineering and construction supervision. Their purpose is to allow a preliminary evaluation to eliminate the apparently uneconomical concepts.

Alternates A3(f1), A3(f2), A3(g1), and A3(g2) were developed based on the potential customers established by the market survey analysis with A3(f1) being the minimum system intended to provide thermal energy for the existing customers plus nine new downtown customers. Alternates A3(f2), A3(g1), and A3(g2) include the requirements of A3(f1) along with the addition of other customers.

Alternate A3(g2) is the largest system requiring a peak hourly heat output of 786.86×10^6 Btu. The potential thermal requirements include an allowance of 10 percent for growth.

Alternate A3(f2r), which has the same heat output as A3(f2), was studied to determine if the use of a reboiler is economically attractive. The treatment of the higher quality water for the 1,450 psig boiler costs more than the treatment required for the water used in a 185 psig district heating system.

It was found that the differential capital costs for the reboiler, larger pipeline, and other related equipment could not be justified by the savings resulting from the lesser water treatment requirements. The additional fixed charges of \$116,000 were three times greater than the estimated \$39,000 in annual savings for the reduced water treatment.

Brief descriptions of each of the 20 schemes, including related operating and cost data, are contained in Appendix A.

4.2 CANDIDATE PLANT - BAY SHORE STATION

The Bay Shore Station is the second closest plant to the downtown area. The differential cost to supply heat from the Bay Shore Station rather than the Acme Station could be as high as \$4.00 or \$5.00 per million Btu. Economics favor the Acme Station since it is capable of supplying the required thermal load. At some time in the future, however, the Bay Shore Station could become a viable source.

The Bay Shore Station is one of the most efficient and reliable in the country. Since a primary consideration in evaluating retrofit schemes is avoiding impairing plant operation, only two schemes were developed for retrofitting Bay Shore. These are schematically shown in Figures 4-9 and 4-10. The first scheme, which utilizes cold reheat steam, is limited to 12 percent of the flow because of restrictions related to the boiler. The second scheme, based on using hot reheat steam, is limited to 15 to 20 percent of the flow to ensure safe turbine operations.

Because of the transmission distances involved, only a HTW system is considered. This results in a limitation on the

pressure of the process steam that can be generated in an industrial user's plant.

Data on these alternate retrofit schemes are contained in Appendix B.

4.3 CANDIDATE PLANT - DAVIS-BESSE STATION

Although classified as a candidate plant, the Davis-Besse Station is too remote to be considered a feasible source for supplying the downtown Toledo heating system. Because steam cannot be transported the 25-mile distance from Davis-Besse to downtown Toledo, process steam required by certain industrial customers could not be provided.

If HTW were supplied to these industrial customers, heat exchangers could provide the required process steam. However, the cost of energy would be prohibitive. Just the transmission pipes to Water Street alone would run from \$12.00 per million Btu for the largest system to \$26.00 per million Btu for the smallest. These costs do not include the retrofit required at the station, the series of booster pumping stations required along the transmission line to

provide reasonable operating pressures above the saturation temperature, or the distribution piping from Water Street.

The contemplated retrofit at the station would provide for heat exchangers to utilize 207.5 psia exhaust steam from the high pressure turbine. The maximum flow of 513,963 lb/hr from this source would supply 523.8×10^6 Btu/hr to the HTW heating system. Requirements above this for Alternates D1(a3) and D1(a4) would have to be supplied from another extraction point or use steam directly from the reactor system. As with the other HTW retrofits, the system would include the heat exchangers, expansion tanks, pumps, and the instrumentation and controls.

In addition to the pumping station at the plant, four or five other booster pumping stations would be required along the transmission line route to maintain the system pressure. These add to the initial capital investment and the continuing operating and maintenance costs.

FIGURE 4-1
ALTERNATES A1(a) AND A1(b)
UTILIZING EXTRACTION STEAM
AT ACME STATION

FIGURE 4-2
ALTERNATES A1(c) AND A1(d)
UTILIZING EXTRACTION STEAM
AT ACME STATION

FIGURE 4-3
ALTERNATES A1(e1) & (e2)
UTILIZING EXTRACTION STEAM
AT ACME STATION

FIGURE 4-4
ALTERNATES A1(f1) & A1(f2)
UTILIZING EXTRACTION STEAM
AT ACME STATION

FIGURE 4-5
ALTERNATES A3 (a), (b), (c), (f1), (f2), (g1) AND (g2)
UTILIZING NEW BACK-PRESSURE TURBINE
AT ACME STATION

FIGURE 4-6
ALTERNATES A3 (d1) AND (d2)
UTILIZING NEW BACK-PRESSURE TURBINE
AT ACME STATION

FIGURE 4-7
ALTERNATES A3 (e1) AND (e2)
UTILIZING STEAM FROM TOPPING TURBINE
AT ACME STATION

**FIGURE 4-8
ALTERNATE A3 (12R)
UTILIZING NEW BACK-PRESSURE TURBINE
AT ACME STATION**

FIGURE 4-9
 ALTERNATE BI (a)
 UTILIZING COLD REHEAT STEAM
 AT BAY SHORE STATION

FIGURE 4-10
ALTERNATES B1(b1) & B1(b2)
UTILIZING HOT REHEAT STEAM
AT BAY SHORE STATION

5.0 DISTRIBUTION SYSTEMS

In district heating, thermal energy is delivered to the end-user by either a steam or a hot water distribution system. A third type, the dual-purpose distribution system, serves both industrial and residential purposes. The following systems may be used singly or in combination, depending upon the requirements of the end-user.

5.1 HOT WATER DISTRIBUTION SYSTEMS

Hot water systems consist of either a primary circuit with secondary loops for end-users or a two-pipe supply and return circuit, also with secondary pumping loops to the end-users. Generally, the primary circuit or the two-pipe system is used with high temperature water (HTW) (250°F to 450°F). With this high temperature in the supply system, it is preferable to separate the high temperature on the supply side from the end-user side. Heat exchangers are used to separate the two sides and provide the end-user with low temperature hot water.

Hot water distribution systems are widely used in Europe for district heating not only because of their known advantages,

but also because of the probable need for hot water (and, possibly, chilled water) storage for load leveling. Such storage is impossible with steam. The advantages and disadvantages of hot water systems are described below.

Advantages:

- o Hot water can be pumped economically over long distances without substantial heat losses.
- o A hot water system has the capacity to store heat.

This capacity to store heat is illustrated in Table 5-1. The table illustrates that for equal amounts of heat output, a hot water system can store over 10 times as much heat as a steam system. In addition, a hot water system has smaller pipes than a steam system.

- o Because of this heat storage capacity, hot water generators need not be sized for peak loads, while steam generators require such sizing to prevent pressure and temperature losses.

- o In steam heating systems, the condensate may not be returned to the power plant for a number of reasons, e.g., corrosion problems, collection problems. The lost condensate is replaced with high quality makeup, thus imposing a severe penalty against steam systems. In hot water systems, the condensate is recovered in the plant.
- o The transmission and distribution pipelines in a hot water system can follow the ground contours because the system is under forced circulation and need not be pitched for condensate drainage. Consequently, fewer and shallower manholes are required. Steam systems are pitched to facilitate condensate flow and drainage.

Disadvantages:

- o A hot water distribution system is a closed-loop system. It is maintained under pressure with booster pumps and so may have higher operation and maintenance costs in comparison to a steam system.

- o As a closed-loop system, a water distribution system has either a four-pipe network system (if chilled water is used) or a two-pipe network system. The additional piping (the return line(s) required for a hot water system) may result in higher capital costs than for a steam system.

5.2 STEAM DISTRIBUTION SYSTEMS

Steam systems consist of either the single-pipe or two-pipe system. In the single-pipe system, condensate is wasted to the sewer. Makeup water requirements make this system costly. In the two-pipe supply and return system, condensate return is either by gravity or by pumping.

A four-pipe distribution system is required if chilled water is used in conjunction with steam or hot water. Otherwise, the standard two-pipe system is used for hot water during the heating season and chilled water during the cooling season.

The majority of existing district heating systems in the United States use steam. Many of these systems were developed years ago when boiler steam and exhaust steam from engines were inexpensive. Also, these steam systems served small areas and the transmission and distribution networks involved were not long; thus, they did not require large capital investments. The advantages and disadvantages of steam are described below.

Advantages:

- o Steam distribution systems are flexible, versatile, and readily adaptable to a wide range of system sizes and process applications.
- o In situations where excessive static water pressure is encountered, steam systems are often preferable to water systems.
- o Initial costs for a steam distribution system are often lower than for a hot water system delivering an equivalent thermal load.

- o Pumping costs for maintaining circulation are eliminated.
- o Building costs are lowered because the building frame is not required to support the water content of expansion tanks and piping.

Disadvantages:

- o For a steam distribution system without condensate recovery, the cost of water treatment and heat losses in the condensate is high.
- o There is an energy loss when warm condensate is discharged to waste.
- o In the event of an outage, condensation occurs and startup of the system is difficult.
- o Length of the distribution system is limited to prevent condensation as a result of heat losses in the system.

- o Recovered condensate must be treated before use as feedwater into the boiler.
- o Condensate disposal along the transmission line is likely to increase maintenance costs.

5.3 COST COMPARISON:

STEAM VS HOT WATER TRANSMISSION/DISTRIBUTION

The transmission costs for steam and hot water systems are shown in Figure 5-1. As the pipe diameter increases, installed costs for a hot water system increase more rapidly than those for a steam system. However, it should be noted that for hot water, the installed costs shown are for a two-pipe system; for steam, the costs are for a single-pipe system.

The curves in Figure 5-2 illustrate the installed transmission/distribution cost comparison between a steam system and a high temperature water system. The curves show that for steam systems with transmission/distribution pressures of 130 psia and above, steam systems cost less than high temperature water systems delivering an equivalent load. If the steam transmission/distribution pressure is

below 100 psia, high temperature hot water systems cost less than steam systems. For the intermediate steam pressures (100-130 psia), the systems are competitive enough that other factors must be considered in selecting a better system.

The curves also illustrate the variation of installed costs with steam supply conditions. As steam transmission/distribution pressure increases, the installed pipe costs decrease.

5.4 DUAL-PURPOSE DISTRIBUTION SYSTEMS

Another distribution system that can meet the needs of a variety of customers is a dual-purpose distribution system. In this system, the cogeneration plant serves both industrial/commercial customers needing process steam and urban/residential customers requiring hot water.

The feasibility of such an integrated system depends on many factors, one of which is the proximity of the cogeneration plant to the industrial and residential community. The advantage of this distribution system is its diversity.

TABLE 5-1

HEAT STORAGE COMPARISON OF
PIPING IN EQUIVALENT-SIZED
STEAM AND HTW SYSTEMS

Quantities	Heat Output: 50 x 10 ⁶ Btu/hr		Heat Output: 200 x 10 ⁶ Btu/hr	
	Steam Load	HTW Load	Steam Load	HTW Load
Operating Pressure - psia	115	220	115	220
Discharge Temperature - °F	338	300	338	300
Return Temperature - °F	180	150	180	150
Enthalpy @ Discharge - Btu/lb	1,189.6	270.0	1,189.6	270
Enthalpy @ Return - Btu/lb	148.0	118.2	148.0	118.2
Enthalpy Difference - Btu/lb	1,041.6	151.8	1,041.6	151.8
Mass Flow Rate - lbs/hr	48,000	329,380	192,000	1,317,500
Density of Fluid - lbs/ft ³	0.258	57.4	0.258	57.4
Volume Flow - ft ³ /sec	51.68	1.59	206.7	6.38
Design Velocity - ft/sec	95	8	102	8
Pipe Diameter - in	10	6	20	12
Pipe Volume/1,000 ft of Pipe Length (ft ³)	545	200	2,020	777
Available Heat - Btu/ft ³	269	8,713	269	8,713
Heat Stored/1,000 ft Pipe - Btu	146,600	1.74 x 10 ⁶	543,380	6.77 x 10 ⁶

FIGURE 5-1
DOE/TEDCO DISTRICT HEATING & COOLING STUDY
INSTALLED TRANSMISSION PIPE COSTS VERSUS PIPE
DIAMETER FOR A STEAM AND HOT WATER SYSTEM

FIGURE 5-2
DOE / TEDCO DISTRICT HEATING & COOLING STUDY
COMPARATIVE TRANSMISSION / DISTRIBUTION COSTS
OF STEAM VERSUS HIGH TEMPERATURE WATER (HTW)

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6.0 END-USER RETROFIT

The market survey analysis identified the end-users as steam or hot water customers plus a few users of both. Figure 6-3 is a schematic diagram showing the existing distribution system and the potential new customers for district heating. Most of the new customers are located in the area served by the present district heating system, but a few are very remote.

Retrofitting the new customers requires connection to the distribution system to supply the customer's existing steam/hot water system. The preferred approach is to separate the user's system from the district heating by heat exchangers, control valves, pressure reducing stations, and pumps. Figures 6-1 and 6-2 illustrate typical end-user retrofit connections for steam and hot water users.

The pressures and temperatures required and used in district heating systems may cause considerable damage if the district heating steam were introduced directly into an existing system not specifically designed for district heating. When an existing district system is in operation for a particular building, separation is still considered

desirable because of possible differences in water chemistry between the user's system and the district heating system. Furthermore, it is likely that local codes require adequate means of separating the potable water supply. A safe and reliable means of separating the district system from the user's system can be achieved with properly designed and installed heat exchangers, temperature/pressure flow controls, and relief and expansion devices.

FIGURE 6-1
END USER RETROFIT
FOR A STEAM SYSTEM

FIGURE 6-2
END USER RETROFIT
FOR A HOT WATER SYSTEM

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7.0 FUEL CONSERVATION POTENTIAL

The implementation of any one of the alternates of the selected retrofit schemes would result in a savings in both total energy use and scarce fuel. Graphically, these savings are shown for the four alternate schemes in Figure 7-1 based on the data developed in Sections 7.1 and 7.2.

7.1 SCARCE FUEL SAVINGS POTENTIAL

The savings in scarce fuels is accomplished with the proposed district heating system by utilizing coal to provide the energy in place of the fuel oil and natural gas presently being used at the Water Street Station and by certain potential customers. Table 7-1 summarizes the annual displacement of the scarce fuels and shows the total equivalent Btus for each of the four alternate schemes. Expressed in gallons, the annual displacement of No. 6 oil would be:

Alternate A3 (f1)	5,236,000 gal/yr
Alternate A3 (f2)	6,077,000 gal/yr

Alternate A3 (g1)	7,327,000 gal/yr
Alternate A3 (g2)	8,442,000 gal/yr

7.2 ENERGY SAVED

The total energy to be saved by the proposed retrofit schemes results from the improvement in efficiencies in utilizing the fuel and the savings resulting from the cogeneration concept. The thermal efficiency at the Acme Station has historically been better than the Water Street Station and should be equal to, or better than, the efficiency of the various potential customers.

Table 7-2 summarizes the energy input required by the present operations that would be displaced by the proposed district heating system. Table 7-3 shows the net energy to be delivered to the customers and the estimated line losses from the steam transmission and distribution systems. The line losses are based on the actual losses experienced with the present downtown heating system in 1978. This was calculated to be 23.3 percent and was used for the study, although it is expected that in a new system it would be somewhat less.

Table 7-4 shows the total energy estimated to be saved by each of the alternate schemes. These savings were determined by subtracting the estimated fuel input for the cogeneration system from the total heat input required to generate the steam and make electric power equivalent to that made by cogeneration. Energy input to produce the steam is based on using No. 16 boiler up to its capacity with any excess requirement being supplied by Acme at a station efficiency of 77.76 percent. Fuel input for the electric power was taken as 13,600 Btu/kWh. On this basis, there is about a 31 percent savings for Alternate A3(f1), 29 for A3(f2), 21 for A3(g1), and 20 for A3(g2).

If all of the energy savings were credited to the generation of the steam, the fuel chargeable to steam (FCS) would be 65 percent of the fuel required in a plant producing only steam for Alternates A3(f1) and A3(f2). The FCS for A3(g1) and A3(g2) would be 70 percent and 71 percent, respectively. Data used to derive these results are shown in Table 7-5.

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TABLE 7-1

POTENTIAL ANNUAL DISPLACEMENT OF
SCARCE FUELS (NATURAL GAS AND FUEL OIL) FOR
THE SELECTED ALTERNATIVES
(1978 BASE YEAR)

<u>Alternative</u>	<u>Customers</u>	<u>Natural Gas NCF</u>	<u>Fuel Oil (Gallons)</u>	<u>Equivalent Btu x 10⁶</u>
A3 (f1)	Existing	139,287 ⁽¹⁾	4,609,702 ⁽²⁾	762,772
	2	2,321		2,321
	3	5,121	33,372 ⁽³⁾	19,793
	5	1,122		1,122
	8	4,472		4,472
	21	<u>3,861</u>		<u>3,861</u>
Total for A3 (f1)		156,184	4,643,074	784,341
A3 (f2)	7	<u>0</u>	<u>900,000⁽³⁾</u>	<u>126,000</u>
Total for A3 (f2)		156,184	5,543,074	910,341
A3 (g1)	15	<u>0</u>	<u>1,250,087⁽²⁾</u>	<u>187,260</u>
Total for A3 (g1)		156,184	6,793,161	1,097,601
A3 (g2)	6	<u>167,000</u>	<u>0</u>	<u>167,000</u>
Total for A3 (g2)		323,184 ⁽⁴⁾	6,793,161	1,264,601

(1) Coke oven gas at 518.7 Btu/cu ft no longer available.

(2) No. 6 Oil - 149,798 Btu per gallon.

(3) No. 2 Oil - 140,000 Btu per gallon.

(4) Including 139,287 MCF of coke oven gas.

TABLE 7-2

POTENTIAL ANNUAL FUEL DISPLACED BY THE PROPOSED DISTRICT HEATING SYSTEM

<u>Alternative</u>	<u>Customers</u>	<u>Fuel Displaced</u>	<u>Equivalent Btu x 10⁶</u>
A3 (f1)	Existing	Oil	762,772
	2	Natural Gas	2,321
	3	Natural Gas, Oil	9,793
	5	Natural Gas	1,122
	8	Natural Gas	4,472
	13	(Not Available)	11,688 (estimate)
	17	Electricity	51,415
	18	Electricity	30,849
	19	Electricity	19,538
	21	Nat Gas, Elec	6,226
		Total For A3 (f1)	900,196
A3 (f2)	7	Oil	126,000
		Total For A3 (f2)	1,026,196
A3 (g1)	15	Oil	187,260
	1	Coal	920,000
		Total For A3 (g1)	2,133,456
A3 (g2)	6	Natural Gas	167,000
		Total For A3 (g2)	2,300,456

TABLE 7-3

ESTIMATED THERMAL SENDOUT REQUIRED
FOR THE SELECTED ALTERNATIVES
(10⁶ Btu/Year)

<u>Alternate</u>	<u>Customers Net⁽¹⁾ Energy Requirements</u>	<u>Estimated⁽²⁾ Line Losses</u>	<u>Required Sendout</u>
A3 (f1)	491,454	114,509	605,963
A3 (f2)	580,954	133,363	716,317
A3 (g1)	1,369,144	319,011	1,688,155
A3 (g2)	1,496,144	348,602	1,844,746

- (1) Based on metered use by existing customers and requirements of the potential customers determined by their fuel input and appropriate efficiency factors
- (2) Line losses of 23.3% of customers' use based on actual operating data of the existing district heating system during 1978.

TABLE 7-4

ENERGY SAVED BY THE PROPOSED DISTRICT HEATING SYSTEM
(10⁶ Btu/yr)

<u>Alternative</u>	<u>Present Energy Input</u>		<u>Energy Used By Proposed DHS</u>	<u>Energy Saved</u>
	<u>For Steam</u>	<u>For Elec. Power⁽¹⁾</u>		
A3 (f1)	900,196	419,372	907,936	411,632
A3 (f2)	1,026,196	495,746	1,073,284	448,658
A3 (g1)	2,133,456	999,197	2,471,393	661,260
A3 (g2)	2,300,456	1,052,428	2,686,789	666,095

⁽¹⁾ Based on estimated electric power generated by cogeneration at the average 1977 Acme heat rate of 13,600 Btu/kWh.

TABLE 7-5

FUEL CHARGEABLE TO STEAM
(10⁶ Btu/yr)

Alternate	Energy Sendout	Energy Input For A Steam Only Plant ⁽¹⁾	Energy Saved ⁽²⁾	Fuel Chargeable To Steam (FCS)	Ratio of FCS To Steam Only Plant
A3(f1)	605,963	750,697	262,133	488,564	0.65
A3(f2)	716,317	887,410	309,872	577,538	0.65
A3(g1)	1,688,155	2,111,274	639,078	1,472,196	0.70
A3(g2)	1,844,746	2,311,463	677,102	1,634,361	0.71

(1) Based on efficiency of 80.72 percent for steam generated by No. 16 boiler and 77.76 percent for requirements in excess of No. 16 boiler capacity.

(2) Energy saved by cogeneration.

ALTERNATE

COMPARISON OF ENERGY INPUT

A3(f1)	EQUIVALENT ENERGY WITHOUT COGENERATION	<table><tr><td>SCARCE FUEL (1) (59%)</td><td>COAL (2) 21,400 TPY (41%)</td></tr></table>	SCARCE FUEL (1) (59%)	COAL (2) 21,400 TPY (41%)	
SCARCE FUEL (1) (59%)	COAL (2) 21,400 TPY (41%)				
	ENERGY REQUIRED USING COGENERATION	<table><tr><td>COAL (2) 36,300 TPY</td><td>31% ENERGY SAVINGS</td></tr></table>	COAL (2) 36,300 TPY	31% ENERGY SAVINGS	
COAL (2) 36,300 TPY	31% ENERGY SAVINGS				
A3(f2)	EQUIVALENT ENERGY WITHOUT COGENERATION	<table><tr><td>SCARCE FUEL (1) (60%)</td><td>COAL (2) 24,500 TPY (40%)</td></tr></table>	SCARCE FUEL (1) (60%)	COAL (2) 24,500 TPY (40%)	
SCARCE FUEL (1) (60%)	COAL (2) 24,500 TPY (40%)				
	ENERGY REQUIRED USING COGENERATION	<table><tr><td>COAL (2) 42,900 TPY</td><td>29.5% ENERGY</td></tr></table>	COAL (2) 42,900 TPY	29.5% ENERGY	
COAL (2) 42,900 TPY	29.5% ENERGY				
A3(g1)	EQUIVALENT ENERGY WITHOUT COGENERATION	<table><tr><td>SCARCE FUEL (1) (35%)</td><td>COAL (3) 81,400 TPY</td></tr></table>	SCARCE FUEL (1) (35%)	COAL (3) 81,400 TPY	
SCARCE FUEL (1) (35%)	COAL (3) 81,400 TPY				
	ENERGY REQUIRED USING COGENERATION	<table><tr><td>COAL (2) 98,900 TPY</td><td>21% SAVINGS</td></tr></table>	COAL (2) 98,900 TPY	21% SAVINGS	
COAL (2) 98,900 TPY	21% SAVINGS				
A3(g2)	EQUIVALENT ENERGY WITHOUT COGENERATION	<table><tr><td>SCARCE FUEL (1) (38%)</td><td>COAL (3) 83,500 TPY (62%)</td></tr></table>	SCARCE FUEL (1) (38%)	COAL (3) 83,500 TPY (62%)	
SCARCE FUEL (1) (38%)	COAL (3) 83,500 TPY (62%)				
	ENERGY REQUIRED USING COGENERATION	<table><tr><td>COAL (2) 107,500 TPY</td><td>20% ENERGY SAVINGS</td></tr></table>	COAL (2) 107,500 TPY	20% ENERGY SAVINGS	
COAL (2) 107,500 TPY	20% ENERGY SAVINGS				

- (1) NATURAL GAS AND FUEL OIL USED AT WATER STREET STATION AND BY POTENTIAL CUSTOMERS
 (2) COAL USED AT ACME STATION
 (3) COAL USED AT ACME STATION AND POTENTIAL CUSTOMER

FIGURE 7-1
 POTENTIAL SCARCE FUEL AND ENERGY SAVINGS FOR THE
 DISTRICT HEATING SYSTEMS UTILIZING COGENERATION

8.0 SELECTED RETROFIT SCHEME

Results of the market survey analysis identify the potential customers and their thermal energy requirements which could be serviced by an expanded district heating system. The retrofit scheme selected utilizes steam from the 1,450 psig boiler at Acme via a new back-pressure turbine. The following studies and evaluations determine which of the various schemes would provide the best district heating system.

8.1 SELECTED POWER GENERATING STATION

The Acme Station, a coal-fired station, is situated close enough to potential customers to provide reasonable capital costs for the transmission system. The station dates back to 1918 and is the oldest plant of the three. In addition, the Acme Station is an intermediate-loaded plant, and its operating equipment and modes make it an appropriate choice for retrofitting and expansion.

Since it is desirable to eliminate the use of fuel oil as the source of energy for generating steam for district heating, the Water Street Station is not considered a viable plant for retrofit or expansion. Water Street Station's

center city location does not lend itself to conversion to a coal-fired unit. Plans for future urban development in the immediate area indicate that abandonment is more appropriate.

The Bay Shore Station and Davis-Besse Station are five miles and 25 miles from potential customers, respectively. Their remote locations dictate the use of HTW system resulting in unacceptable limitations at certain end-users' plants. The Bay Shore Station is highly efficient and does not have a real potential for providing truly cogenerated steam without an adverse effect.

8.2 DISTRIBUTION SYSTEM SELECTION

The selection of the steam distribution system for district heating is based on the following:

- o The capital cost for a single-pipe steam supply is less than a two-pipe HTW system.
- o The use of HTW within the present district heating system would require conversion to a two-pipe system at an estimated cost of \$14,000,000.

- o The IHW system cannot provide the energy to generate required process steam at certain customer's plants.
- o Most of the new customers identified in the market survey use steam.

8.3 ACME STATION RETROFIT

Of the two categories studied, a back-pressure turbine is considered the best source of steam for district heating. Using extraction steam from the present condensing turbines was considered but rejected because of physical and capacity limitations.

The available steam from the highest extraction pressure point on No. 2 turbine is about 50,000 lb/hr. This does not provide enough steam for even the minimum proposed system. The turbine manufacturer has advised that this is the maximum flow for safe operation of this machine. A copy of the letter dated March 13, 1979 covering allowable extractions is included at the end of this section. If further consideration must be given to an increase in the extraction flow, an engineering study is required to determine what modifications, if any, can be made and their

cost. The cost for such modifications plus any losses due to an extended outage would then be compared to the cost for installation of a new back-pressure unit.

The alternates involving extraction steam from turbine Nos. 2, 5, and 6 do not have sufficient capacity and are not considered a viable heat source.

Installation of a new back-pressure turbine generator using 1,450 psig steam from No. 16 boiler appears to be the best option for cogenerated steam for district heating. Installation in parallel with No. 2 turbine has the added benefit of allowing operating flexibility. Either or both units can be operated and scheduled around both steam and electric demands. In the final design of the selected retrofit scheme, it may be more appropriate to install two half-size turbine generators to provide flexibility and improve operating efficiencies.

No. 16 boiler, which is coal-fired, has the highest operating pressure of all Acme units. With a specific exhaust pressure, this provides the highest AER (0.38). Selection of 235 psig exhaust pressure is compatible with the present low pressure system and keeps transmission pipe sizes reasonable.

A preliminary study to optimize pipeline sizes made for 400 million Btu/hr indicates that larger pipes and a lower exhaust pressure could be justified by increased revenue from the increased electric output. However, the lower steam pressures are not adequate to meet all of the customer's required process steam pressures.

Any steam requirements in excess of the capacity of No. 16 boiler would be furnished from the exhaust of the existing topping turbine. Actual operating experience and future system growth will determine the need and timing for increasing high pressure boiler capacity and adding another back-pressure turbine.

Figure 8-1 shows schematically the sources of steam at Acme and emphasizes the amount of backup available for heating system steam. Steam in the 235 psig system is furnished through the existing topping turbine, directly by boiler Nos. 9, 10, 11, and 12, or through pressure-reducing valves from the 825 psig and 1,450 psig boilers.

Figure 8-2 shows the proposed retrofit with the new back-pressure turbine generator installed parallel to the No. 2 unit. Using extraction steam for feedwater heating and the 235 psig steam for deaeration benefits the overall

system by generating additional electric power. This steam flow, which is about 50 percent of the export steam flow, generates about 31 percent of the total electric power output.

8.4 ALTERNATE SYSTEMS

Four alternates of the selected retrofit system differ only in their thermal energy output requirements. The first alternate, A3(f1), is the minimum system which supplies the present steam customers plus nine potential customers within the area of the present downtown distribution system. Alternate A3(f2) is an extension of this system now furnished by the Water Street Station and includes a hospital (Customer No. 7).

Alternate A3(g1) more than doubles the thermal requirements by the addition of a second hospital (Customer No. 15) and a large manufacturing plant (Customer No. 1) where both process and heating steam are required. In this alternate, distribution requires two branch lines, one to the remote district heating station and one to Customer No. 1.

Alternate A3(g2) is a further increase by the addition of another industrial plant (Customer No. 6) which is located along the route.

The peak hourly demands for each of the four alternates are shown diagrammatically on Figure 8-2. The demands are determined by adding 10 percent for growth to the present reported peak loads. In addition, the output steam from Acme Station must provide for the thermal losses throughout the distribution system.

Data related to the selected schemes are contained in Appendix A. Each alternate was studied as a separate scheme, that is, the equipment and pipelines are sized for the specified peak demand with no provisions for additional customers. The 14-in transmission line in A3(f1) is far from adequate for A3(g2) which employs a 24-in line. The original installation must be based on the anticipated ultimate system.

FIGURE 8-1
SCHEMATIC ARRANGEMENT
OF ACME STATION

FIGURE 8-2
DIAGRAM OF SELECTED
DISTRICT HEATING SYSTEMS.

GENERAL ELECTRIC

ELECTRIC UTILITY

SALES DIVISION

GENERAL ELECTRIC COMPANY 3 PENN CENTER PLAZA
PHILADELPHIA, PENNSYLVANIA 19102
(215) 241-5234

March 13, 1979

TOLEDO EDISON
ACME UNIT #2-TB. NO. 87453

Mr. George Melick
Stone & Webster Engineering Corp.
P.O. Box 5200
Cherry Hill, NJ 08034

Dear Mr. Melick:

George, to confirm our telephone conversation, the following is the information I conveyed to you. This unit was designed to have a valves wide open flow capacity of 676,000 lb/hr, when operating with steam conditions of 1450 psig and 1000°F. The unit has not been designed to extract steam for other than normal feedwater heating. Extracting additional steam for other purposes will result in increased loadings on those stages upstream of the extraction point. To restore these loadings to within their design values, flow through the affected stages is reduced by imposing a load restriction. This restriction includes the loss in MW's because the flow to the unit has been reduced and the extracted steam does not pass through the downstream stages.

In order to study the feasibility of modifying the unit for additional extraction without a load reduction, would require extensive engineering time, and we would need a requisition in order to do this.

If I can be of any assistance in this matter and if you have any additional questions, please don't hesitate to call.

Very truly yours,

Bob Willis

R.C. WILLIS
GENERATION SALES ENGINEER

RCW:gmz

9.0 DESCRIPTION OF THE CANDIDATE RETROFIT

As previously stated, the four alternate schemes are the same except for capacity and the distribution system. The following is a discussion of the equipment involved.

9.1 TURBINE GENERATOR

Each scheme includes one noncondensing steam turbine with back-pressure governor for operation with inlet steam of 1,450 psig and 235 psig exhaust pressure. One uncontrolled extraction provides steam for the feedwater heater. The turbine is connected to an air-cooled generator with the following gross electric output:

A3(f1)	15.9 MWe
A3(f2)	18.6 MWe
A3(g1)	31.4 MWe
A3(g2)	31.4 MWe

9.2 BOILER FEEDWATER SYSTEM

The suggested basic equipment contained in this system is:

- o Two half-size deaerators operating at 235 psig utilizing turbine exhaust steam.
- o Three 50-percent capacity high pressure feedwater pumps arranged in parallel.
- o Two half-size feedwater heaters arranged in parallel using turbine extraction steam.
- o Three half-size makeup pumps.

9.3 WATER TREATMENT

With no return of condensate from the district heating system, the present makeup water treatment system is inadequate. A suitable water treatment plant is included in the capital costs to provide makeup equal to the peak export steam plus any required blowdown. Quality of the feedwater will be as required by the 1,450 psig operating pressure.

9.4 SUPPLEMENTAL STEAM

Based on the proposed system arrangement, No. 16 boiler cannot furnish sufficient steam to meet the requirements of Alternates A3(g1) or A3(g2). A connection with the present 235 psig system will supply the additional requirements either via the topping turbine or directly from a boiler.

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10.0 ECONOMIC ANALYSIS

10.1 CAPITAL COSTS

This section presents the order-of-magnitude cost estimates for the four alternate schemes based on the retrofits described in Section 9 and the required transmission and distribution pipelines. The following are the totals including direct costs, distributables, and indirects:

<u>Alternate</u>	<u>Estimated Capital Cost - 2/79 Dollars</u>
A3 (f1)	\$11,100,000
A3 (f2)	\$14,000,000
A3 (g1)	\$32,500,000
A3 (g2)	\$34,400,000

The above do not include any costs which may be required by the customers to utilize the steam. Table 10-1 shows the breakdown of the cost estimates.

In addition to the direct costs, each estimate includes distributable and indirect costs and an allowance for indeterminates. These are defined as follows:

Indirect: Those costs, including salaries, expenses, overhead, payroll taxes, and fee, associated with the AE's engineering and design activities including all support services.

Distributable: Those field costs associated with the operation of construction management field offices and support of direct construction activities. These include both temporary services, manual labor and field supervisory nonmanual labor with associated benefits, payroll taxes, insurance, expenses, and premium pay. Also included are materials and equipment associated with the construction facilities, utilities, etc.

Allowance for Indeterminates: This is a contingency figure provided for unknowns and is affected by the type of estimate and engineering information available.

For conceptual estimates, the amount allowed for each of these items is usually a percentage established from previous projects of similar nature.

The estimates were prepared and are presented according to accounts established by the Federal Energy Regulatory Commission.

10.2 FIXED CHARGES

Table 4-1 shows fixed charges for all alternatives based on the total heat output for an annual load factor of 0.3 and fixed charge rate of 17 percent. These data are useful for comparing the cost of steam produced, but fixed charges must be recovered from the steam actually delivered to the customers. Based on current customer requirements from the market study, steam prices must include the following fixed charge component:

<u>Alternate</u>	Customers Net	<u>Fixed Charges</u> <u>(\$/10⁶Btu)</u>
	Energy Requirement <u>10⁶Btu/yr</u>	
A3(f1)	491,454	3.84
A3(f2)	580,954	4.10
A3(g1)	1,369,144	4.04
A3(g2)	1,496,144	3.91

10.3 REDUCTION IN PLANT ELECTRIC GENERATING CAPACITY

Each of the four schemes evaluated for supplying district heating steam reduces the electrical power which can be generated at Acme Station. The loss in generation capacity is shown in Figure 10-1 for alternate schemes A3(f1) and A3(f2).

In alternate scheme A3(f1) with a steam sendout of 212,000 lb/hr, maximum generating capacity of Unit No. 2 and the new back-pressure turbine is 57.5 MW at peak boiler flow. This capacity is 18 MW less when compared to Unit No. 2 generating capacity at zero sendout.

In alternate scheme A3(f2) with a sendout of 248,000 lb/hr, maximum generation is 52.5 MW. Compared to Unit No. 2's generating capacity at zero sendout, this scheme reduces overall plant capacity by 23.0 MW.

For alternate schemes A3(g1) and A3(g2) with maximum steam sendouts, the net loss of capacity is approximately 54 and 58 MW respectively. It should be emphasized that no hardware changes are proposed which reduce the Acme Plant capability with no steam sendout. Before assigning any

capability penalties, the noncoincidence of steam and electrical peak loads should be considered, and steam-only backup sources investigated.

TABLE 10-1

COST ESTIMATES FOR THE
SELECTED RETROFIT SCHEMES
(February 1979 Dollars)

	A3 (f1)	A3 (f2)	<u>ALTERNATES</u> A3 (g1)	A4 (g2)
Turbine Generator	2,800,000	3,100,000	4,250,000	4,250,000
Feedwater Equipment	660,000	740,000	1,030,000	1,030,000
Piping	390,000	400,000	570,000	570,000
Electrical and I&C	255,000	255,000	375,000	375,000
Foundations	180,000	190,000	490,000	490,000
Removal of Existing Equipment	195,000	195,000	195,000	195,000
Water Treatment	<u>470,000</u>	<u>530,000</u>	<u>900,000</u>	<u>1,000,000</u>
SUBTOTAL	4,950,000	5,410,000	7,810,000	7,910,000
Transmission Piping	3,800,000	5,820,000	19,250,000	20,850,000
TOTAL DIRECTS	8,750,000	11,230,000	27,060,000	28,760,000
Distributables	870,000	1,120,000	2,710,000	2,880,000
Indirects	970,000	990,000	1,150,000	1,110,000
TOTAL	10,590,000	13,340,000	30,920,000	32,750,000
Allowance for Indeterminants	510,000	600,000	1,580,000	1,650,000
GRAND TOTAL	11,100,000	14,000,000	32,500,000	34,400,000

ACME 2 PLUS NEW BACK PRESSURE TURBINE
ALTERNATES $A_3 (f_1)$ & $A_3 (f_2)$

FIGURE 10-1
THROTTLE FLOW VERSUS MW
GENERATION FOR VARIOUS
STEAM SENDOUTS
FROM ACME STATION

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APPENDIX A

ACME STATION RETROFIT - ALTERNATE A1(a)

STEAM FOR DISTRICT HEATING

Steam Flow: 145,000 lb/hr

Heat Output: 195×10^6 Btu/hr

Source: Steam is taken from the first extraction points on existing turbine generator Nos. 2, 5, and 6.

Retrofit: System involves only the three connections, control valves, instrumentation and controls, and the piping system.

Transmission: One 14-in line from Acme to district heating distribution system.

Capital Costs:	Retrofit	\$ 531,000
	Pipeline	<u>2,244,000</u>
	TOTAL	\$2,775,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$0.92

Advantages:

- o Retrofit costs are low.
- o Heat output meets present anticipated requirement.
- o Capital costs for transmission are relatively low.
- o Backup source is available from five boilers.

Disadvantages:

- o All three turbine generators must operate to provide the design output.
- o Turbine outages reduce electric output as a result of bypassing operating units to make up total required export steam.
- o The feedwater system balance is affected and, in turn, affects generation. Further detailed study is required to determine full effect under varying operating conditions.

Effect on Operation: Using steam from the first extraction points causes a minimal reduction of the generator outputs. However, to meet the full heating system requirements, all three turbine generators must operate, including less efficient units, which affects the overall system operation. Since no condensate is returned, water makeup is increased.

Scarce Fuel Conservation Potential: 4,900,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio:	No. 2 Turbine	-	0.37
	No. 5 Turbine	-	0.20
	No. 6 Turbine	-	0.19

ACME STATION RETROFIT - ALTERNATE A1(b)

HTW FOR DISTRICT HEATING

Steam Flow: 143,000 lb/hr

HTW Flow: 1,000,000 lb/hr (400°F)

Heat Output: 159×10^6 Btu/hr (net)

Source: Steam is taken from the first extraction points on existing turbine generator Nos. 2, 5, and 6.

Retrofit: System includes connections to the three existing extraction lines and installation of two full-size heat exchangers, three half-size circulating pumps, expansion tanks, instrumentation and control, and related piping.

Transmission: Two 10-in lines from Acme to the district heating distribution system.

Capital Costs:	Retrofit	\$1,370,000
	Pipeline	<u>2,957,000</u>

	TOTAL	\$4,327,000
--	-------	-------------

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$1.76

Advantages:

- o Condensate is maintained within the existing system.
- o Backup sources of steam are available from six boilers.

Disadvantages:

- o Transmission capital costs are high for the net heat output.
- o Turbine outages affect steam source and, in turn, electric generation.
- o As with Alternate A1(a), the feedwater systems are affected.
- o Heat output is only about 75 percent of projected requirements.

Effect on Operation: Using steam from the first extraction points should cause a minimal reduction of the generator

outputs. However, to meet the full heating system requirements, all three units must operate. This causes use of less efficient operating units during periods of low electric demand and affects the overall system operation. Condensate is returned causing no increase in feedwater makeup.

Scarce Fuel Conservation Potential: 4,000,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio:	No. 2 Turbine	-	0.37
	No. 5 Turbine	-	0.20
	No. 6 Turbine	-	0.19

ACME STATION RETROFIT - ALTERNATE A1(c)

STEAM FOR DISTRICT HEATING

Steam Flow: 50,000 lb/hr

Heat Output: 66×10^6 Btu/hr

Source: Steam is taken from the first extraction point on existing turbine generator No. 2.

Retrofit: System involves only the connection to the extraction line, instrumentation and controls, and the piping system.

Transmission: One 10-in line from Acme to the district heating distribution system.

Capital Costs:	Retrofit	\$ 103,000
	Pipeline	<u>1,800,000</u>
	TOTAL	\$1,903,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$1.87

Advantages:

- o The steam output is readily backed up by five boilers and the amount required is minor and should cause no significant effect in operations.
- o Retrofit costs are second lowest of all schemes.

Disadvantages:

- o Steam for district heating by cogeneration is limited to a single source.
- o Operation of the feedwater system is affected. A detailed study is needed to determine the extent.
- o Heat output is low and does not meet projected needs.
- o Distribution capital cost per million Btu is very high.
- o No condensate is returned.

Effect on Operation: Use of the high-pressure extraction steam should not greatly affect

generator output. Source of cogeneration steam is limited by availability of a single turbine. Backup would take steam away from other generating units if the plant were at peak operations. Required continuous use of No. 2 unit may eliminate option to generate power utilizing a more efficient unit. Loss of condensate requires treatment of additional boiler feedwater.

Scarce Fuel Conservation Potential: 1,600,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio: 0.37

ACME STATION RETROFIT - ALTERNATE A1(d)

HTW FOR DISTRICT HEATING

Steam Flow: 50,000 lb/hr

HTW Flow: 355,000 lb/hr (400°F)

Heat Output: 55 x 10⁶ Btu/hr (net)

Source: Steam is taken from first extraction point on No. 2 turbine generator.

Retrofit: System includes connection to the extraction line and installation of two full-size heat exchangers, three half-size recirculating pumps, expansion tanks, instrumentation and control, and the related piping and valves.

Transmission: Two 6-in lines from Acme to the district heating distribution system.

Capital Costs:	Retrofit	\$ 515,000
	Pipeline	<u>2,302,000</u>

TOTAL	\$2,817,000
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Fixed Charges per 10⁶ Btu at 0.3 Load Factor: \$3.31

Advantages:

- o Backup steam is readily available.
- o Condensate is maintained within the system.

Disadvantages:

- o Heating steam by cogeneration is limited to a single source.
- o Operation of the existing feedwater system is affected.
- o Heat output is low and does not meet projected requirements.
- o Capital costs for the retrofit are high for the resulting heat output.

Effect on Operation: Use of high-pressure extraction steam should have only minimal effect on generator output. Source of cogeneration steam is limited by availability of one turbine. Backup

A-8

takes steam from other generating units at peak loads. Required continuous use of No. 2 turbine may eliminate the option to generate power utilizing a more efficient unit or reduce efficiency of unit in operation. Condensate is returned so water treatment system is not affected.

Scarce Fuel Conservation Potential: 1,300,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio: 0.37

ACME STATION RETROFIT - ALTERNATE A1(e1)

HTW FOR DISTRICT HEATING

Steam Flow: 143,000 lb/hr

HTW Flow: 1,000,000 lb/hr (350°F)

Heat Output: 143.6×10^6 Btu/hr (net)

Source: Steam is taken from the first extraction points on turbine generator Nos. 2, 5, and 6.

Retrofit: At Acme, the system includes the three connections, control valves, instrumentation and controls, and the required piping. Steam from Acme is sent to a district heating system substation where it is used in a HTW system consisting of two full-size heat exchangers, three half-size pumps, expansion tanks, instrumentation and control, and the interconnecting piping.

Transmission: One 14-in line from Acme to the district heating distribution system.

Capital Costs:	Retrofit at Acme	\$ 531,000
	Pipeline	2,444,000
	Substation	<u>839,000</u>
	TOTAL	\$3,814,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$1.72

Advantages:

- o Lower transmission cost.
- o Has the option of using some steam.

Disadvantages:

- o Loss of condensate and its heat content.
- o Losses in energy by transmitting steam a long distance before using to produce HTW.
- o Lower net heat output to district heating system when compared to Alternate A1(b).

Effect on Operation: Using steam from the first extraction points causes a minimal reduction of the generator output. However, to meet the full heating

system requirements, all three units must operate. This may eliminate the option to utilize more efficient modes of operation during periods of reduced electric demand and affect overall system results. Since no condensate is returned, there is an increase in feedwater treatment.

Scarce Fuel Conservation Potential: 3,600,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio:	No. 2 Turbine	-	0.37
	No. 5 Turbine	-	0.20
	No. 6 Turbine	-	0.19

ACME STATION RETROFIT - ALTERNATE A1(e2)

HTW AND STEAM FOR DISTRICT HEATING

Steam Flow: 143,000 lb/hr

HTW Flow: 500,000 lb/hr using 50% of steam (350°F)
1,000,000 lb/hr using all of steam

Heat Output: HTW 71.8×10^6 Btu/hr at 50%
Steam 87.4×10^6 Btu/hr

TOTAL 159.2×10^6 Btu/hr

Source: Steam is taken from the first extraction points of turbine Nos. 2, 5, and 6.

Retrofit: At Acme, the system includes the three connections, control valves, instrumentation and controls, and the required piping. Steam from Acme is sent to a district heating system substation where it is used in a HTW system consisting of two full-size heat exchangers, three half-size pumps, expansion tanks, instrumentation and controls, and the interconnecting piping. In addition, a pressure-regulating system is provided to send steam directly to consumers.

Transmission: One 14-in line from Acme to the district heating distribution system.

Capital Costs:	Retrofit at Acme	\$ 513,000
	Pipeline	2,444,000
	Substation	<u>879,000</u>

TOTAL \$3,836,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$1.57

Advantages:

- o Lower transmission cost.
- o Flexibility is provided for future demands.
- o HTW generation can be increased as heating steam demand diminishes.
- o Steam is available to consumers now requiring it in their existing systems.

Disadvantages:

- o Loss of condensate and its heat content.

o Loss of energy due to long distance transmission before use to produce HTW.

Effect on Operation: Using steam from the first extraction points causes a minimal reduction of the generator output. However, to meet the full heating system requirements all three units must operate. This may eliminate the option to utilize more efficient modes of operation during periods of reduced electric demand and affect overall system results. Since no condensate is returned, there is an increase in feedwater treatment.

Scarce Fuel Conservation Potential: 4,000,000 gal oil/year
at 0.3 load factor at
50% HTW

Available Energy Ratio:	No. 2 Turbine	-	0.37
	No. 5 Turbine	-	0.20
	No. 6 Turbine	-	0.19

ACME STATION RETROFIT - ALTERNATE A1(f1)

HTW FOR DISTRICT HEATING

Steam Flow: 50,000 lb/hr

HTW Flow: 347,000 lb/hr (350°F)

Heat Output: 53×10^6 Btu/hr (net)

Source: Steam is taken from first extraction point on No. 2 turbine generator.

Retrofit: At Acme, the system includes connection to the extraction line, instrumentation and controls, and the related piping. Steam from Acme goes to a district heating system substation where it is used in a HTW system consisting of two full-size heat exchangers, three half-size pumps, expansion tanks, instrumentation and control, and interconnecting piping.

Transmission: One 10-in line from Acme to the district heating distribution system.

Capital Costs:	Retrofit at Acme	\$ 103,000
	Pipeline	1,800,000
	Substation	<u>412,000</u>
	TOTAL	\$2,315,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$2.83

Advantages:

- o Total retrofit costs are low.
- o More than adequate backup steam.

Disadvantages:

- o Loss of condensate and its heat content.
- o Loss of energy due to long distribution system before using steam to generate HTW.
- o Very high capital cost for transmission based on low heat output.

Effect on Operation: Use of the high-pressure extraction steam should not greatly affect generator output. Source of cogeneration steam is limited by availability of a single turbine.

Backup would take steam away from other generating units if the plant were at peak operations. Required continuous use of No. 2 unit may eliminate option to generate power utilizing a more efficient unit. Loss of condensate requires treatment of additional boiler feedwater.

Scarce Fuel Conservation Potential: 1,300,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio: 0.37

ACME STATION RETROFIT - ALTERNATE A1(f2)

HTW AND STEAM FOR DISTRICT HEATING

Steam Flow: 143,000 lb/hr

HTW Flow: 173,500 lb/hr using 50% of steam (350°F)
347,000 lb/hr using all of steam

Heat Output: HTW 26.5 x 10⁶ Btu/hr at 50%
Steam 30.3 x 10⁶ Btu/hr

TOTAL 56.8 x 10⁶ Btu/hr

Source: Steam is taken from first extraction point on No. 2 turbine generator.

Retrofit: At Acme, the system includes connection to the extraction line, instrumentation and controls, and the related piping. Steam from Acme goes to a district heating system substation where it is used in a HTW system consisting of two full-size heat exchangers, three half-size pumps, expansion tanks, instrumentation and control, and interconnecting piping. In addition, a pressure-regulating system is provided to send steam directly to consumers.

Transmission: One 10-in line from Acme to the district heating distribution system.

Capital Costs:	Retrofit at Acme	\$ 103,000
	Pipeline	1,800,000
	Substation	<u>452,000</u>

TOTAL	\$2,355,000
-------	-------------

Fixed Charges per 10⁶ Btu at 0.3 Load Factor: \$2.68

Advantages:

- o Total retrofit costs are low.
- o More than adequate backup steam.

Disadvantages:

- o Loss of condensate and its heat content.
- o Loss of energy due to long transmission of steam before use to produce HTW.
- o High cost for transmission line for heat obtained.

o Reduced use of No. 2 turbine.

Effect on Operation: Use of the high-pressure extraction steam should not greatly affect generator output. Source of cogeneration steam is limited by availability of a single turbine. Backup would take steam away from other generating units if the plant were at peak operations. Required continuous use of No. 2 unit may eliminate option to generate power utilizing a more efficient unit. Loss of condensate requires treatment of additional boiler feedwater.

Scarce Fuel Conservation Potential: 1,400,000 gal oil/year
at 0.3 load factor at
50% NTW

Available Energy Ratio: 0.37

ACME STATION RETROFIT - ALTERNATE A3(a)

HTW FOR DISTRICT HEATING

Steam Flow: 430,000 lb/hr

HTW Flow: 2,667,000 lb/hr (400°F)

Heat Output: 400 x 10⁶ Btu/hr (net)

Source: Steam at 1,450 psig is furnished by No. 16 boiler.

Retrofit: This scheme provides for the installation of a new, noncondensing turbine generator in parallel with No. 2 turbine to use the steam from No. 16 boiler. The turbine exhaust is used to generate HTW at 400°F.

The new backpressure turbine operates with a throttle pressure of 1,450 psig and an exhaust pressure of 300 psig. Electric power generation is 20.7 MW (gross) at a throttle flow of 430,000 lb/hr, which is the steam required to heat up the heating system water from 250°F return temperature to 400°F supply temperature. Backup steam for the HTW system is provided by either of the 825 psig units (boilers 13, 14, and 15) or the 820 psig units (boilers 91 and 92).

The HTW system portion of the retrofit includes two parallel, full-size heat exchangers, three half-size circulating pumps, expansion tanks, three half-size condensate return (boiler feedwater) pumps, instrumentation and controls, and the water distribution system. The present concept used for cost estimating purposes provides pumping capacity to circulate the design flow of 5,329 gpm without return pumping facilities at Water Street.

Transmission: Two 18-in lines from Acme to the district heating distribution system.

Capital Costs:	Retrofit	\$ 5,700,000
	Pipeline	<u>5,043,000</u>
	TOTAL	\$10,743,000

Fixed Charges per 10⁶ Btu at 0.3 Load Factor: \$1.73

Advantages:

- o Availability of the relatively high throttle pressure of 1,450 psig still provides high turbine efficiency, even with a back pressure of 300 psig.
- o The back-pressure turbine arrangement can provide for a design maximum heat output of 400 million Btu/hr. If such a quantity is found to be unnecessary, the system can be sized to meet the specific demand.
- o backup source of steam is available from five existing boilers.

Disadvantages:

- o Capital costs are the highest of the retrofit schemes applied at Acme Station.
- o No. 2 turbine may be down or may operate at a lower efficiency.
- o The 430,000 lb/hr flow to No. 2 turbine generates about 56 MW. The difference (56-20.7 MW) not generated by cogeneration may have to be generated in a less efficient unit within the grid system. This would affect the total energy use.
- o Steam rate for the back-pressure turbine is almost three times as high as No. 2 turbine.

Effect on Operation: Utilizing steam from No. 16 boiler necessitates shutting down or reducing the load on existing No. 2 condensing turbine generator, which has a maximum output of 75 MW. Reduced throttle flow lowers the efficiency of No. 2. Reduction of electric output requires an increase in output from another source, possibly at a higher heat rate. Condensate is returned within the system causing no increase of water treatment.

Scarce Fuel Conservation Potential*: 10,000,000 gal oil/year at 0.3 load factor.

Available Energy Ratio: 0.33

*Assumes that district heating would be expanded to utilize output capacity.

ACME STATION RETROFIT - ALTERNATE A3(B)

STEAM FOR DISTRICT HEATING

Steam Flow: 400,000 lb/hr for heating

Heat Output: 527×10^6 Btu/hr

Source: Steam is taken from No. 16 boiler at 1,450 psig.

Retrofit: This scheme provides for installation of a new, noncondensing turbine generator. The exhaust steam at 235 psig pressure is sent to Water Street for district heating.

With a throttle flow of 593,000 lb/hr at 1,450 psig, the new back-pressure turbine generator produces 27.7 MW of electric power. Of this flow, 400,000 lb/hr is available for district heating. The balance is utilized in the deaerator and feedwater heating. Total heat exported would be 527×10^6 Btu/hr. No consideration has been given to return of the condensate.

In addition to the turbine generator, which would be installed in parallel with No. 2 turbine, the retrofit includes deaeration equipment, feedwater heaters, instrumentation and controls, and the distribution system. Backup for the export steam is the existing 235 psig header, which can be fed from any of the boilers at the station.

Transmission: One 16-in line from Acme to the district heating distribution system.

Capital Costs:	Retrofit	\$4,900,000
	Steam line	<u>2,587,000</u>
	TOTAL	\$7,487,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$0.92

Advantages:

- o Multiple backup steam sources, which result in a very reliable heating source.
- o Extracting steam for feedwater heating provides additional electric power generation.
- o The relatively high throttle pressure is adequate to provide high turbine efficiency.

- o Capital cost per million Btu is low.
- o Heat exported meets projected maximum demand.
- o Relatively low capital cost for the transmission system.

Disadvantages:

- o No condensate is returned, thus requiring water treatment of the full flow. The higher pressure boiler requires a higher degree of treatment than lower pressure systems.
- o Retrofit cost is relatively high in total and per million Btu.
- o Loss of electric power caused by not using No. 2 turbine must be made up within the system, possibly at a higher heat rate.

Effect on Operation: Utilizing steam from No. 16 boiler requires shutting down or reducing the load on No. 2 turbine generator, which has a maximum output of 75 MW. A reduced throttle flow lowers the efficiency on No. 2 and affects the heat rate. Reduction of electric output requires picking up the load at another source, possibly at increased heat input. Since condensate is not returned, there is an increase in requirements for treating boiler feedwater.

Scarce Fuel Conservation Potential*: 12,900,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio: 0.38

*Assumes that new customers presently using scarce fuels would be added to utilize the capacity of district heating system. The 527×10^4 Btu/hr of this alternate exceeds output capacity of Water Street Station.

ACME STATION RETROFIT - ALTERNATE A3(c)

STEAM FOR DISTRICT HEATING

Steam Flow: 400,000 lb/hr for heating

Heat Output: 512×10^6 Btu/hr

Source: Steam is taken from No. 16 boiler at 1,450 psig.

Retrofit: This scheme provides for installation of a new, noncondensing turbine generator. The exhaust steam at 160 psig pressure is sent to Water Street for district heating.

With a throttle flow of 598,000 lb/hr at 1,450 psig, the new back-pressure turbine generator produces 33.5 MW of electric power. Of this flow, 400,000 lb/hr would be available for district heating. The balance is utilized in the deaerator and feedwater heating. Total heat exported is 512×10^6 Btu/hr. No consideration has been given to return of the condensate.

In addition to the turbine generator, which is installed in parallel with No. 2 turbine, the retrofit includes deaeration equipment, feedwater heaters, instrumentation and controls, and the distribution system. Backup for the export steam is the existing 235 psig header, which can be tied from any of the boilers at the station.

Transmission: One 24-in line from Acme to the district heating distribution system.

Capital Costs:	Retrofit	\$5,640,000
	Steam line	<u>3,564,000</u>

	TOTAL	\$9,214,000
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Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$1.16

Advantages:

- o Multiple backup steam sources for improved availability.
- o Feedwater heating steam increases electric power output.
- o Throttle pressure is high enough to provide high turbine efficiency.

- o Heat exported meets maximum projected demand.
- o Capital cost for transmission is relatively low.

Disadvantages:

- o Lower export pressure requires larger transmission line to maintain a reasonable pressure at Water Street. This increases capital cost.
- o No condensate return increases operating costs.
- o Retrofit costs are relatively high.
- o Steam rate of turbine is higher than Unit No. 2.
- o Decrease in electric output must be made up somewhere in the system, possibly at a higher heat rate.

Effect on Operation:

Utilizing steam from No. 16 boiler requires shutting down or reducing the load on No. 2 turbine generator which has a maximum output of 75 MW. A reduced throttle flow lowers the efficiency on No. 2 and affects the heat rate. Reduction of electric output requires picking up the load at another source, possibly at increased heat input. Since condensate is not returned, there is an increase in requirements for treating boiler feedwater.

Scarce Fuel Conservation Potential*: 12,900,000 gal oil/year at 0.3 load factor.

Available Energy Ratio: 0.43

*Assumes that new customers presently using scarce fuels would be added to the system to utilize the available capacity. The 527×10^6 Btu/hr of this alternate exceeds output capacity of Water Street Station.

ACME STATION RETROFIT - ALTERNATE A3(d1)

HTW FOR DISTRICT HEATING

Steam Flow: 400,000 lb/hr

HTW Flow: 2,900,000 lb/hr (350°F)

Heat Output: 440×10^6 Btu/hr (net)

Source: Steam is taken from No. 16 boiler at 1,450 psig.

Retrofit: This scheme provides for the installation of a noncondensing turbine generator at Acme Station using steam from No. 16 boiler. Rather than produce HTW at Acme Station, the steam is sent to a district heating substation where it is used with heat exchangers to generate the HTW at that location.

The back-pressure turbine is located at Acme Station while the two full-size heat exchangers, circulating pumps, expansion tanks, instrumentation and control are at Water Street.

Transmission: One 16-in line from Acme to the district heating distribution system.

Capital Costs:	Retrofit at Acme	\$4,900,000
	Pipeline	2,587,000
	Addition at Water St.	<u>800,000</u>
	TOTAL	\$8,287,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$1.22

Advantages:

- o Heat output meets projected maximum demand.

Disadvantages:

- o Loss of condensate and its heat content.
- o Loss of energy due to long transmission of steam before use to produce HTW.

Effect on Operation: Utilizing steam from No. 16 boiler requires shutting down or reducing the load on No. 2 turbine generator which has a maximum output of 75 MW. A reduced throttle flow lowers the efficiency on No. 2 and affects the heat rate. Reduction of electric

output requires picking up the load at another source, possibly at increased heat input. Since condensate is not returned, there is an increase in requirements for treating boiler feedwater.

Scarce Fuel Conservation Potential*: 11,000,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio: 0.38

*Assumes that the district heating would be expanded to utilize the available capacity.

ACME STATION RETROFIT - ALTERNATE A3(d2)

HTW AND STEAM FOR DISTRICT HEATING

Steam Flow: 400,000 lb/hr

HTW Flow: 1,450,000 lb/hr using 50% of steam (350°F)
2,900,000 lb/hr using all steam

Heat Output: HTW 220 x 10⁶ Btu/hr (net) at 50%
Steam 256 x 10⁶ Btu/hr

Source: Steam is taken from No. 16 boiler at 1,450 psig.

Retrofit: This scheme provides for the installation of a noncondensing turbine generator at Acme Station using steam from No. 16 boiler. Rather than produce HTW at Acme Station, the steam is sent to a district heating system substation where it is used with heat exchangers to generate the HTW at that location. A pressure regulating station is also provided to send steam directly to the consumer. The back-pressure turbine is located at Acme Station while the two full-size heat exchangers, circulating pumps, expansion tanks, pressure regulating system, and instrumentation and controls are at Water Street.

Transmission: One 16-in line from Acme to the district heating distribution system.

Capital Costs:	Retrofit at Acme	\$4,900,000
	Pipeline	2,587,000
	Addition at Water St.	<u>850,000</u>

TOTAL	\$8,337,000
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Fixed Charges per 10⁶ Btu at 0.3 Load Factor: \$1.13

Advantages:

- o Flexibility in providing either steam or HTW to heating system.

Disadvantages:

- o Loss of condensate and its heat content.
- o Loss of energy over long distribution line before generation of HTW.
- o Reduced use of No. 2 turbine.

Effect on Operation: Utilizing steam from No. 16 boiler requires shutting down or reducing the load on No. 2 turbine generator which has a maximum output of 75 MW. A reduced throttle flow lowers the efficiency on No. 2 and affects the heat rate. Reduction of electric output requires picking up the load at another source, possibly at increased heat input. Since condensate is not returned, there is an increase in requirements for treating boiler feedwater.

Scarce Fuel Conservation Potential*: 12,000,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio: 0.38

*Assumes that district heating system will be expanded to utilize output capacity and that new customers would have been using scarce fuels.

ACME STATION RETROFIT - ALTERNATE A3(e1)

HTW FOR DISTRICT HEATING

Steam Flow: 220,000 lb/hr

HTW Flow: 1,100,000 lb/hr (400°F)

Heat Output: 237×10^6 Btu/hr (net)

Source: Exhaust steam is taken from existing topping turbine.

Retrofit: This scheme produces HTW using 235 psig steam exhausted from the existing topping turbine. Condensate is directed to a deaerator.

The equipment required is only for the HTW system and includes the heat exchanger, circulating pumps, expansion tank, instrumentation and controls, and the distribution piping.

Transmission: Two 10-in lines from Acme to the district heating distribution system.

Capital Costs:	Retrofit	\$1,470,000
	Pipeline	<u>2,957,000</u>

TOTAL	\$4,427,000
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Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$1.20

Advantages:

- o Relatively low retrofit costs for resulting heat output.
- o System provides heat output required to meet present demand.
- o Relatively low cost per million Btu output.

Disadvantages:

- o Steam utilized in the HTW system must be made up to meet demands of the present steam system.

Effect on Operation: Assuming that present exhaust from the topping turbine is required by the 235 psig system, the added load for the heating system must be made up by another boiler through a

pressure reducing station. Overall effect under those conditions would be that heating steam does not result from cogeneration. Condensate is returned to system with no adverse effect on water treatment system.

Scarce Fuel Conservation Potential: 6,000,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio: 0.28

ACME STATION RETROFIT - ALTERNATE A3(e2)

STEAM FOR DISTRICT HEATING

Steam Flow: 220,000 lb/hr

Heat Output: 288×10^6 Btu/hr

Source: Exhaust steam is taken from existing topping turbine.

Retrofit: This scheme transmits the 235 psig steam exhausted from the topping turbine for use in the district heating system.

The equipment for this proposal involves only the steam line connection, the related flow instrumentation, and the distribution system.

Transmission: One 18-in line from Acme to the district heating distribution system.

Capital Costs:	Retrofit	\$ 50,000
	Pipeline	<u>2,930,000</u>
	TOTAL	\$2,980,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$0.74

Advantages:

- o Lowest cost for retrofit.
- o Low cost for delivered heat.
- o Utilizes existing equipment and requires no additional control.
- o Provides required heat output to meet present demand.

Disadvantages:

- o Steam required by existing 235 psig system normally provided via the turbine must be provided from other sources.

Effect on Operation: Assuming that present exhaust from the topping turbine is required by the 235 psig system, the added load for the heating system must be made up by another boiler through a pressure reducing station. Overall effect under those conditions would be that heating steam does not

result from cogeneration.
Condensate is not returned resulting
in increased demand and treating of
feedwater.

Scarce Fuel Conservation Potential: 7,200,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio: 0.28

ACME STATION RETROFIT - ALTERNATE A3(f1)

STEAM FOR DISTRICT HEATING

Steam Flow: 212,000 lb/hr for heating

Heat Output: 278.6×10^6 Btu/hr

Source: Steam is taken from No. 16 boiler at 1,450 psig.

Retrofit: This scheme provides for installation of a new, noncondensing turbine generator. The exhaust steam at 235 psig pressure is sent to Water Street for district heating in the downtown area.

With a throttle flow of 319,000 lb/hr at 1,450 psig, the new back-pressure turbine generator produces 15.9 MW of electric power. Of this flow, 212,000 lb/hr is available for district heating. The balance is utilized in the deaerator and feedwater heating. Total heat exported would be 278.6×10^6 Btu/hr. No consideration has been given to return of the condensate.

In addition to the turbine generator, which would be installed in parallel with No. 2 turbine, the retrofit includes deaeration equipment, feedwater heaters, instrumentation and controls, and the distribution system. Backup for the export steam is the existing 235 psig header, which can be fed from any of the boilers at the station.

Transmission: One 14-in line from Acme to the district heating distribution system.

Capital Costs:

TOTAL \$ 11,100,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$2.58

Advantages:

- o Multiple backup steam sources, which result in a very reliable heating source.
- o Extracting steam for feedwater heating provides additional electric power generation.
- o The relatively high throttle pressure is adequate to provide high turbine efficiency.

- o Capital cost per million Btu is low.
- o Heat exported meets projected maximum demand.
- o Relatively low capital cost for the transmission system.

Disadvantages:

- o No condensate is returned, thus requiring water treatment of the full flow. The higher pressure boiler requires a higher degree of treatment than lower pressure systems.
- o Retrofit cost is relatively high in total and per million Btu.
- o Loss of electric power caused by not using No. 2 turbine must be made up within the system, possibly at a higher heat rate.

Effect on Operation: Utilizing steam from No. 16 boiler requires shutting down or reducing the load on No. 2 turbine generator, which has a maximum output of 75 MW. A reduced throttle flow lowers the efficiency on No. 2 and affects the heat rate. Reduction of electric output (18.5 MW loss at peak DHS sendout) requires picking up the load at another source, possibly at increased heat input. Since condensate is not returned, there is an increase in requirements for treating boiler feedwater.

Scarce Fuel Conservation Projected*: 5,236,000 gal oil/year

Available Energy Ratio: 0.38

*Based on actual data on potential customers.

ACME STATION RETROFIT - ALTERNATE A3(f2)

STEAM FOR DISTRICT HEATING

Steam Flow: 248,000 lb/hr for heating

Heat Output: 325.8×10^6 Btu/hr

Source: Steam is taken from No. 16 boiler at 1,450 psig.

Retrofit: This scheme provides for installation of a new, noncondensing turbine generator. The exhaust steam at 235 psig pressure is sent to Water Street for district heating in the downtown area and one hospital.

With a throttle flow of 373,000 lb/hr at 1,450 psig, the new back-pressure turbine generator produces 18.6 MW of electric power. Of this flow, 248,000 lb/hr is available for district heating. The balance is utilized in the deaerator and feedwater heating. Total heat exported would be 325.8×10^6 Btu/hr. No consideration has been given to return of the condensate.

In addition to the turbine generator, which would be installed in parallel with No. 2 turbine, the retrofit includes deaeration equipment, feedwater heaters, instrumentation and controls, and the distribution system. Backup for the export steam is the existing 235 psig header, which can be fed from any of the boilers at the station.

Transmission: One 16-in line from Acme to the district heating distribution system.

Capital Costs:

TOTAL \$14,000,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$2.78

Advantages:

- o Multiple backup steam sources, which result in a very reliable heating source.
- o Extracting steam for feedwater heating provides additional electric power generation.
- o The relatively high throttle pressure is adequate to provide high turbine efficiency.

- o Capital cost per million Btu is low.
- o Heat exported meets projected maximum demand.
- o Relatively low capital cost for the transmission system.

Disadvantages:

- o No condensate is returned, thus requiring water treatment of the full flow. The higher pressure boiler requires a higher degree of treatment than lower pressure systems.
- o Retrofit cost is relatively high in total and per million Btu.
- o Loss of electric power caused by not using No. 2 turbine must be made up within the system, possibly at a higher heat rate.

Effect on Operation: Utilizing steam from No. 16 boiler requires shutting down or reducing the load on No. 2 turbine generator, which has a maximum output of 75 MW. A reduced throttle flow lowers the efficiency on No. 2 and affects the heat rate. Reduction of electric output (22.8 MW loss at peak DHS sendout) requires picking up the load at another source, possibly at increased heat input. Since condensate is not returned, there is an increase in requirements for treating boiler feedwater.

Scarce Fuel Conservation Projected*: 6,077,000 gal oil/year

Available Energy Ratio: 0.38

*Based on actual data on potential customers.

ACME STATION RETROFIT - ALTERNATE A3 (f2R)

STEAM FOR DISTRICT HEATING

Steam Flow: 249,300 lb/hr for heating

Heat Output: 325.8×10^6 Btu/hr

Source: Steam taken from No. 16 boiler via a back-pressure turbine is used in a reboiler to generate heating steam.

Retrofit: This scheme provides for installation of a new, noncondensing turbine generator. The exhaust steam at 235 psig is used to generate heating steam in a reboiler.

With a throttle flow of 379,000 lb/hr at 1,450 psig, the new turbine generator produces 18.8 MW of electric power. Of this flow, 339,000 lb/hr is used in the reboiler. The balance is utilized in the deaerator and feedwater heating. Total heat exported would be 325.8×10^6 Btu/hr. No consideration has been given to return of the condensate. Condensate from the turbine cycle is recirculated within the closed system.

In addition to the turbine generator, which would be installed in parallel with No. 2 turbine, the retrofit includes deaeration equipment, feedwater heaters, reboilers, pumps, instrumentation and controls, and the distribution system.

Transmission: One 18-in. line from Acme to the DHS distribution system.

Capital Costs:

TOTAL \$14,700,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor:

Advantages:

- o Multiple backup steam sources, which result in a very reliable heating source.
- o Extracting steam for feedwater heating provides additional electric power generation.
- o The relatively high throttle pressure is adequate to provide high turbine efficiency.

- o Heat exported meets projected requirements.
- o Use of a reboiler allows a closed circuit for the turbine steam, which minimizes makeup of higher quality feedwater. Water for district heating steam can be of a lower quality.

Disadvantages:

- o No condensate is returned from the heating system, thus requiring water treatment of the full flow.
- o Retrofit cost is relatively high in total and per million Btu.
- o Loss of electric power caused by not using No. 2 turbine must be made up within the system, possibly at a higher heat rate.
- o Savings resulting from the use of lower quality water for the district heating steam does not justify the increased capital costs for the required reboiler and larger pipeline.

Effect on Operation: Utilizing steam from No. 16 boiler requires shutting down or reducing the load on No. 2 turbine generator, which has a maximum output of 75 MW. A reduced throttle flow lowers the efficiency on No. 2 and affects the heat rate. Reduction of electric output (23.1 MW loss at peak DHS sendout) requires picking up the load at another source, possibly at increased heat input. Since condensate is not returned, there is an increase in requirements for treating boiler feedwater.

Scarce Fuel Conservation Projected*: 6,077,000 gal oil/year

Available Energy Ratio: 0.38

***Based on actual data on potential customers.**

ACME STATION RETROFIT - ALTERNATE A3(q1)

STEAM FOR DISTRICT HEATING

Steam Flow: 551,000 lb/hr for heating
 418,000 lb/hr from back-pressure turbine
 133,000 lb/hr from 235 psig system

Heat Output: 723×10^6 Btu/hr

Source: Steam is taken from No. 16 boiler at 1,450 psig.

Retrofit: This scheme provides for installation of a new, noncondensing turbine generator. The exhaust steam at 235 psig pressure is sent to Water Street for downtown district heating and to one hospital with a branch main servicing another hospital and one industrial customer.

With a throttle flow of 630,000 lb/hr at 1,450 psig, the new back-pressure turbine generator produces 31.4 MW of electric power. Of this flow, 418,000 lb/hr is available for district heating. The balance is utilized in the deaerator and feedwater heating. Total heat exported would be 723×10^6 Btu/hr with the difference supplied from the existing 235 psig system. No consideration has been given to return of the condensate.

In addition to the turbine generator, which would be installed in parallel with No. 2 turbine, the retrofit includes deaeration equipment, feedwater heaters, instrumentation and controls, and the distribution system. Supplemental and backup steam for the export is the existing 235 psig header, which can be fed from any of the boilers at the station in addition to the existing topping turbine.

Transmission: 24-in, 20-in, 12-in, and 8-in lines

Capital Costs:

TOTAL \$32,500,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$2.91

Advantages:

- o Multiple backup steam sources, which result in a very reliable heating source.

- o Extracting steam for feedwater heating provides additional electric power generation.
- o The relatively high throttle pressure is adequate to provide high turbine efficiency.
- o Capital cost per million Btu is low.
- o Heat exported meets projected maximum demand.
- o Relatively low capital cost for the transmission system.

Disadvantages:

- o No condensate is returned, thus requiring water treatment of the full flow. The higher pressure boiler requires a higher degree of treatment than lower pressure systems.
- o Retrofit cost is relatively high in total and per million Btu.
- o Loss of electric power caused by not using No. 2 turbine must be made up within the system, possibly at a higher heat rate.

Effect on Operation: Utilizing steam from No. 16 boiler requires shutting down or reducing the load on No. 2 turbine generator, which has a maximum output of 75 MW. A reduced throttle flow lowers the efficiency on No. 2 and affects the heat rate. Reduction of electric output (44 MW loss at peak DHS sendout) requires picking up the load at another source, possibly at increased heat input. Since condensate is not returned, there is an increase in requirements for treating boiler feedwater.

Scarce Fuel Conservation Projected*: 7,327,000 gal oil/year

Available Energy Ratio: 0.38

*Based on actual data on potential customers.

ACME STATION RETROFIT - ALTERNATE A3(q2)

STEAM FOR DISTRICT HEATING

Steam Flow: 600,000 lb/hr for heating
 418,000 lb/hr from back-pressure turbine
 182,000 lb/hr from 235 psig system

Heat Output: 788×10^6 Btu/hr

Source: Steam is taken from No. 16 boiler at 1,450 psig.

Retrofit: This scheme provides for installation of a new, noncondensing turbine generator. The exhaust steam at 235 psig pressure is sent to Water Street for downtown district heating and to one hospital with a branch main servicing another hospital and two industrial customers.

With a throttle flow of 630,000 lb/hr at 1,450 psig, the new back-pressure turbine generator produces 31.4 MW of electric power. Of this flow, 418,000 lb/hr is available for district heating. The balance is utilized in the deaerator and feedwater heating. Total heat exported would be 788×10^6 Btu/hr with the difference supplied from the existing 235 psig system. No consideration has been given to return of the condensate.

In addition to the turbine generator, which would be installed in parallel with No. 2 turbine, the retrofit includes deaeration equipment, feedwater heaters, instrumentation and controls, and the distribution system. Backup for the export steam is the existing 235 psig header, which can be fed from any of the boilers at the station.

Transmission: 24-in, 20-in, 12-in, and 8-in lines

Capital Costs:

TOTAL \$34,400,000

Fixed Charges per 10^6 Btu at 0.3 Load Factor: \$0.92

Advantages:

- o Multiple backup steam sources, which result in a very reliable heating source.
- o Extracting steam for feedwater heating provides additional electric power generation.

- o The relatively high throttle pressure is adequate to provide high turbine efficiency.
- o Capital cost per million Btu is low.
- o Heat exported meets projected maximum demand.
- o Relatively low capital cost for the transmission system.

Disadvantages:

- o No condensate is returned, thus requiring water treatment of the full flow. The higher pressure boiler requires a higher degree of treatment than lower pressure systems.
- o Retrofit cost is relatively high in total and per million Btu.
- o Loss of electric power caused by not using No. 2 turbine must be made up within the system, possibly at a higher heat rate.

Effect on Operation: Utilizing steam from No. 16 boiler requires shutting down or reducing the load on No. 2 turbine generator, which has a maximum output of 75 MW. A reduced throttle flow lowers the efficiency on No. 2 and affects the heat rate. Reduction of electric output (44 MW loss at peak DHS sendout) requires picking up the load at another source, possibly at increased heat input. Since condensate is not returned, there is an increase in requirements for treating boiler feedwater.

Scarce Fuel Conservation Projected*: 8,442,000 gal oil/year

Available Energy Ratio: 0.38

*Based on actual data on potential customers.

APPENDIX B

BAY SHORE STATION RETROFIT - ALTERNATE B1(a)
HTW FOR DISTRICT HEATING

Steam Flow: 440,000 lb/hr

HTW Flow: 2,667,000 lb/hr (400°F)

Heat Output: 400 x 10⁶ Btu/hr (net)

Source: Steam is taken from the cold reheat lines on turbine generator Nos. 1, 2, 3, and 4.

Retrofit: By tapping the four cold reheat lines which have steam ranging in pressure from 450 psia to 518 psia, the system meets the projected heating load. The steam boosts the temperature of the thermal medium (water) from 250°F return temperature to 400°F supply temperature.

The system includes the four connections with pressure-regulating stations, two full-size heat exchangers, three half-size circulating pumps, expansion tanks, instrumentation and controls, and the required distribution system. Condensate is directed to existing deaerators.

Transmission: Two 18-in lines from Bay Shore to the district heating distribution system via Acme Station.

Capital Costs:	Retrofit	\$ 1,500,000
	Pipeline	<u>35,296,000</u>
	TOTAL	\$ 36,796,000

Fixed Charges per 10⁶ Btu at 0.3 Load Factor: \$5.95

Advantages:

- o Projected heating requirements are met.
- o Retrofit costs per million Btu are low.

Disadvantages:

- o The location of the station, which is remote from the center of town, results in high capital costs for transmission of the HTW.
- o Cost of delivered energy is highest of all the schemes.
- o Long piping system to be maintained.

Effect on Operation: The amount of cold reheat steam which may be extracted from a turbine is limited by the safe operation of the reheater. The design flow for this alternative is approximately 12 percent of the total cold reheat flow. The extraction of more than this requires a boiler study. A reduction in flow is required when one or more units are out of service. Plant output is reduced, but there are no other major effects on plant operation.

Scarce Fuel Conservation Potential*: 10,000,000 gal oil/year
at 0.3 load factor

Available Energy Ratio: 0.33

*Assumes that district heating system would be expanded to utilize system capacity for customers presently using scarce fuels.

BAY SHORE STATION RETROFIT - ALTERNATE B1(b1)
HTW FOR DISTRICT HEATING

Steam Flow: 254,000 lb/hr
 HTW Flow: 1,751,000 lb/hr (400°F)
 Heat Output: 273.2 x 10⁶ Btu/hr (Net)
 Source: Steam is taken from the hot reheat lines
 on turbine generator Nos. 1, 2, 3, and 4.

Retrofit: By tapping the four hot reheat lines which have pressures ranging from 372 psia to 592 psia at full throttle flow, the system can provide the required steam using any two of the units and be within the 15 to 20 percent allowable limit. The steam raises the temperature of the HTW from 250°F return to the 400°F supply temperature.

The retrofit system includes the four connections, two full-size heat exchangers, three half-size circulating pumps, pressure controls, expansion tanks, instrumentation and controls, and the required distribution system.

Transmission: Two 14-in lines from Bay Shore to the district heating distribution system via Acme Station. A booster pump installation is required at Acme Station.

Capital Costs:	Retrofit	\$ 1,400,000
	Pipeline	<u>23,800,000</u>
	TOTAL	\$ 25,200,000

Fixed Charges per 10⁶ Btu at 0.3 Load Factor: \$5.97

Advantages:

- o Projected heat requirements are met.
- o Retrofit costs are low.

Disadvantages:

- o The remote location results in high capital costs for transmission of the HTW.
- o High cost of delivered energy.
- o Long piping system to be maintained.
- o Reduced throttle flows to the turbines have an adverse effect on HTW generation.

- o Use of hot reheat steam limited to 15 to 20 percent of the specific required flow at each operating mode.
- o System pressure is relatively high.

Effect of Operation: Turbine generator units must operate at the capacities required to provide the steam and still remain within the 15 to 20 percent limitation allowed to be extracted. This may result in scheduling operations around heating system loads rather than electric demand.

Scarce Fuel Conservation Potential: 6,900,000 gal oil/year
at 0.3 load factor.

Available Energy Ratio: 0.27

BAY SHORE STATION RETROFIT - ALTERNATE B1(b2)
HTW FOR DISTRICT HEATING

Steam Flow: 625,000 lb/hr
 HTW Flow: 4,312,000 lb/hr (400°F)
 Heat Output: 742 x 10⁶ Btu/hr (Net)

Source: Steam is taken from the hot reheat lines on turbine generator Nos. 1, 2, 3, and 4.

Retrofit: By tapping the four hot reheat lines which have pressures ranging from 372 psia to 592 psia at full throttle flow, the system can provide the required steam using all four units. The steam raises the HTW from the return temperature of 250°F to the 400°F supply temperature.

The retrofit system includes the four connections, two full-size heat exchangers, three half-size pumps, pressure regulation, expansion tanks, instrumentation and controls, and the required distribution system.

Transmission: The transmission of the HTW to the district heating distribution system and the other potential customers requires a two-pipe system using 24-in, 18-in, 16-in, 12-in, and 8-in pipes. A booster pump installation is required at Acme Station.

Capital Costs:	Retrofit	\$ 2,600,000
	Pipeline	<u>51,200,000</u>
	TOTAL	\$ 53,800,000

Fixed Charges per 10⁶ Btu at 0.3 Load Factor: \$4.69

Advantages:

- o Retrofit costs are low.

Disadvantages:

- o The remote location results in high capital costs for transmission of the HTW.
- o System pressure is relatively high.
- o High cost of delivered energy.
- o Long piping system to be maintained.

- o Use of reheat steam requires operation of all four units at peak heating demand.
- o The HTW cannot provide the thermal energy required for the process steam at the Jeep Corporation.

Effect on Operation: All four turbine generator units must operate at the peak demand of the heating system. This may cause scheduling based on heating load rather than electric demand.

Scarce Fuel Conservation Potential*: 700,000 gal oil/year at 0.3 load factor

Available Energy Ratio: 0.27

*Assumes district heating system would be expanded to utilize the output capacity for customers presently using scarce fuels.

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

Task 5

Institutional Analysis

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Toledo, Ohio

April, 1979

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3.5 TASK 5 - INSTITUTIONAL ANALYSIS

ABSTRACT

Battelle Columbus Laboratories (BCL) is a member of the Demonstration Team employed as a subcontractor by Toledo Edison to investigate several institutional issues affecting the success of district heating. The Toledo Edison legal staff reviewed the legal aspects of mandate to serve, easement and franchise requirements, and corporate charter requirements. The principal findings of both the Battelle investigations and the legal research are summarized in the following text. A complete discussion of each issue is included in the two sections labeled "Legal Issues" and "Institutional Issues".

The task deliverables are incorporated into the summary for the convenience of the reader. The section on ownership options was added in response to suggestions from ANL program management to address the alternative ownership/financing arrangements during Phase 1.

3.5.1 Task Deliverables

Supply an analysis explaining why the Demonstration Project will or will not be subject to utility regulation, and the consequences for the project if it is regulated.

3.5.1 Regulatory Process

Municipalities in Ohio have the option to exercise "home rule" and establish utility rates by negotiating with utilities to set rates. This method has been used consistently to formulate steam rates for

users of the existing steam distribution system in the central business district of Toledo, Ohio. The rates are filed with the Public Utilities Commission of Ohio (PUCO) for information purposes but formal rate cases have not been filed.

If the district heating system develops as proposed under this Demonstration Program, the rates for district heating could still be negotiated at the local level. The complicating factor is that the source will be a cogeneration facility which means that the cost of electricity and steam at the plant are inherently combined. Since the PUCO regulates the cost of electricity, they will automatically be involved in the cost allocation for the district heating system. Therefore, the PUCO is represented on the Demonstration Team in a review and advisory capacity to comment on these matters.

The major powers exercised by the PUCO include:

- . The fixing of tariffs.
- . The establishment of an acceptable system of accounts.
- . The requirement that any or all public utility contracts be filed, reviewed and approved by the PUCO.
- . The granting of approval for the issuance of stocks, bonds or notes prior to issuance.

As public utility, Toledo Edison already conforms with these requirements. Only the setting of tariffs is presently settled without PUCO involvement.

Municipal ownership of the district heating system, municipal ownership with lease back to Toledo Edison and the establishment of a non-profit corporation are three methods to circumvent involvement with the PUCO.

The economic analysis to be performed in Task 6 will determine the extent to which the tax advantages and lower cost of capital associated with such options affect the overall economic viability of the project. Regulation by itself is not sufficient reason to elect an alternative ownership/financing arrangement.

3.5.2 Task Deliverables

Explain the views of the Utility Company toward the project and determine the requirements that must be met to persuade it to own and operate the Demonstration Project.

3.5.2 Ownership/Financing Options and Toledo Edison's Involvement

Seven ownership/financing options were reviewed as part of Task 5. Evaluation of the advantages and disadvantages of each option lead to the conclusion that there are two good choices. Public utility or municipal ownership are the most feasible options. Municipal ownership with lease back to the utility is a possible compromise since the city would not have to operate the system. This concept will require further legal research to determine if it is legally feasible. Municipal ownership is effective only if the economic advantages are substantial because of the exclusion from taxes and because of the access to financing at lower interest rates. Task 6 - "Economic Analysis" will determine the magnitude of the tax advantages of municipal ownership upon the overall viability of the project.

Toledo Edison ownership is considered to be the most likely alternative.

The principal reasons for this assessment include the following:

1. Existing property does not change hands which avoids complex legal and financial arrangements.
2. Toledo Edison is familiar with financing major construction projects and may be able to incorporate the district heating project into its regular financing plans.
3. Toledo Edison is experienced in dealing with the Public Utilities Commission of Ohio.
4. Toledo Edison has the talent and work force to supervise the expansion of the system and maintain the district heating system.

Toledo Edison intends to pursue development of a district heating system by using by-product heat from an electric generating plant until sufficient evidence is assembled which will permit the Company to make a prudent business decision. If further study indicates that such an investment will:

- a. provide a reliable energy supply to our customers at a lower incremental cost than alternative energy sources,
- b. conserve natural resources,
- c. provide a satisfactory return on investment to our stockholders,
- d. remain within reasonable bounds on risk, and
- e. is within the Company's ability to finance,

then the Company will act favorably on the establishment of a system.

Toledo Edison envisions utility ownership as the most likely outcome. The economic analysis will help us determine to what extent the choice of ownership alternatives impacts the ultimate success of the project.

3.5.3 Task Deliverables

Explain the legal requirements for obtaining franchises to occupy the public right-of-way and determine whether or not the project can obtain

such franchises. Explain any requirements for obtaining certificates of convenience and necessity and whether or not the project can qualify for such certificates.

3.5.3 Franchises to Occupy Public Right-of-Way

Toledo Edison has franchise rights within the City of Toledo dating back to 1894 which permit the utility to install facilities to distribute steam or hot water. This permission is at best a license to use the public right-of-way at the utility's risk. The franchise does continue indefinitely.

The alternative to using public right-of-way is to obtain easements on private property. This alternative may be pursued in some instances but in the central business district is seldom possible. Often there is no building setback and the building foundation is practically on the property line. In other areas the problems of obtaining private easements may be substantial. Use of the public right-of-way involves risk but utilities are aware of the risk each day as additional facilities are installed. Proper coordination and planning with city officials should result in a satisfactory installation in the public right-of-way with minimal conflict in the future.

3.5.4 Task Deliverables

Determine the taxes the Demonstration Project will be subject to and evaluate the effects of such taxes on the economic viability of the project.

3.5.4 Taxes Applicable to District Heating

State and local taxes include excise tax on gross revenues resulting from retail utility sales, real property tax, and tangible personal property tax. The Ohio revised code defines a heating company as a business supplying water, steam, or air through pipes to consumers for heating purposes. The code includes this business as a public utility which is obligated to pay a 4% excise tax. Property tax is assessed locally on land and buildings. A recent Ohio law provides real and personal property tax exemptions for certain energy related facilities. The property that is used in a district heating system falls under the provisions of this bill and will, therefore, not be a factor in Task 6 - "Economic Analysis". Tangible property tax is assessed at the state level on the equipment used in the operation of the utility.

Federal income tax applies to the profits realized from the sale of district heating energy. To help reduce this tax obligation the normal investment tax credit is applicable. The energy tax credit does not apply to public utilities so this credit would not be an incentive. However, the federal energy tax credit law provides some incentive for the end user.

3.5.5 Task Deliverables

Determine whether or not the project will be subject to a statutory mandate to serve all customers willing to pay for services, the effects this will have on the viability of the project, and any steps that can be taken so the project can either avoid or meet such a mandate.

3.5.5 Mandate to Serve

In Ohio, legal precedent indicates that a district heating system could be established to render service in two different ways. First, a well defined service area could be established, as it is now, and the district heating services would then be distributed within that area without unjust discrimination. Alternatively, service contracts could be written to serve individual customers or groups of customers with district heating energy. Both of these concepts must be carefully structured in accordance with Ohio law and are subject to scrutiny by the PUCO.

Presently, Toledo Edison limits the market for district heating by requiring that potential customers be located within a specified area in the central business district. The Company further limits growth by accepting loads only if the steam can be supplied without the need for additional production capacity or increasing the capacity of existing distribution mains. Future development of an expanded district heating system requires careful planning so that production capacity and the connected loads are matched. The opportunity exists to formulate an appropriate legal basis for a successful Demonstration Project which will continue to grow only to the extent that the overall economics will be maintained.

3.5.6 Task Deliverables

Explain in detail the environmental regulations the project will have to meet and whether or not the project will be able to qualify for construction and operating permits under such regulations.

3.5.6 Environmental Regulations

Environmental regulations apply to both the impact of construction and the continuing impact of operating a district heating system. Since the source for the district heating system is an existing power plant, there are no siting problems like there are for new plants. The layout of the system proposed for Toledo requires that the main steam line cross the Maumee River. The dredging that will be required to install the line below the shipping channel is the only construction procedure which has the potential for significant environmental impact. Proper disposal of the dredged material appears to be the significant issue. Approved disposal sites are readily available since the shipping channel is dredged to maintain the proper depth. The details of the involvement with the U. S. Army Corp of Engineers, U. S. Environmental Protection Agency and the U. S. Coast Guard are well documented in the Task 5 report.

The proposed power plant to be retrofitted for the production of district heating energy is a source of emissions which affect both air and water quality. However, since the capacity of Acme Station will not change as a result of the retrofit, no additional emissions will result. In other words, a portion of the electrical output will be replaced by a thermal output to the district heating system. The boiler capacity of the plant will remain constant. Because the retrofit of existing facilities will have minimal impact on the plant residuals, the Ohio EPA does not currently anticipate that a "permit to install" will be required. Subject to more detailed discussions with Ohio EPA is Phase 2 of the program.

Water Street Station presently is the source of steam for the existing district heating system. Replacing the need for this station with cogenerated steam from Acme will remove a source of air emission from urban Toledo. The oil which is burned at Water Street will be replaced by the combustion of coal at Acme. The usage of the Acme boilers will increase, but air emissions criteria will not change since no new boiler capacity will be utilized.

3.5.7 Task Deliverables

Determine whether or not the project will be subject to any Power Siting Statutes and whether or not it can qualify under such statutes. Explain how the project may or may not meet zoning law restrictions and the process established for obtaining zoning approvals or variances.

3.5.7 Applicable Power Siting Statutes

The Ohio Power Siting Commission (OPSC) was established to determine criteria for environmental evaluation of power plant sites. A major utility facility is defined to be an electrical generating plant capable of operation at a capacity of at least 50 megawatts. This criterion has been interpreted by the OPSC to be an electrical measure and not a thermal equivalent. The proposed retrofitting of the Acme Station is not likely to exceed the above limitation. However, once the decision is made to retrofit Acme Station, a letter of intent will be filed with the OPSC so an official determination may be made.

Depending upon the configuration of the district heating system, there may be the need for a small building to house a pressure reduction station and other auxiliary equipment. There is sufficient flexibility

in the choice of site for this facility that zoning problems are minimal. Opposition to the selected site would delay zoning approval. Construction of the distribution system itself does not require zoning approval.

3.5.8 Task Deliverables

Provide a legal opinion as to the Contractor's ability to proceed.

3.5.8 Corporate Charter Provisions

The Amended Articles of Incorporation of the Toledo Edison Company created in 1977 clearly establishes that the Company is in the district heating business. There are no legal impediments which would prohibit Toledo Edison from constructing the expanded district heating system. Other ownership arrangements would require detailed study. The existing district heating system is pledged under the Company's Indenture of Mortgage. It is possible to release the district heating system from the indenture to facilitate alternative ownership arrangements. The legal intricacies of this procedure will be developed only if another ownership arrangement is identified as necessary for successful demonstration. This possibility will be investigated in Task 6 - "Economic Analysis".

3.5.9 Task Deliverables

Provide a plan for obtaining the requisite approvals, identifying the person or persons responsible for granting each approval and the kind of data required in the application for respective approvals.

3.5.9 Schedule of Approvals

The complete text of the Task 5 report provides a detailed explanation of how the various federal, state and local agencies are involved with the construction of an expanded district heating system. To summarize this involvement, three tables have been created which are included at the end of the executive summary for your convenient reference.

If all agencies had to fully review the impact of the project, approximately eighteen months would be required to obtain all the necessary approvals. This schedule is based on obtaining all approvals during the first pass through the process. Since the lengthy procedures involved in Ohio EPA permits and Ohio Power Siting Commission will not be necessary because the retrofit project is not anticipated to fall within their jurisdiction, a 12-month approval process is much more likely. A majority of that time will be spent coordinating the regulatory framework with the Public Utilities Commission of Ohio.

The most important finding of the institutional investigation completed during Phase 1 is that there are no serious institutional barriers which jeopardize the Demonstration Project. The results of the investigation are completely documented in the attached report. The legal aspects are covered in the first segment and the remaining issues are covered in the second portion of the report which was prepared by Battelle Columbus Laboratories. The Table of Contents, found behind the Institutional Issues tab, is useful in guiding the reader to sections of specific interest.

FIGURE 1. PRELIMINARY SCHEDULE OF PERMITS/APPROVALS* - FEDERAL AGENCIES

* This schedule is simply a first approximation of the time required to secure appropriate permits and approvals. It gives an indication of priorities and the range of time frames likely to be required to obtain necessary permits and approvals.

** Both the NPDES and air quality permits are being pursued by Toledo Edison independent of the proposed project. In addition, it appears quite likely that a permit to install will not be required because of the minor effect of the project on residual emissions at Acme Station. This cannot be confirmed until more details are submitted to OEPA/USEPA for review in Phase II. Consequently, the above schedule is an estimate of the time requirements should the permit to install be required.

FIGURE 2. PRELIMINARY SCHEDULE OF PERMITS/APPROVALS* - STATE AGENCIES

* This schedule is simply a first approximation of the time required to secure appropriate permits and approvals. It gives an indication of priorities and range of time frames likely to be required to obtain necessary permits and approvals.

** It now appears likely that a permit to install will not be required because of the minor effect of the proposed project on residual emissions at Acme Station. This, however, cannot be confirmed until more details are submitted to OEPA/USEPA for review in Phase II. Consequently, the above schedule is an estimate of the time requirements should the permit to install be required.

FIGURE 3. PRELIMINARY SCHEDULE OF PERMITS/APPROVALS* - LOCAL AGENCIES

* This schedule is simply a first approximation of the time required to secure appropriate permits and approvals. It gives an indication of priorities and range of time frames likely to be required to obtain necessary permits and approvals.

** It now appears likely that a permit to install will not be required because of the minor effect of the proposed project on residual emissions at Acme Station. This, however, cannot be confirmed until more details are submitted to OEPA/USEPA for review in Phase II. Consequently, the above schedule is an estimate of the time requirements should the permit to install be required.

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MEMORANDUM REGARDING THE DISTRICT
HEATING AND COOLING PROJECT

I. Introduction

At the request of Toledo Edison Company's (TECo's or the Company's) Research and Development Department, Legal Services Department has investigated certain specific legal requirements which impact on the feasibility of a District Heating and Cooling project within the Company. Specifically, the following items were investigated:

1. The mandate of a public utility to provide adequate service to customers within its service area at a just, reasonable and lawful rate.
2. The Company's existing franchise agreements with the City of Toledo regarding the placement of public utility service equipment in the public right-of-way.
3. The Company's Articles of Incorporation and Mortgage Indenture, as impacting on the Company's ability to proceed on a project of this type.

The reader of this memorandum should keep in mind several items regarding this study. First, the Public Utilities

Commission ("PUCO" or "Commission") has not been contacted regarding the items listed above. In a recent "interim" meeting with TECo and Battelle - Columbus ("B-C"), B-C indicated that they were in communication with PUCO Staff members, and would incorporate any PUCO comments into the Task 5 Final Report. Second, a "legal opinion as to the Contractor's ability to proceed" cannot be provided until a thorough study is made of all the other barriers, both internal and external. Full consideration would have to be given to all the "external" barriers (such as local, state and federal regulations) as well as the "internal" barriers (such as utility arrangements available to TECo, including risk-shifting mechanisms). With respect to the "external" barriers it would be extremely beneficial to obtain from regulatory officials, to the extent they are willing, an "advisory opinion" as to the feasibility of this project. Since this project is relatively novel, at least within the confines of the State of Ohio, it may be possible to obtain such opinions.

II. PUCO Mandate to Serve

A. General Duty to Serve Public

A public utility company in Ohio, such as TECo is highly regulated as to the furnishing of service to the public. Ohio law¹ vests within the PUCO the power and jurisdiction to

¹Section 4905.04, Ohio Revised Code.

supervise and regulate public utilities, and require these public utilities to render its services in accordance with the statutes of Ohio and the directives of the Commission. For example, TECo must keep the PUCO informed as to franchises², obtain approval prior to abandoning facilities³, and, most importantly,

"furnish necessary and adequate service and facilities . . . All charges made or demanded for any service rendered, or to be rendered, shall be just, reasonable, and not more than the charges allowed by law or by order of the public utilities commission."⁴ (Emphasis added).

It is also well settled in Ohio that a utility is bound to serve to the extent of its capacity to serve the public who need the service and are within the utility's field of operation.⁵ On the other hand, a public utility is not obligated to serve an area which it has never professed to render service⁶, but rather, must provide adequate service, without unjust discrimination to the extent of its undertaking⁷.

In the case of the proposed District Heating and Cooling system, it would thus be advantageous for TECo to establish a limited form of service to a well-defined area, such as a

²Section 4905.06, Ohio Revised Code.

³Section 4905.20, Ohio Revised Code.

⁴Section 4905.22, Ohio Revised Code.

⁵Industrial Gas Co. v. PUCO, 135 OS 409 (1939).

⁶45 O. Jur. 2d §61, Duty to Serve.

⁷Ibid.

particular portion of the downtown Toledo area. By specifically limiting the undertaking in this fashion (whether by franchise, service contract or arrangement) TECo would arguably meet the common law requirements of furnishing service to the extent of its undertaking. Once TECo had thus established its steam service area, it would be generally required to serve the public within that area without unjust discrimination⁸.

B. Service Contracts

In general, it may be said that since a public utility is closely regulated by state law, and since the public utility's service is governed by its contract for service, any contract for service must be in accord with the state statute⁹. Ohio law seemingly provides several means whereby a public utility can lawfully render service to a designated area. First, a utility can provide service to a group of customers pursuant to general service schedule which is filed with the PUCO¹⁰. Following this filing, the PUCO would have the right to prescribe changes in the form of these schedules. In the case of an original rate filing, the PUCO can provide perfunctory approval to the utility's application to establish a rate¹¹.

⁸16 Am. Jur. 2d §16, General Duty to Serve.

⁹45 O. Jur. 2d §68, Service Contracts and Breach Thereof.

¹⁰Section 4905.30, Ohio Revised Code.

¹¹Cookson Pottery v. PUCO, 161 O. St. 498, 120 NE 2d 98 (1954).

This is to be distinguished from the situation where a utility company files an application to increase an existing rate, where detailed filings are required¹².

In addition to the above method, Ohio law specifically permits a utility company to enter into an arrangement with an individual customer or group of customers providing for such matters as: Variable rates, based on stipulated variations in cost; minimum service charges and service classifications¹³. Such arrangements are deemed to be "special contracts" and are not lawful unless the details of the arrangement and the embodied rate are filed and approved by the PUCO¹⁴. Thereafter, the public utility is required to conform its schedules of rates in accordance with these special contracts¹⁵, and the PUCO may modify or alter these contracts¹⁶.

It should also be recalled that the Ohio Constitution specifically provides that:

"Municipalities shall have authority to exercise all powers of local self-government and to adopt and enforce within their limits such local police, sanitary and other

¹²Sec. 4909.18, Ohio Revised Code.

¹³Sec. 4905.31, Ohio Revised Code.

¹⁴45 O. Jur. 2d §137, Special Contracts.

¹⁵Ibid.

¹⁶Sec. 4905.31, Ohio Revised Code.

similar regulations, as are not in conflict with general laws.¹⁷

This "home rule" power has thus been permitted a municipal corporation to fix the rate of a public utility's service within the municipal limits¹⁸.

In summary, there are various methods by which TECO could establish a steam rate with individual customers. Before attempting to evaluate which option, or combination of options, would best fit TECO's needs, it is necessary to consider the law of Ohio regarding service classifications.

C. Discrimination and Classification as to Service

It can safely be assumed, for purposes of this memorandum, that TECO would wish to limit the scope of this steam project, for obvious economic reasons. Ohio law provides that discrimination as to service is not prohibited, but rather must be based on a reasonable classification¹⁹. In other words, all customers within a given class must be treated equally.

In the case at hand, TECO could elect to either serve a select group of customers and so contract on an individual basis, or serve the public at large within a small geographic area. If TECO were to file and gain PUCO approval of a "special

¹⁷Art. XVIII, §3, Ohio Constitution.

¹⁸Cleveland Tel. Co. v. Cleveland, 98 OS 358, 121 NE 701.

¹⁹45 O. Jur. 2d §62, Discrimination as to Service.

contract" with an individual customer, as previously described, TECo would not obligate itself to serve customers other than those with which it has contracts²⁰. However, should TECo file for PUCO approval a schedule of rates pursuant to a general service schedule, it would become obligated to serve without discrimination all applicants within the prescribed area at the rates fixed by the schedule²¹.

With regard to the actual rates charged various customers, Ohio law permits varying rates when such rates are based upon differences in the services rendered or in the conditions under which it is rendered²². This would seemingly further permit flexibility for TECo to setting rates for the individual customer based, in part, on site specific factors.

As a final matter, it should be kept in mind, that by municipal ordinance (pursuant to Ohio's "home rule" provisions) the City of Toledo could establish an ordinance providing for service to a limited portion of the city, such as the downtown area. This, in essence, is the methodology which TECo employed in establishing its present low pressure steam heating service. This service contract, established by Ordinance No. 69-78 of

²⁰45 O. Jur. 2d §139, Discrimination and Classification, Generally.

²¹Cookson Pottery v. PUCO, 161 O. St. 498, 120 NE 2d 98 (1954).

²²45 O. Jur. 2d §141, Classification, Generally.

the City of Toledo, passed January 31, 1978, contains two especially relevant provisions:

. . . (3) Service is available to any customer connected to the steam distribution system of the Company in the central business district of the City of Toledo.

(4) The Company will accept such new loads only if the steam can be supplied without adding steam production capacity or increasing the capacity of existing distribution mains . . .

To summarize this discussion, there exist several means by which TECo could establish a limited steam service to designated locales and/or customers. To minimize the risk of being forced to expand this steam heating and cooling service beyond the point which TECo determines to be economically viable, TECo should well consider establishing either "special contracts" with individual or groups of customers or request the City of Toledo City Council to pass a municipal ordinance containing mutually agreeable terms.

III. Franchise and Easement Requirements

A. Franchise Arrangements

As briefly touched upon in the previous section of this memorandum, the granting of a franchise by a municipality to a public utility creates dual obligations. The public utility assumes a public duty to render service reasonably adequate to meet the wants of the territory²³. On the other hand, the

²³45 O. Jur. 2d §141, Extension on Increase of Services.

municipality authorizes the public utility to install, utilize and maintain its necessary equipment in the public right-of-way so as to be able to serve the public.

Toledo Edison Company has obtained franchise agreements from the various municipalities within its service territory. For purposes of simplification, this portion of the memorandum will only deal with two sets of franchises, those involving the City of Oregon and the City of Toledo. These are the two communities within which Bay Shore and Acme Stations, respectively, are located.

Pursuant to Ordinance No. 43, passed July 7, 1958 and accepted August 6, 1958, the Council of the City of Oregon granted a 50 year franchise to the Toledo Edison Company to construct, operate, maintain, etc. various equipment to serve the public. Regarding the ability of the Company to site and maintain steam lines in the City of Oregon, Section 1 of this franchise outlines the scope of the grant as follows:

That The Toledo Edison Company, its successors and assigns (hereinafter collectively referred to as "grantee"), be and it is hereby granted the right and franchise to erect, construct, reconstruct, replace, maintain, operate and use, and to continue to maintain, operate and use, for a period of fifty (50) years from and after the date of the acceptance by said company of this Ordinance, poles, towers, wires, cables, guy wires, stubs, anchors, fixtures and appurtenances thereto for the conduction, transmission and distribution of electricity and telephone and telegraph circuits in, under, over, along, across and upon the streets, alleys, lanes, lands, squares and public places in the City of Oregon, Lucas County, Ohio. (emphasis added)

It thus appears that the Company presently does not have a franchise agreement with the City of Oregon to install and utilize a steam distribution system. Such authorization would be required prior to proceeding with any steam heating project involving Bay Shore Station.

With regard to the City of Toledo, it should be noted that the Company's various predecessor companies were parties to at least seven franchise agreements with the City of Toledo. The earliest of these agreements is dated March 26, 1881 and involved the Toledo Electric Light and Power Company, while the most "recent" is dated July 15, 1895 and involved the Toledo Consolidated Electric Company. Before analyzing the terms of the various franchises applicable to the proposed steam heating project, it should be recalled that the Company is presently providing low pressure steam heating service in the central business district of the City of Toledo pursuant to a municipal ordinance. Since the present service contract does not specify that the steam must be produced at a specific location, the Company arguably has the existing right to: (1) utilize the present steam system with a new steam source (other than Water Street Station), and (2) expand the existing system within the central business district, without the need to obtain supplemental franchise rights.

In any case, there are two existing "steam" franchise agreements with the City of Toledo, both of which specify that the rights and benefits inure to the successors or assigns in

interest. The first, a franchise granted to Central Chandelier Company, dated November 20, 1893 and amended by Ordinance No. 10-110, dated March 15, 1894 provides as follows:

BE IT ORDAINED BY THE COMMON COUNCIL OF THE CITY OF TOLEDO THAT permission and authority is hereby granted to the Central Chandelier Company, its successors and assigns, to use and occupy such portion of the avenues, streets, lanes, alleys, public lands, landings, wharfs, squares and public places of the City of Toledo as may be necessary for the purpose of laying down, maintaining and operating mains and conduits and for the purpose of erecting, constructing, maintaining and operating poles, wires and house connections for the manufacturing, selling and furnishing electricity, steam or hot water for heat, light and power purposes, together with the necessary fixtures, posts, piers, abutments, required for the wires and fittings . . . (emphasis added)

It should also be noted that this franchise was granted for an indefinite time period.

The second franchise is similar to the first in that there is no specified time limitation. It is dated March 18, 1895 and designated as Ordinance 10-246 which amended Ordinance 10-200, and contains the following provisions:

Be it ordained by the Common Council of the City of Toledo, that the consent of the municipal authorities of the City of Toledo, be and the same hereby is given and the right, authority and permission is hereby granted to The Toledo Consolidated Electric Company, its successors and assigns, to construct, maintain and operate lines for conducting electricity for power, light and other purposes, for which electricity is or may be used, (and to construct, maintain and operate pipes for conducting steam or hot water for heat, power and other purposes for which steam or hot water is or may be used) through the streets, alleys, lanes, lands, squares and public places of the City of Toledo, by the erection, maintenance and use of the necessary fixtures . . . (emphasis added)

In conclusion, two franchises exist between the City of Toledo and predecessors of the Toledo Edison Company permitting the construction and operation of a steam heating system on the public right-of-way within the City of Toledo. As a practical matter, the Company might well prefer to obtain a new "steam" franchise from the City of Toledo rather than rely upon the previously noted eighty year old franchises.

B. Easement Arrangements

This portion of the memorandum will deal solely with easement arrangements within the City of Toledo, since, it has been assumed that, at least in the initial stages of construction, the proposed steam heating service would only be economically feasible in a dense steam load location such as the City of Toledo.

In order to permit construction by a public utility in the public right-of-way within Toledo, the City of Toledo requires that the utility submit for approval a form entitled "Utility Work in the Public Right-of-Way for New Construction, Relocation or Replacement". In reviewing this document, it should be noted that no easement interest is created, as there is no conveyance of any property rights on the part of the City of Toledo. The public utility at best receives a license to occupy the public right-of-way. In other words, the utility receives the revocable and unassignable permission to construct facilities on property

belonging to the City of Toledo without having an interest in such property. Should the City of Toledo feel it necessary that the public utility relocate a portion of its facilities, the City could arguably revoke the license. Since the general law in Ohio provides that a license is not made irrevocable by expenditures or reliance thereon²⁴, the Company would be forced to rely on equitable principles of law to attempt to avoid massive equipment relocation expenditures.

In the related situation where the Company would attempt to locate such steam lines on private property, it would be required to obtain necessary easements from the individual property owners. Should condemnation proceedings be required, the landowner would be afforded the basic constitutional protection of compensation for the fair value of such property²⁵.

In conclusion, the obtaining of easements and/or licenses within the City of Toledo to construct and operate steam lines is governed by the same general principles applicable to siting electrical distribution facilities. In that regard, research has revealed no insurmountable legal barriers to the construction and operation of this steam heating system, although steam franchise rights from the City of Oregon would be required for a project involving Bay Shore Station.

²⁴34 O. Jur. 2d §12, Revocability as Affected by Expenditures or Action in Reliance on License.

²⁵Art. I, §19, Ohio Constitution; Amendment V, U. S. Constitution.

IV. Corporate Charter Requirements

A. Corporate Articles of Incorporation

The Amended Articles of Incorporation of The Toledo Edison Company dated July 1, 1977; as amended to September 27, 1977 establish the basic framework of the Company. Article III of this document outlines the purposes for which the Company is formed.

Section A provides as follows:

To manufacture, generate, develop, create and produce from any source and by any means, and to purchase, otherwise acquire, use, transmit, transport, store, distribute, sell, exchange, lease as lessor or as lessee, otherwise dispose of, grant licenses with respect to, furnish any kind of service by means of or with respect to and engage in research with respect to, any kind or form of electricity, energy, radiation, light, refrigeration, cooling, heat, water, steam, gas, petroleum, coal and other fuels; to engage in any kind or form of transportation or communication; . . .
(emphasis added)

This provision clearly authorizes the Company to engage in the business of generating and selling steam energy, and the Company's present central business district steam distribution system bears witness to this fact.

B. Mortgage Indenture Requirements

Before discussing the potential impact of the Company's Indenture of Mortgage and Deed of Trust to The Chase National Bank of the City of New York ("mortgage indenture"), it should be recalled that the author has not considered the general topic of "utility arrangements" within this memorandum. As such, the

impact of the mortgage indenture with respect to the Company's ability to establish, for instance, a subsidiary corporation must be considered in the final report for Task 5 of this project. Should such a subsidiary corporation be considered, the impact of the Company's mortgage indenture on the Company's ability to capitalize the subsidiary corporation would have to be considered in detail.

The granting clauses of the mortgage indenture provide that certain properties of the Company in existence at the date of execution of the indenture are pledged to the mortgagee. Part Six of this granting clause specifically deals with the "Heat Generating Plants and Heat Transmission and Distribution Systems of the Company". This provision brings within the scope of the indenture all of the then-existing steam facilities of the Company as well as the steam distribution system and the interests in the previously-noted franchise agreements with the City of Toledo.

The chief impact of the indenture on the proposed steam heating project would be that all property rights acquired in this system (whether real or personal property) unless exempted, would be considered to be pledged property, pursuant to the "after-acquired property" provision contained within the mortgage indenture. This is no different from the often-occurring situation where the Company constructs additional electrical generation, transmission, or distribution equipment. In sum, the Company's mortgage indenture

would have an impact on possible financing arrangements for this steam distribution system.

As noted previously, this indenture would also have severe ramifications upon the type of legal ownership arrangement under which this proposed system would be built. Further detailed study will be required in this area once specific ownership arrangements have been proposed.

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CHAPTER 1. INTRODUCTION AND BACKGROUND

The concept of district heating and cooling is one in which byproduct heat (in this case, from modified electric generating plants) is captured and used to supply thermal energy for heating and/or cooling. Historically in the United States, the low cost and convenience of other energy sources (e.g. oil and natural gas) have inhibited the widespread adoption of the district heating and cooling concept. The U.S. experience stands in stark contrast to parts of Western Europe where cogeneration has played a significant role in the energy budget of several nations, most notably Sweden.

Recent scarcity of alternative fuels in the United States, rising energy costs and a consequent concern for energy conservation/ use efficiency has stimulated renewed interest in district heating and cooling options. Studies in the last few years have indicated that potentially significant energy conservation benefits can be realized by combining power generation with district heating and cooling in selective applications. To do so successfully, however, there must be a match between the supply of and demand for both electrical and thermal energy in a given service area. In order to develop such a match, it is commonly the case that potentially significant technical, economic and institutional issues must be overcome.

This report is devoted to an initial evaluation of institutional issues that may pose difficulties in a specific service area, that of Toledo Edison Company, Toledo, Ohio. The paragraphs that follow describe in more detail the specific context in which this institutional analysis was conducted.

THE TOLEDO SETTING

The Toledo Edison Company currently owns and operates a central station steam heating system that serves 40 to 50 commercial buildings in a 30-block area of the Toledo Central Business District (CBD). Water Street Station, the plant that serves this area, was constructed in 1896 and connected to a steam distribution system in 1930. This plant is currently used exclusively for the generation of steam to serve existing customers. Until 1974 Water Street Station was fired by coal, but in that year, all its boilers were converted to oil and all coal-handling facilities were removed. The building itself has architectural/historical significance because it was designed by Daniel Burnham, an early famous U.S. architect. Because of the high cost of district heat attributable to the fuel source currently used at the Water Street Station, Toledo Edison Company is considering this proposed project and serving an expanded steam system with the nearby Acme Station.

Acme Station is located approximately one mile from the Toledo CBD, and across the Maumee River from the Water Street Station and the existing steam distribution system. Acme is an intermediate-load, electric-generating plant with both oil-fired and coal-fired boilers that have been installed over the last three decades. The current study of an expanded district heating system for the Toledo area concluded that Acme Station would be the most feasible option to supply steam with the closing of the Water Street Station. This would, of course, require retrofitting Acme to accommodate a district heating system. The institutional analysis described herein assumed this preferred, most feasible option as a baseline condition.

SIGNIFICANCE OF INSTITUTIONAL CONSTRAINTS/BARRIERS

While technical and economic considerations are important in the evaluation of the district heating and cooling concept, potential

institutional constraints are also critically important to the ultimate success or failure of such a venture. The identification of institutional constraints includes an assessment of:

- The role to be played by Federal, state and local agencies with possible jurisdiction over a district heating and cooling project (e.g. permits, approvals, etc.)
- Alternative ownership and financing options and their implications for construction, operation and maintenance of a district heating and cooling system
- The effect of local tax laws on the viability of a district heating and cooling project.

Institutional constraints identified in any of these assessments can have a significantly adverse effect upon the desirability and/or viability of an expanded district heating system in the Toledo Edison Company service area.

Consequently, institutional considerations were evaluated in parallel with technical and economic factors in this overall study. Early analysis of institutional factors in this fashion has facilitated the incorporation of such findings into both the technical and economic analyses. In addition, an early dialogue has been established with relevant Federal, state and local agencies concerning the proposed project and its basic elements. This dialogue will be continued in subsequent phases of study, and will likely pay considerable dividends in terms of time and cost savings in the implementation of an expanded district heating system in Toledo (should such a system prove to be technically, economically and institutionally viable).

The specific objectives that guide the institutional analysis are described in Chapter 2.

CHAPTER 2. OBJECTIVES OF THE INSTITUTIONAL ASSESSMENT

The major objectives of the Task 5 institutional assessment for which Battelle had responsibility were initially outlined as follows:

- Assess the extent and effects of Public Utilities Commission of Ohio (PUCO) regulations (Subtask 5.1)
- Evaluate alternative institutional arrangements for the ownership, financing and operation of the proposed district heating system (Subtask 5.2)
- Assess the effect of State and local tax laws on the economic viability of the proposed project (Subtask 5.4)
- Investigate the extent and effect of Federal, state and local environmental regulations on the concept (Subtask 5.6)
- Evaluate the extent and effect of the Ohio Power Siting Commission regulations and local ordinances on the feasibility of district heating and cooling (Subtask 5.7).

As the Task 5 work proceeded, additional objectives for the study emerged, primarily due to the fact that a significant number of additional government agencies were identified as having potential authority over the project. The next chapter, entitled "Scope of the Institutional Assessment", outlines in more detail the nature of the additional work that was conducted to fulfill these objectives.

In addition to the specific objectives outlined above, the Task 5 effort also was guided by the following generic objectives:

- Identify and characterize any potentially significant institutional constraints and their implications for the project
- Outline (where possible) steps to be taken in project implementation to avoid unnecessary pitfalls
- Initiate a productive (and hopefully continuing) dialogue with all relevant regulatory authorities
- Interface effectively with the ongoing work being done on technical and economic tasks (including the market analysis).

These objectives (specific and generic) form the foundation for the work described on the pages that follow.

CHAPTER 3. SCOPE OF THE INSTITUTIONAL ASSESSMENT

This chapter is intended to clarify the scope of this Phase I institutional assessment by putting it into the context of the forthcoming phases where a refinement of the material contained herein will be made. In addition, limitations to the Task 5 work are described as they relate to the interpretation and use of the Phase I institutional analysis results.

PHASE I IN CONTEXT

The Phase I work, in general, has involved the preliminary exploration of technical, economic and institutional considerations that relate to the formulation and implementation of an expanded district heating system in Toledo Edison's service area. Consequently, the scope of the initial Phase was relatively broad in terms of the number of institutional issues and ownership/financing options explored. Because the Phase I institutional analysis was conducted in parallel with the conceptualization of alternative plant retrofit schemes, as well as with the conduct of a market survey, and with the analysis of preliminary economic factors, it was not possible to precisely describe the details of the proposed system to agencies that were interviewed during the Phase I institutional assessment. Instead, the generic district heating concept was described as outlined in Chapter 1. Agency responses were consequently limited to:

- A description of under what circumstances the agency would have jurisdiction.

- An overview of the process involved in securing necessary permits and approvals
- An identification of potential obstacles (generic) that could pose a problem for a district heating program
- A description of the time required, under normal circumstances to secure required permits and approvals (generally given in ranges)
- Suggestions concerning the avoidance of institutional pitfalls that could unnecessarily delay or even prevent the proposed program (where appropriate).

In contrast, the Phase II institutional work will undertake more focused discussions with relevant agencies based upon specific district heating alternatives. This will allow for more detailed substantive discussions with such agencies concerning the specific, most feasible district heating schemes that emerge from the overall Phase I analysis. Thus, a refinement of the findings outlined in this Phase I institutional report will be made in Phase II.

This clearly means that Phase I has not resulted in the granting of any formal, preliminary agency permits and approvals. The agencies did not have the required information in Phase I to grant such permits and approvals. The groundwork has been laid in Phase I, however, for expeditious and informed action by relevant agencies in subsequent phases.

With respect to the analysis of alternative ownership/financing options, the Phase I work described in this report considers a wide range of conceivable options. The analysis of the advantages and disadvantages of each option has lead to the reduction of the

total menu of options to a subset of most feasible options for this specific district heating program. This subset of options will be given more detailed consideration in Phase II, again based upon more specifically characterized system alternatives.

With the Phase I scope limitations outlined above, it was impossible to secure any of the required permits or approvals (however preliminary) in this Phase. However, the agency discussions held in Phase I did identify the nature of approval/permit requirements, and the time required to secure such approvals/permits (where there is uncertainty, ranges are given). This information is provided in Chapter 7. A preliminary schedule of required approvals and permits is provided in summary form in Chapter 8.

CHAPTER 4. OVERVIEW OF THE METHODOLOGY EMPLOYED

The methodology utilized in the conduct of the Task 5 institutional analysis included the following major elements:

- Review of relevant reports and documents
- Review of appropriate legislation, regulations and guidelines (Federal, state and local)
- Use of market survey data inputs
- Conduct of personal interviews with key agency personnel (Federal, state and local).

The initial step taken in performing the Task 5 work was the collection of past reports and other documents that addressed potential institutional issues associated with the district heating and cooling concept. Sources of this information included proceedings from recent conferences, Battelle's extensive library holdings, and materials collected from government agencies and other external sources. Energy-related journals and periodicals (e.g. "Energy User News") were also screened for articles relevant to the Task 5 work.

In addition to the literature review, copies of potentially relevant legislation, regulations and guidelines were secured and reviewed by the Task 5 project team. Such materials were collected from sources at the Federal, state and local level. The significant provisions of this material are described in Chapter 7 as they related to the implementation of a district heating system in the Toledo Edison service area.

The market survey also provided input to the institutional analysis. The survey instrument used to help characterize the demand for a district heating system included questions designed to elicit information from respondents on perceived institutional constraints to their participation in such a program. While the responses to these questions were not major outputs of the market analysis, they did provide some insight into the perceptions of potential customers concerning institutional constraints. These perceptions were considered in the evaluation of the potentially real institutional constraints identified in Task 5.

A major effort was made to personally interview key decision-makers in each agency (Federal, state and local) that has a potential role to play in the implementation of a district heating project in the Toledo area. General topics explored in each of these interviews included:

- Clarification of each agency's authority/jurisdiction with respect to the project
- Description of the process for securing all necessary approvals/permits (including time considerations)
- Identification of potentially serious institutional constraints or problems
- Clarification of mechanisms/actions to expedite the implementation progress.

The results of each interview were then analyzed in the context of appropriate legislation regulations and guidelines. Where follow-up discussions were necessary to clarify questions, additional contact was made with appropriate agency personnel.

The chapters that follow outline the results of the Task 5 work conducted in accordance with this methodology.

CHAPTER 5. OWNERSHIP/FINANCING ALTERNATIVES

This chapter presents the results of an analysis of ownership and financing alternatives for the proposed district heating project.

The objective of this task is to characterize and evaluate possible ownership and financing alternatives. The scope of this activity includes:

- Characterization of a range of ownership/financing alternatives
- A qualitative assessment of these alternatives in terms of the advantages and disadvantages
- Characterization of the ownership/financing/operation alternatives most appropriate to the goals and objectives of this specific district heating project.

While there are several factors (e.g. technology, distance to market) which are critical to the success of a district heating system, the formulation of a workable ownership arrangement and financial plan can be one of the most significant steps in project planning. Therefore, an analysis of the range of available public and private ownership/financial alternatives is necessary to identify the most workable option.

The ownership alternatives that were evaluated for this project are:

- Public utility ownership
- Utility subsidiary ownership
- Municipal ownership
- Joint venture ownership (public utility/
municipality)
- Joint venture ownership (public utility/
private investor)
- Nonprofit corporation ownership
- Customer ownership.

DEFINITIONS OF ALTERNATIVES

In this section, the alternative ownership arrangements will be briefly described. In all cases, ownership of the district heating capital/equipment within Acme Station is assumed to be maintained by Toledo Edison. Ownership of the steam distribution system, however, is variable in the alternatives discussed below.

Public Utility Ownership

This alternative is the status quo arrangement whereby Toledo Edison owns the entire steam production and distribution system. The system would be modified by retiring the boilers at the Water Street Station, making the required changes at the Acme Station, and constructing a pipeline from Acme to the existing network at Water Street. Also included would be the planned incremental expansion of the existing district heating system.

Utility Subsidiary Ownership

Toledo Edison could form a subsidiary which would acquire ownership of all existing distribution facilities and make the required incremental steam system additions. The subsidiary would purchase steam from the Acme plant and would be responsible for operation and maintenance of the distribution system.

Municipal Ownership

The City of Toledo could purchase the district steam system and operate it as a municipal utility. The point of purchase would be either at Water Street Station or at Acme Station, depending on whether the pipeline between these two locations was owned by the City or the Utility.

Joint Venture Ownership (Public Utility/Municipality)

Ownership of the steam distribution system could be in the form of a joint venture between Toledo Edison and the City of Toledo. The contribution made by each party would depend upon the specific arrangement agreed upon.

Joint Venture Ownership (Public Utility/Private Investor)

Ownership could be shared between Toledo Edison and a private investor which may or may not be a steam customer. Either a corporation or partnership (limited or general) arrangement is conceivable.

Public Utility Ownership

Ownership by Toledo Edison would be the least complicated alternative. For purposes of financial control and because of regulatory requirements, independent accounts would have to continue to be maintained for this system. All of the usual financial options would be available to the company. The advantages and disadvantages of utility ownership are described below.

The total capital cost requirements in 1979 dollars for the entire project range from an estimated \$11 million to \$36 million. This compares to Toledo Edison's overall construction budget of approximately \$200 million per year. Several sources of funds are available. These include issuance of common and preferred stock, the sale of bonds, and commercial credit. All of these options are currently quite costly. Because this project is small compared to the company's other investments, obtaining the necessary funds is not expected to exert a significant strain on capital budgets.

Advantages

Because this is essentially the status quo and, therefore, the least complicated alternative, administrative and transaction costs would be minimized. While operation of the cogeneration/district heating system is marginally riskier (small customer base, good substitutes for the service, significant seasonal fluctuations) than Toledo Edison's other operations, it is too small to affect the company's financial standing.

The impact of this project upon the company's bond rating and stock price is expected to be negligible. Because Toledo Edison is already engaged in financing a large capital construction program, no special financing will be required for this project. This, along

* Source: Stone and Webster Engineering Corporation.

with the company's experience with the capital markets, will greatly reduce the administrative costs of obtaining capital financing. Furthermore, as a large utility, Toledo Edison is able to obtain capital at a slightly lower cost than many industrial firms. The company's average cost of capital over the coming years is estimated to be approximately 12 percent.*

The company is also well acquainted with the rules and procedures of the Public Utilities Commission of Ohio (PUCO). Therefore, it has a comparative advantage over other private firms which might own and operate the system.

Disadvantages

As a profit-seeking utility, Toledo Edison's operations are fully taxable. The company is subject to Federal corporate taxes, a gross receipts tax and property taxes. These taxes raise the cost of providing the steam service and are reflected in the rates. Interest earned on bonds issued by the company is also subject to state and Federal income taxes. This adds to the cost of debt and thus raises the overall cost of capital.

Toledo Edison's operations are regulated by the Public Utilities Commission of Ohio (PUCO). By right of "home rule", the City of Toledo also has jurisdiction over several aspects of Toledo Edison's operations. Historically, the City has chosen to set steam rates by ordinance. Both the utility and its customers have the right to appeal a decision to the PUCO, although this has not been done in recent years. Whether this subjection to regulation is an advantage or disadvantage depends largely upon how the regulation is administered. It does provide all parties with some protection without resorting to the court system.

* Conversation with Gary Hawkinson, Finance Supervisor, Toledo Edison.

To overcome some of the cost disadvantages (taxation) of utility ownership, alternative financing methods are available. One is the use of income bonds whereby the company would be obligated to pay interest only to the extent that earnings are available after payment of interest on senior debt. In the spectrum of available financial instruments, income bonds fall between mortgage bonds and preferred stock both in terms of risk and return.

Because income bonds are more costly than mortgage bonds, a utility would not be expected to utilize them unless issuance of additional mortgage bonds was prohibited. While nonpayment of interest on income bonds is not considered a default, some negative impact upon the company's financial standing is likely in such circumstances. Weighting the advantages and disadvantages of income bonds, it does not appear that Toledo Edison could make good use of them. The PUCO is not aware of any major utility in Ohio which has utilized them.

Another method of increasing the use of debt financing, and thus lowering the cost of capital for the project, is project financing. This method requires separation of the district heating project from the utility's other operations. This would allow debt to be issued specifically for this project, with no backing from other company assets or revenues. Because the danger of default is relatively high compared to conventional mortgage bonds, interest rates would be higher. Additionally, long-term steam sales contracts or some type of third-party guarantee would probably be necessary to reduce risk and insure saleability of the bonds. This reduces the attractiveness of this financing method. Furthermore, it may be prohibited by existing bond covenants.* Project financing does not appear to be a useful method for funding the proposed district heating project.

* This is a legal determination beyond the scope of Battelle's responsibilities in Task 5.

Utility Subsidiary Ownership

Ownership of the district heating system by a wholly-owned subsidiary of Toledo Edison is an alternative to direct utility ownership. This would offer some advantages which accompany a complete separation of the steam heating system from the utility's major operations.

Advantages

This approach is distinguished from direct utility ownership in that risk to Toledo Edison is limited to its holdings in the subsidiary. Thus, effects on the utility's bond rating would be minimal. Another potential advantage is that separation of district heating revenues and expenses from other utility operations may be made more complete. This would permit any savings achieved from lower cost financing methods to accrue exclusively to district heating customers, rather than be spread over all Toledo Edison operations. Use of industrial revenue (development) bonds or government loans or guarantees by Toledo Edison for the project would, therefore, be done best through a subsidiary company.

Industrial revenue (development) bonds are issued on behalf of a private company by a governmental organization. Interest payments on these bonds are tax exempt and, therefore, the bonds can be sold with a relatively low interest rate. While use of industrial revenue (development) bonds is an attractive method of financing many projects, there are limitations which may prohibit their use for the proposed district heating project. Most importantly, the bonds are only permitted for "industrial, commercial, distribution and research activities."¹ Furthermore, the bonds cannot be used "for facilities to be constructed for the purpose of providing electric or gas utility service to the public."¹ Because use of the

¹ Ohio Constitution, Article VIII, Section 13.

bonds for district steam heating does not appear to be explicitly permitted or prohibited, additional research is required to determine the legality of this use of industrial revenue bonds.*

Additionally, utilization of a wholly owned subsidiary form of ownership allows the parent company to capitalize the subsidiary with a high debt-to-equity ratio. As a result, the cost of capital can be reduced. Furthermore, the cost of equity for the subsidiary would be taken as the overall cost of capital for the parent company. This has the effect of further reducing capital costs.

Disadvantages

The subsidiary must be adequately financed to enable it to be viable. This requires utility funding to the same extent as with direct ownership. Similarly, no special tax treatment or regulatory exemption is available.

The wholly owned subsidiary is still subject to regulation by the Public Utilities Commission of Ohio (PUCO) and/or the City of Toledo. The major difference from a regulatory perspective is that the cost of capital calculation would be specific to the steam system rather than the company as a whole. The PUCO would also want to assure that costs were properly allocated between steam and electric customers.

To insure the viability of the project, it may be desirable to enter into long-term contracts with some or all steam customers. Any such contracts would be subject to PUCO review and possible alteration. If long-term contracts are a key to the success of this project, PUCO approval is likely. There is a heavy burden on PUCO to overturn a contract which has been freely agreed upon. The

* Such research is beyond the scope of Battelle's Task 5 responsibilities.

primary regulatory concern is on equitable and compensatory rates. If rates differ for various customers, a basis for this discrimination must be demonstrated.

Municipal Ownership

Purchase of the steam distribution system by the City of Toledo would change the ownership from a private to a public body. Significant financial, tax and regulatory changes would accompany this action.

Advantages

The most obvious advantage of a municipally owned system would be its tax exempt status. The City of Toledo does not have to pay excise or property taxes and would be able to obtain a lower interest rate on a bond issue used to finance the purchase. Either general obligation or revenue bonds could be utilized.

When financing a project through municipal general obligation bonds, a municipality guarantees repayment in the most fundamental way it can, i.e. by backing up its bond obligations with its tax base. These types of bonds are rated according to the financial condition of the municipality and not by the uncertainty of the specific projects being bonded. Thus, a lower interest rate is expected. However, a city's revenues are subject to potential diversion if the project is a financial failure.

Because of this potential risk to the community, there are tight restrictions governing issuance of general obligation bonds. The amount that can be issued without voter approval through a referendum is limited. At this time, the City of Toledo would not need voter approval to issue general obligation bonds to finance this

project. Such use of general obligation bonds is not without precedent. Voters in Columbus, Ohio recently approved sale of over \$100 million in general obligation bonds to finance a municipal trash-fired power plant. A campaign to promote the issue, however, can be costly. Considering the relatively small amount of funds to be raised for this project, a significant percentage increase in the cost of the issue would result.

Use of revenue bonds would not require voter approval. This approach is a method of financing in which the bond holders guarantee of repayment rests solely on the project's ability to generate revenue. Bond holders cannot rely on the assets of the municipality to secure debt. Thus, the interest rate on revenue bonds would normally be higher than on general obligation bonds.

The costs, prices and types of contracts for the sale of products or services from a district heating project become a central concern to the potential revenue bond buyer. Contracts negotiated by the municipality with both customers and suppliers are major sources of confidence to prospective investors. An establishment of firm, long-term contracts before the bond prospectus is issued is desirable under any financing plan. However, such contracts are the essential guarantee when revenue bond financing is used.

Customers with whom the municipality must have secure contracts are the large commercial establishments. The contracts initially secured need not approach full utilization of the system capacity. For example, a Nashville, Tennessee facility began in 1974 with only 50 percent of its capacity contracted.

In addition to freedom from taxation, municipal ownership offers one other advantage; virtual exclusion from state public utility regulation. This provides the municipality with potentially greater flexibility in setting rates, service policies and in the method of conducting its business.

Disadvantages

If the City of Toledo purchased the district heating system, it would lose part of its tax base, existing and potential. In 1977, the total amount of real and tangible personal property taxes levied on the steam system was \$114,000. This tax loss is one factor which could discourage the City from acquiring the system.

Another disadvantage of municipal ownership is that the City of Toledo does not have any experience in operating a district heating system. This could lead to inefficient operation of the system, at least until the necessary experience is gained.

The primary factor working against municipal ownership is the lack of a clear motive to the City. Because the district heating system serves only a small portion of Toledo, it takes on the nature of a special service rather than a general public service. Provision of this type of service is looked upon with disfavor by Toledo city officials. They would consider ownership of the district heating system only if the City as a whole would be significantly affected. In their view, this would have to entail the prevention of a change in the system which would adversely impact development of the downtown area. Presently, the City of Toledo does not foresee such a change and does not perceive a motive for acquiring the system.

If the City of Toledo would determine that public ownership was desirable, it may wish to establish a public authority. It is not unusual for a special purpose public authority to be established for a project like district heating. One example is the Harrisburg (Pennsylvania) Incinerator Authority. The Authority is now installing a connecting 3-4 mile pipeline from its refuse-fired steam generating station to the existing coal-fired Pennsylvania Power and Light (PP&L) cogeneration plant located downtown. However, PP&L will continue to operate the district heating network. Harrisburg is different from

the Toledo circumstance in that the Authority generates the energy while the Utility operates the district heating network. Despite this fact, the ownership considerations are similar.

A public authority would be able to offer tax-free bonds, and thus, finance capital improvements at a relatively low cost. The City of Toledo would limit its risk to guarantees it might provide the authority. Furthermore, the City would not have to make use of its own credit authority. Similarly, Toledo Edison would not be required to provide capital to finance the project or to incur future risks.

Because an authority would normally have only its own steam lines and promises of revenues as backing for any debt, issuance of bonds would be more difficult. Therefore, it would be necessary to obtain a steady, reliable stream of revenue through the completion of long-term contracts with the major customers. A long-term contract with Toledo Edison for a supply of steam would also be beneficial. In addition, loan guarantees by the City of Toledo would make bonds more attractive and would help procure lower interest rates.

Joint Venture Ownership (Public Utility/Municipality)

A joint venture is a business association between two or more co-owners for a specific undertaking. The joint venture is established by a contract in which the respective rights and liabilities of the parties are identified.

The joint venture may be a single undertaking of short duration or may be a continuing business with numerous transactions over a prolonged period.

In forming a joint venture, two points should be considered:

- (1) The scope of the joint venture should be clearly limited to the district heating system.
- (2) The description of the joint venture should be tailored with a view to achieving optimal Federal and/or state tax and regulatory results.

Initial and continuing financial arrangements among the parties should be included in any agreement. These arrangements should include interim and permanent financing arrangements for construction, initial and subsequent capital contributions by the parties and continuing operational financing. Any agreement should specify the amounts or percentages to be contributed by the parties. If a member of the joint venture is not required to make a capital contribution, it should be so stated and that member's rights and responsibilities in the joint venture properly identified. The agreement should also state whether a part of that member's or any other member's distribution share of future net profits is to be allocated to a capital account.

Advantages

One advantage of a joint venture is the possibility of sharing the capital costs. Two parties can raise the required funds more easily than either one by itself. Various methods also exist to limit a partner's liability commensurate with his involvement in the venture.

Both Toledo Edison and the City of Toledo could potentially make a valuable contribution to a joint venture. Toledo Edison has the experience and expertise to operate the district heating system while the City of Toledo has the ability to obtain less expensive

capital funding and is free from taxation. Whether all these benefits could, in fact, be realized would depend upon the exact nature of the joint venture.

One method is city ownership with a lease back to Toledo Edison to operate. It would appear that this arrangement would free the system from taxation and PUCO regulation. At the same time, the City of Toledo would be free from directly operating and maintaining the system. Research is required to determine the legality and practicality of this arrangement.*

Disadvantages

A joint venture agreement must be carefully drawn up to meet the objectives of each party. The partners will require that their liability be limited to an acceptable extent should the project fail. This could result in costly and time-consuming negotiations.

If Toledo Edison and the City of Toledo do desire to enter into a joint venture to produce and distribute steam, the legality of such an arrangement must be determined. If it turns out that this is not a well-defined area of law, then extensive legal research and possible challenges may result.*

Finally, a joint city-utility venture may not overcome the objections to the city involvement stated by Toledo city officials. Some additional incentive to the City of Toledo will need to be found to persuade them to enter a joint venture should this be deemed the optimal approach to system ownership.

* Such legal research is beyond the scope of Battelle's Task 5 responsibilities.

Joint Venture Ownership
(Public Utility/Private Investor)

A joint venture between Toledo Edison and another private firm (or group of firms) is another alternative. A possible partner is one or more of the major steam customers. The existing customers have an interest in retaining the steam system, and therefore, may be willing to share in the costs of making the required improvements. Large potential customers may also be willing to form a partnership in order to obtain steam service.

Advantages

A major advantage is that the costs of improving the system could be pooled among two or more companies. This would ease the burden of raising the required capital. Depending upon the precise form the partnership would take, it may also be desirable to make use of a leveraged lease to lower capital costs.

If one party can gain substantially greater tax benefits from ownership than the other, a highly leveraged capitalization structure together with a long-term lease to the other party may prove to be optimal. If an institutional investor (e.g. insurance companies, pension funds, etc.) could put up 20-40 percent of the total project cost and borrow the remainder, overall capital costs would be reduced. This high debt/equity ratio could be obtained by reducing risk through a long-term lease arrangement with the operator, in this case, Toledo Edison.

Disadvantages

A significant risk associated with a joint venture partnership is the unlimited liability which each party assumes. This may be

overcome, however, in at least two ways. Liability may be limited via the venture agreement. Alternately, a corporation may be formed to own and operate the steam distribution system. This would limit each party's liability to its investment in the corporation.

The corporate form of joint venture would also reduce another potential disadvantage, PUCO regulation. Any non-utility would certainly desire to keep its main operations free from PUCO jurisdiction. This could be accomplished by forming a special subsidiary to own the steam system.

Nonprofit Corporation

A nonprofit corporation could be formed to acquire ownership of the district heating system. An example of this is the Nashville Thermal Transfer Corporation which owns and operates a refuse incinerator/district heating and cooling system. Passage of a special act by the Tennessee General Assembly was required to enable the organization to attain tax exempt status.

Advantages

Creation of a nonprofit corporation would offer several advantages. It would most likely allow the district heating system to be free from PUCO regulation. Most taxes, including property and Federal income tax, would not apply. The corporate form could be used as a means of obtaining representation of all interested parties, including Toledo Edison, the City of Toledo and steam customers.

Disadvantages

Because a nonprofit corporation would normally have only steam lines and promises of revenues as backing for any debt, issue of bonds may be difficult. Therefore, it would be necessary to obtain a steady, reliable stream of revenue through the completion of long-term contracts with the major customers.

Organizing the corporation would also be a difficult task. Formation of a nonprofit corporation for this purpose may not now be allowed under Ohio law. Legal research into this matter will be required.*

The nonprofit corporation will also face the problem of determining how to effectively manage and operate the system. It is likely that Toledo Edison would need to retain this responsibility because of their experience with such matters.

Customer Ownership

Because the existing steam customers have the greatest stake in retaining the district heating system, they may want to consider direct ownership. The formation of a separate corporation is one logical method of organizing such a venture. It may also be possible to do this on a cooperative basis.

Advantages

The existing customers have a common objective of obtaining steam on a reliable, efficient basis. By actually owning the system, they may be able to exert greater control than through any other method.

* Such legal interpretations are beyond the scope of Battelle's Task 5 responsibilities.

By pooling resources, obtaining capital financing would be relatively easy. Furthermore, neither the City of Toledo nor Toledo Edison would be required to raise additional capital, other than for the latter's Acme Station modifications.

In order to keep costs as low as possible, the customers may desire to form a nonprofit corporation. The advantages and disadvantages of this type of organization were described in the previous section.

A cooperative would also serve to keep down costs. It would have characteristics which are very similar to a nonprofit corporation. Whether and under what precise conditions either form of organization is legally permitted is not known. Specialized legal research is required to determine the applicability of these ownership options to the district heating system.*

Disadvantages

Unless nonprofit status could be attained, a customer-owned corporation in the business of distributing steam appears to fall under the jurisdiction of the Public Utilities Commission. While this may not be burdensome, it may be enough to discourage the prospective partners. Likewise, tax benefits would also depend upon nonprofit status.

The owners presumably would have no expertise in the operation of the system. Therefore, a contract or lease arrangement for operation of the facility could be necessary. Toledo Edison is a likely candidate to operate the system. Such a lease could also shift the regulatory obligations back to the utility.

* Such legal interpretations are beyond the scope of Battelle's Task 5 efforts.

Actual operation and administration of a customer-owned utility may be the greatest problem to overcome. For example, how would the addition of new customers be handled? How would rates be set? In general, how would major decisions be made? Representation could be on a per building, per owner or per steam usage basis. If a cooperative could be established, decision-making power would probably need to be based on steam consumption. In any event, assuring that each customer's interest is protected may be a substantial roadblock to the formation of any customer-owned corporation.

CONCLUSION

Several ownership and financial alternatives for the cogeneration/district heating project have been studied. Each has several advantages and disadvantages which must be balanced (see Table 1). While additional research in Phase II will be required before the optimal alternative can be determined, some conclusions can be drawn from the work done thus far.

All ownership plans involving the City of Toledo as a direct participant are considered to be somewhat questionable at this time. City officials do not currently perceive any strong rationale for municipal ownership. However, if municipal ownership could be shown to positively affect downtown development, the City would likely consider involvement in the system.

If Toledo officials eventually perceive an advantage to municipal involvement in the project, a joint venture with Toledo Edison is probable. A joint venture would provide the City with the utility's operating expertise and experience. It would also help ensure a good relationship between the steam generation and distribution portions of the system, because Toledo Edison would continue to have an interest in the success of the system.

Ownership by steam customers also does not appear to be a feasible alternative. There exist substantial problems with multiple ownership. Moreover, no significant advantages appear to exist. Only if a customer-owned organization could obtain tax-free status would this alternative be worth pursuing.

A joint venture between Toledo Edison and another firm can also be ruled out. The only real benefit to such an organization is cost sharing. Because the cost of the system is expected to be relatively small, Toledo Edison does not foresee an appreciable impact on its current capital financing program. It does not require a partner to share costs.

If a nonprofit form of organization can legally be attained, it may be an attractive alternative. Limited liability, freedom from taxation and possibly from PUCO regulation are among the advantages. Any impetus to form a nonprofit corporation appears to be lacking, however. The feasibility of this type of organization is largely dependent upon city participation in some way, but this does not now appear likely.

Continued ownership by Toledo Edison is the most likely alternative. The utility has the advantage of experience and technical expertise. Transaction costs associated with ownership transfer would be avoided. The only significant drawback to continued Toledo Edison ownership is the apparent unavailability of special low-cost financing.

If a governmental grant, loan or other low-cost financing does become available, formation of a Toledo Edison subsidiary should be considered. This would allow the benefits to be passed directly to the steam customers, rather than be spread over all Toledo Edison customers. If capital costs cannot be lowered in some manner, formation of a subsidiary offers no significant advantages. Direct Toledo Edison ownership would then be the most practical alternative.

Further analysis of particular alternatives in Phase II should concentrate on Toledo Edison and municipal ownership. The former is considered the most likely alternative while the latter is potentially the least-cost alternative. If Toledo Edison maintains ownership of the system, the utility's overall cost of capital is appropriate for analysis of the project. This assumes that no special financing will be utilized.

If the City of Toledo were to acquire ownership, issuance of revenue bonds would be the preferred financing method. The bond's saleability and interest rate will depend upon the system's economic prospects which have not yet been determined. If revenue bonds provided infeasible, general obligation bonds could probably be utilized, although their use is extremely unlikely for a project of this nature. Thus, it can be assumed for this analysis that municipal ownership is contingent upon the ability to finance with revenue bonds.

TABLE 1. COMPARATIVE ANALYSIS OF OWNERSHIP/FINANCING OPTIONS

Option	Advantages	Disadvantages
1) Public Utility Ownership	<ul style="list-style-type: none"> 1a) Least complicated with minimal administrative and transaction costs b) Relatively small risk to utility's overall financial standing c) Capital available at relatively low cost d) Special financing may not be required e) Familiarity with PUCR regulations and procedures 	<ul style="list-style-type: none"> 1a) Operations would be taxable (Federal corporate, gross receipts and property taxes) b) Subject to PUCO regulation although steam rates have historically been set by City ordinance
2) Utility Subsidiary Ownership	<ul style="list-style-type: none"> 2a) Risks limited to utility's holdings in the subsidiary b) Separation of revenues and expenses would be more complete c) Parent company can capitalize the subsidiary with a high debt-to-equity ratio d) Cost of equity for the subsidiary is taken as the overall cost of capital for the parent company 	<ul style="list-style-type: none"> 2a) Requires utility funding to the same extent as direct ownership b) Still subject to PUCO and/or City regulation
3) Municipal Ownership	<ul style="list-style-type: none"> 3a) System would be tax exempt b) Lower interest rates likely for financing (general obligation or revenue bonds) c) Limited PUCO regulatory authority (offers flexibility in rate setting, and setting service policies) 	<ul style="list-style-type: none"> 3a) City would lose part of its existing and potential tax base b) No experience in operating a district heating system

TABLE 1. COMPARATIVE ANALYSIS OF OWNERSHIP/FINANCING OPTIONS (Cont.)

Options	Advantages	Disadvantages
4) Joint Venture Ownership (public utility/municipality)	4a) Possibility of sharing capital costs b) Combines system experience with tax exempt potential and ability to secure cheaper capital (depends on the specific agreement made) c) Potentially limited PUCO regulatory authority	4a) Potential problems with liability b) Complex, costly and time-consuming negotiations c) Legal complications may become significant d) Questionable incentive for municipal participation
5) Joint Venture Ownership (public utility/private investor)	5a) Costs can be pooled between two or more companies b) Risk-reducing long-term lease arrangements possible	5a) Unlimited liability assumed by each party (potentially) b) Questionable incentive for private sector participation
6) Nonprofit Corporation Ownership	6a) Limited PUCO regulatory authority b) Exempt from property and income taxes c) Means of representing all interested parties	6a) Issue of bonds may prove difficult due to lack of debt backing b) Complex to organize c) Difficult to effectively manage and operate a system
7) Customer Ownership	7a) Customers exert greater control over the system b) By pooling resources, capital financing would be fairly easy c) No additional capital for the system required of the utility or the City	7a) Could be treated as a public utility by PUCO (unless it was nonprofit) b) Lack of experience with system ownership/operation c) Complexity of organization day-to-day decision-making

CHAPTER 6. TAX CONSIDERATIONS

INTRODUCTION

The tax climate in a state or smaller region can directly impact the feasibility of industrial location or expansion and experimentation with alternative technologies by existing industry. In the State of Ohio, there are three main taxes to which a public utility is subject, and which may influence the feasibility of a district heating system.

At the State level, there is the public utility excise tax which enters into the economic analysis. Locally, there are real property taxes, and tangible personal property taxes. Federal corporate income taxes are an additional item in the investment decision.

Sometimes offsetting Federal, state and local tax liabilities there are tax credits, abatelements and other types of financial incentives offered by the governmental units. Both the taxes and the incentives will be discussed here as inputs to the economic analysis of a district heating system in the Toledo metropolitan area.

STATE TAXES

The public utility excise tax is a tax on the gross receipts from intrastate business of all companies classified as public utilities, except those utilities owned by municipal corporations which are exempt from the tax. Allowable deductions from the gross receipts base that are important to this analysis are sales to other public

utilities for resale, and receipts from business done for the Federal government. The excise tax rates range from 1.70 percent to 6.00 percent depending on the class of the utility. Most utilities, including electric, gas, telephone, heating and cooling are taxed at a rate of 4.00 percent.

The Tax Commissioner of the State of Ohio is responsible for the administration of the public utility excise tax, as cited in Chapter 5727 of the Ohio Revised Code. Revenues from the excise tax go directly to the State General Revenue Fund. Utilities liable for this tax are exempt from the Ohio corporate franchise tax as well as from taxes on profits as assessed by municipalities.

LOCAL TAXES

Public utility property taxes, the largest state or local tax paid by utilities in Ohio, are actually comprised of two taxes, the real property tax and the tangible personal property tax. The tax base of the real property tax consists of land and improvements to the land (buildings) and is assessed at 35 percent of true (market) value. Public utility tangible personal property tax includes machinery and equipment and is assessed at 100 percent of true value except for the personal property of rural electric companies which is assessed at 50 percent of true value.

The apportionment of the tax base of public utility property is not handled in the same manner as that of other business and industry whose property is generally under the jurisdiction of the county auditor. Public utility property is valued as a statewide unit and the values are distributed to the taxing districts in which the property is located, whereas tangible personal property values are apportioned (using a specific apportionment base) among the taxing districts. The Tax Commissioner is responsible for the

administration of public utility real and tangible personal property taxation although each county auditor acts as the agent of the Tax Commissioner in assessing utility real property.

Property tax rates vary from one taxing jurisdiction to another. Tax rates may be enacted by legislative authority or by the voters within the taxing jurisdiction, i.e. the county, township, municipal corporation and school districts. Property tax rates for the City of Toledo total 51.15 mills (includes Port Authority, TARTA, County, School and Municipal taxes). The tax rates are not applied equally to both real and personal property, because all real property taxes are reduced by a computed reduction factor (in the case of Toledo, 1971) when real property values within the taxing jurisdiction increase.

Entering into the economic analysis of a district heating and cooling system are some major property tax exemptions and credits that could apply to such a system; these include:

- Property of municipally owned utilities are exempt.
- Certified air, water and noise pollution control facilities are exempt.
- Personal property under construction is exempt.
- Real property tax bills are reduced by ten percent.

The revenues generated by the taxation of public utility property are distributed by the county treasurers to counties, townships, incorporated municipalities and school districts according to their taxable values and millages. Chapters 319, 323, 5705, 5709, 5715, 5719, 5727 and 6111 of the Ohio Revised Code set forth the public utility property tax legislation.

The applicability of certain state and local taxes and incentives are influenced by the definition of a public utility, and how the organization in question fits that definition. By section 5727.01 of the Ohio Revised Code, a "public utility includes each corporation, firm, individual and association; its lessees, trustees or receivers, elected or appointed by any authority; and referred to as an express company, telephone company, ..., electric light company, ... heating company, cooling company, ... or railroad company. Public utility includes any plant or property owned or operated by any such company, corporation, firm, individual or association." For further clarification, under the same section of the Code, a heating company is one "engaged in the business of supplying water, steam, or air through pipes or tubing to consumers within the State for heating purposes" and a cooling company is "engaged in the business of supplying water, steam, or air through pipes or tubing to consumers within this State for cooling purposes."

TAX INCENTIVES

The tax incentives available to a public utility for the investment in a district heating system come from both the state and Federal level.

The General Assembly of the State of Ohio recently passed Am.Sub.H.B. 467, which according to Tax Commission Rule 5703-1-09, does apply to public utilities. This bill provides sales, corporate franchise, and real and personal property tax exemptions to three classes of energy-related facilities. These facilities* are:

- (1) Energy conversion facilities - property or equipment that is necessary: a) to replace natural gas with an alternate fuel other than propane, butane or naptha; or b) to replace

* Am.Sub.H.B. 467 (As reported by S. Ways & Means).

fuel oil with an alternate fuel other than natural gas, propane, butane or naptha. The energy conversion property or equipment must be installed, and the alternate fuel must be used, at an industrial or commercial plant, building or site.

- (2) Thermal efficiency improvement facilities - property or equipment that is used exclusively to recover and use waste heat or waste steam produced incidentally to an industrial process, electric power generation, lighting, refrigeration, or space heating if the property or equipment is used in an industrial or commercial plant, building, or site.

- (3) Solid waste energy conversion facilities.

Tangible personal property used directly in rendering a public utility service is already exempt from sales and use taxes, and utilities pay an excise tax in lieu of corporate franchise taxes so the tax exemption of particular importance to utilities under this legislation is the exemption from property taxes. It is stated in the Act that "Tangible personal property and improvements to real property are exempt from local property taxes."* However, "only that portion of a facility the Tax Commissioner determines is necessary for energy conversion or that is used exclusively for thermal efficiency improvement ... would receive the benefit of these exemptions."*

Some of the district heating end users may also be able to take advantage of the provisions of H.B. 467 if retrofits are considered to be energy conversion facilities. In particular, it appears that those users converting from natural gas or fuel oil would be eligible

* Am.Sub.H.B. 467 (As reported by S. Ways & Means).

for sales, corporate franchise and real and personal property tax exemptions. Those converting from coal or electricity would not meet eligibility requirements (see Table 14, pg. 38 of Battelle's Task 3 Report, "An Energy Market Analysis for District Heating and Cooling Systems in Toledo, Ohio", February 28, 1979).

A Federal incentive, the investment tax credit, was made permanent with Public Law 95-600 which was signed into law November 6, 1978. The credit allowable is ten percent of the eligible investment and is limited to the income tax liability, or \$25,000 plus sixty percent of the tax liability in excess of \$25,000. To qualify for an investment tax credit, the property must be depreciable; have a useful life of at least three years; be tangible personal property used as an integral part of manufacturing, production, etc.; and be placed in service in a trade or business or for production of income during the year. Therefore, it appears that a utility, or other group operating the district heating and cooling system would be eligible for the investment tax credit. The end users, on the other hand, may not qualify for the investment tax credit. Internal Revenue Service Publication 334 indicates that, generally, central heating and air-conditioning systems are structural components of a building and do not qualify as tangible personal property. This would indicate that end users would not be eligible for an investment tax credit on the investment for retrofit.

Energy property acquired after September, 1978, may qualify for a new ten percent credit that may be claimed in addition to the regular investment tax credit. This credit was legislated with the passage of the Energy Tax Act, Public Law 95-618. Energy property is defined as any of the following:

- Alternative energy property
- Solar or wind energy property
- Specially defined energy property
- Recycling equipment

- Shale oil equipment
- Equipment for producing natural gas from geopressured brine.

However, under Title III of PL 95-918, Section 301 (b)(3), it is stated:

"(B)Exclusion for Public Utility Property -
The terms 'alternative energy property', 'solar or wind energy property', and 'recycling equipment' do not include property which is public utility property (within the meaning of Section 46(f)(5))."

In Section 46(f)(5), the definition of public utility property includes "property used predominantly in the trade or business of furnishing or sale of (i) steam through a local distribution system or (ii) the transportation of gas or steam by pipeline, if the rates for such furnishing or sale are established or approved by a governmental unit, agency, instrumentality or commission described in subsection (c)(3)(B)."

However, the retrofit that the end users will have to undertake may qualify for an energy tax credit as "alternative energy property." Thus, in the economic analysis, it will be assumed that the primary incentives for district heating and cooling in Ohio are Am.Sub.H.B. 467, applying to the operator as well as the end user, the regular investment tax credit, applying to the operator only, and the energy tax credit, for which only the end user would be eligible.

CHAPTER 7. OVERVIEW OF POTENTIAL INSTITUTIONAL CONSTRAINTS

INTRODUCTION

This chapter reports on the results of the background investigations on and interviews with potentially relevant agencies at the Federal, state and local level. These agencies have the potential to impact, in varying degrees, the prospective district heating project in the Toledo metropolitan area. In some instances, the research indicated that certain agencies have no permit or approval authority the way the project is currently constituted. For the sake of completeness, these agencies are also discussed from the standpoint of clarifying conditions under which the proposed project would require their approval.

The discussions of each agency that follow include, as appropriate, the following significant topics:

- An overview of agency authority/jurisdiction over the proposed project (permits, approvals, etc.)
- A description of the process for securing all necessary approvals and permits (including estimates of the time required)
- Identification of any potentially significant institutional constraints to the implementation of a district heating project in the study area
- Suggestions concerning actions that can be taken to expedite the project by avoiding unnecessary institutional pitfalls.

For convenience, the agencies are discussed in sequence beginning with potentially relevant Federal agencies, then appropriate state agencies, and finally, local agencies with a possible role to play in the project.

FEDERAL AGENCIES

There are three major Federal agencies that will possibly play a role in the implementation of any district heating project in the Toledo Edison service area. These agencies are:

- The U.S. Army Corps of Engineers
- The U.S. Environmental Protection Agency
- The U.S. Coast Guard.

The role of the U.S. Department of Energy (U.S. DOE) in stimulating the development of district heating programs nationwide is gratefully acknowledged. The first phase and subsequent phases of this project supported by U.S. DOE have provided and will provide impetus for considering the district heating concept in Toledo. Because the U.S. DOE role is well-known, it is not discussed further here.

U.S. Army Corps of Engineers

Under Section 10 of the River and Harbor Act of 1899, Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) and Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (P.L. 92-532), the U.S. Army Corps of Engineers is responsible for issuing permits authorizing structures and work in or affecting navigable waters of the United States, and the discharge of dredged or fill material into the waters of the United States. In administering these laws, the Corps of

Engineers has authorized certain construction activities in advance by issuance of a "nationwide permits" (as published in Sections 332.4 and 323.4 of Title 330 of the Code of Federal Regulations), and District Engineers have issued similar "general permits" for construction activities in specific geographical regions that will cause only a minimal adverse environmental impact. However, construction activities typically requiring individual permits include dredging, filling, pipes and cables, dams, dikes, weirs, boat ramps, levees, etc.

The application form (ENG Form 4345) which must be submitted to the District Engineer of the Buffalo District Corps of Engineers Office to obtain a permit to construct the proposed pipeline from the Acme Plant underneath the Maumee River to the vicinity of the Water Street Plant is shown in Figure 1. Essentially, this permit application form requires the following information:

- A detailed description of the proposed activity, including the purpose, use, type of structures, facilities for handling wastes and the type, composition and quantity of dredged or fill material.
- Names and addresses of adjoining property owners and others, on the opposite side of streams or lakes or whose property fronts on a cove, who may have a direct interest because they could possibly be affected by the project.
- Complete information about the location, including street number, tax assessor's description, political jurisdiction and name of waterway in enough detail so that the site can be easily located during a field visit.

Figure 1. APPLICATION FOR A DEPARTMENT OF THE ARMY PERMIT
For use of this form, see EP 1145-2-1

The Department of the Army permit program is authorized by Section 10 of the River and Harbor Act of 1899, Section 404 of P. L. 92-500 and Section 103 of P. L. 92-532. These laws require permits authorizing structures and work in or affecting navigable waters of the United States, the discharge of dredged or fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping it into ocean waters. Information provided in ENG Form 4345 will be used in evaluating the application for a permit. Information in the application is made a matter of public record through issuance of a public notice. Disclosure of the information requested is voluntary; however, the data requested are necessary in order to communicate with the applicant and to evaluate the permit application. If necessary information is not provided, the permit application cannot be processed nor can a permit be issued.

One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application (see sample drawings and checklist) and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

1. Application number (To be assigned by Corps) 	2. Date <div style="border-top: 1px solid black; display: flex; justify-content: space-between; width: 100%;"> Day Mo. Yr. </div>	3. For Corps use only.
4. Name and address of applicant. <div style="text-align: right; margin-top: 20px;">Telephone no. during business hours</div> <div style="margin-top: 10px;">A/C () _____</div> <div style="margin-top: 5px;">A/C () _____</div>	5. Name, address and title of authorized agent. <div style="text-align: right; margin-top: 20px;">Telephone no. during business hours</div> <div style="margin-top: 10px;">A/C () _____</div> <div style="margin-top: 5px;">A/C () _____</div>	
6. Describe in detail the proposed activity, its purpose and intended use (private, public, commercial or other) including description of the type of structures, if any to be erected on fills, or pile or float-supported platforms, the type, composition and quantity of materials to be discharged or dumped and means of conveyance, and the source of discharge or fill material. If additional space is needed, use Block 14. 		
7. Names, addresses and telephone numbers of adjoining property owners, lessees, etc., whose property also adjoins the waterway. 		
8. Location where proposed activity exists or will occur.		
Address: <div style="border-bottom: 1px solid black; margin-bottom: 5px;">Street, road or other descriptive location</div> <div style="border-bottom: 1px solid black; margin-bottom: 5px;">In or near city or town</div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> County State Zip Code </div>	Tax Assessor's Description: (If known) <div style="display: flex; justify-content: space-between; margin-bottom: 5px;"> Map No. Subdiv. No. Lot No. </div> <div style="display: flex; justify-content: space-between; margin-bottom: 5px;"> Sec. Twp. Rge. </div>	
9. Name of waterway at location of the activity. 		

10. Date activity is proposed to commence.	
Date activity is expected to be completed	
11. Is any portion of the activity for which authorization is sought now complete? ☐ YES ☐ NO If answer is "Yes" give reasons in the remark section. Month and year the activity was completed. Indicate the existing work on the drawings.	
12. List all approvals or certifications required by other federal, interstate, state or local agencies for any structures, construction, discharges, deposits or other activities described in this application.	
Issuing Agency	Type Approval
Identification No.	Date of Application
Date of Approval	
13. Has any agency denied approval for the activity described herein or for any activity directly related to the activity described herein? ☐ Yes ☐ No (If "Yes" explain in remarks)	
14. Remarks or additional information.	
15. Application is hereby made for a permit or permits to authorize the activities described herein. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete, and accurate. I further certify that I possess the authority to undertake the proposed activities.	
Signature of Applicant or Authorized Agent	
The application must be signed by the applicant; however, it may be signed by a duly authorized agent (named in item 5) if this form is accompanied by a statement by the applicant designating the agent and agreeing to furnish upon request, supplemental information in support of the application.	
18 U. S. C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up by any trick, scheme, or device a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false fictitious or fraudulent statements or entry, shall be fined not more than \$10,000 or imprisoned not more than five years, or both. Do not send a permit processing fee with this application. The appropriate fee will be assessed when a permit is issued.	

- A list of the status of all approvals and certifications required by other Federal, state and local governmental agencies. This information is important because review time is often reduced by joint or simultaneous processing.
- Reasons that explain denial of any approvals or certifications required by other government agencies. (When other approvals or authorizations are denied, application for a Corps permit may not be approved.)

Also, a set of good-quality, easily reproducible drawings of maps and engineering plans on 8 x 10 1/2" paper showing the location, extent and character of the proposed construction in relation to the existing waterway, and structures there within, must also accompany the submission of ENG Form 4345. A Corps of Engineers pamphlet EP-1145-2-1 entitled "U.S. Army Corps of Engineers Permit Program: A Guide for Applications" provides an overview of the permit requirements and examples of completed forms.

Upon receipt of a completed application, the Corps will initiate a review process as shown in Figure 2 to determine the probable impact the activity will have on the environment and the public interest. The Corps will issue a public notice of the proposed construction permit to approximately 200 Federal, state and local agencies, individuals (e.g. adjoining property owners) and organizations who have thirty days to submit written comments on the project to the Corps. If there are no serious objections to the proposed construction activity, a permit usually is issued within 60-90 days after receipt of the completed application. If major objections to the proposed project are raised during the review process which require modification of the proposed project, if public hearings become necessary, or if an environmental impact statement is required, the application processing

typical corps permit review process

FIGURE 2. TYPICAL CORPS PERMIT REVIEW PROCESS.

Source: "U.S. Army Corps of Engineers Permit Program: A Guide For Applicants" (EP 1145-2-1), November 1, 1973.

time could become a year or longer. When issuing a permit, the Corps reserves the right to inspect the construction activity with the applicant paying for the inspection costs.

With respect to the proposed pipeline crossing of the Maumee River, no major issues have been identified during agency contacts which would delay the normal Corps permit process or necessitate the preparation of an environmental impact statement. However, certain conditions such as the timing of the work (not during peak shipping seasons or fish spawning) and the refilling of the trench to cover the pipeline with clean materials (e.g. gravel instead of the dredged river bottom materials) may be imposed in the construction permit.

U.S. Environmental Protection Agency

The Region V office of the U.S. Environmental Protection Agency (U.S. EPA) located in Chicago, Illinois, works closely with the Ohio Environmental Protection Agency, and generally, acts only in a permit review and policy advisory capacity in environmental matters related to power plant design and operation. However, the U.S. EPA retains the authority to invalidate any state-issued permits which do not meet Federal standards for the attainment and/or maintenance of national air and water quality standards. U.S. EPA air and water quality regulations and permit procedures relevant to Toledo Edison's proposed district heating and cooling project are noted in the following paragraphs.

From an air quality perspective, the U.S. EPA will review the permit to install when issued by the Ohio EPA to ensure compliance with Federal emission offset regulations. Additionally, since the City of Toledo is located within a designated Prevention of Significant Deterioration (PSD) area, Toledo Edison will be required to file an

application with the U.S. EPA Region V office for a PSD permit if more than 100 tons per year of any single air pollutant will be emitted during power and steam generation at the retrofitted Acme Plant. U.S. EPA regulations for PSD were published in the Federal Register of December 21, 1976 (Vol. 41, No. 246, pp. 55524-55530) and revised regulations were published in the Federal Register of January 19, 1979 (Vol. 44, No. 11, pp. 3274-3285). The U.S. EPA guidelines for preparing the PSD permit application (should it be required) will be supplied to Toledo Edison with this report. After receipt of a completed permit application, the U.S. EPA has one year in which to make a final determination on the permit application. However, the U.S. EPA Region V office normally requires only four to nine months to complete the application process. After review of the application, the U.S. EPA issues a preliminary determination of the permit application within 30 days of receipt. This determination only authorizes the printing of a public notice in local newspapers for a 30-day public comment period, and is not authorization for commencement of any construction. Depending upon public comments received, a public hearing may be held. Additionally, if the proposed retrofitted plant will emit more than 50 tons/year of any pollutant, U.S. EPA will require and review air quality modeling data and proposed provisions for using Best Available Technologies (BAT) for the attainment and/or maintenance of National Ambient Air Quality Standards (NAAQS). Depending upon the provisions of the forthcoming Ohio State Implementation Plan (SIP), the air quality improvements resulting from the termination of operations at the Water Street Station may qualify for "banking" at the Acme Plant under the January 16, 1979 Emission Offset Interpretative Ruling.

Once the engineering plans for the proposed retrofit of the Acme Plant have been completed, a summary of the proposed retrofit scheme (including the existing percentage of boiler capacity being utilized, the estimated increment of additional boiler use, and the total boiler capacity) should be submitted to the U.S. EPA Region V office who, in turn, will provide an advisory response listing formal steps that will be required for obtaining PSD permit approval. In

general, the U.S. EPA favors the installation of equipment rather than use of low sulfur coal as insurance of proper emission control in the "worst case" situation, and they favor the installation of baghouses over electrostatic precipitators.

The Water Permits Branch of the U.S. EPA Region V office will review the U.S. Army Corps of Engineers 404 Permit Notice for the proposed Maumee River pipeline crossing to insure proper disposal of dredge spoil materials. They will also review the National Pollutant Discharge Elimination System (NPDES) permit to be issued for the Acme Plant by the Ohio Environmental Protection Agency. This review must be completed within 90 days. Present effluent standards for steam-electric plant have been promulgated under the Federal Water Pollution Control Act Amendments of 1977, and previous water quality legislation, and are specified in 40 CFR Part 423.10.

Once Toledo Edison has been granted a NPDES permit for the Acme Plant, and should they decide to implement the retrofitting of the Acme Plant to produce steam, a notice of intent to process modification should be submitted to Ohio EPA for possible NPDES permit amendments, and for the record to facilitate the renewal of the NPDES permit. Presently, only short-term NPDES permits, which are valid through September 30, 1980, are being approved by U.S. EPA, since the U.S. EPA expects to propose more stringent effluent guidelines (especially for toxic substances and chlorine compounds) in June 1979; and at that time will likely require the renewed five-year (FY 81 - FY 86) NPDES permits to include the use of Best Available Technologies (BAT) to control the emission of such pollutants into water bodies.

U.S. Coast Guard

The U.S. Coast Guard, a component of the U.S. Department of Transportation, is responsible for enforcing on the high seas and

navigable waters of the United States the Federal laws governing navigation, vessel inspection, port safety and security, marine environmental protection and resource conservation. Accordingly, the 9th U.S. Coast Guard District Office (Great Lakes Area) in Cleveland, Ohio, will review the U.S. Army Corps of Engineers' notice to issue a permit for the Maumee River pipeline crossing and the local Toledo Coast Guard office will become involved in coordinating navigation on the Maumee River during the construction phase of the project.

Depending upon the composition of river bottom sediments at the bottom of the proposed river crossing, the Coast Guard Environmental Impact Statement Coordinator may recommend as part of the marine environmental protection program that the river bottom sediments (especially oily materials and other hazardous polluting substances) not be used to backfill the pipeline trench, but instead, be placed in a dredged material containment area. During the construction of similar pipeline river crossings, the Coast Guard has required as part of its port safety and security program, and aid to navigation operations that:

...notice of construction be given to mariners sailing on the river in the construction zone; "No Anchoring" signs be placed on both sides of the channel to keep ships from damaging the pipeline; floating barges be properly marked and lighted; and a four-hour advance notice be given to the Coast Guard when a mobile refueling transfer onto the dredging barge is scheduled (in case of a spill).

Also, the Coast Guard would have to approve design plans and periodically inspect the pipelines if they were constructed as part of a bridge infrastructure. Also, the Coast Guard could possibly support winter construction activities by using icebreaking vessels to maintain an open channel.

STATE AGENCIES

This section summarizes the roles of potentially significant state agencies in the development of a new district heating system in the Toledo metropolitan area. These agencies are:

- Ohio Power Siting Commission
- Ohio Department of Energy
- Ohio Environmental Protection Agency
- Ohio Department of Industrial Relations
- Public Utilities Commission of Ohio.

The Ohio Power Siting Commission

The Power Siting Commission was created in Chapter 4906 of the Ohio Revised Code (ORC). Membership is composed of the chairman of the PUCO, the Director of the OEPA, the Director of Health, the Director of Development, and an engineer appointed by the Governor. The duties of the Commission are to:

- Review and comment on the reports filed by major utilities which contain ten-year forecasts by loads, resources and prospective sites
- Compile and publish yearly the general locations of proposed power plant sites and general locations of transmission lines, making such information available to the public through newspapers circulating within the area affected
- Require information from persons subject to its jurisdiction as is necessary to assist in the conduct of hearings or investigations

- Adopt rules establishing criteria for environmental evaluation of sites, projected needs for electrical power, and other rules necessary to carry out Chapter 4906
- Approve or disapprove applications for certificates.

According to Section 4906.04 of the ORC, "No person shall commence to construct a major utility facility in this state without first having obtained a certificate for the facility." The ORC and the Rules and Regulations of the Power Siting Commission, specifically PSC-1-02M, define "major utility facility" as "an electrical generating plant and associated facilities designed for, or capable of operation at a capacity of 50 megawatts." This has been interpreted by the PSC to be measured in units of electrical generation rather than the thermal equivalent. Also, a certificate is required for any substantial addition to a facility already in operation. A "substantial addition" is defined in PSC-1-02R as "any modification of a utility not operating under a certificate which modification creates a major utility or a substantial environmental or social impact." Such an addition might be the addition of a 50 MW or greater generating unit to an existing plant or the addition of a 50 MW or greater generating unit designed to operate in conjunction with an existing unit to establish a combined cycle unit.

If certification is required, then an application containing the following information is required:

- Description of the location and of the major facility to be built on it
- Summary of any studies which have been done on the environmental impact of the facility
- Statement explaining the need for the facility

- Statement of the reasons why the proposed location is best suited for the facility
- Statement of how the facility fits into the applicant's forecasts of loads and resources
- Other relevant information to the applicant or to the Commission.

The application must be made no less than two but no more than five years prior to the planned beginning of construction. Proof must also be submitted that notice of the planned facility has been given to heads of municipalities, counties and each public agency charged with protecting the environment or land use planning in the areas affected. Seven days prior to the filing of an application, notice must be given to persons residing in the affected areas. This is usually accomplished through newspaper circulation.

After the application and application fee (based on the kilowatt electric capacity and anticipated years between commencement of construction and initial operation) have been received by the Commission, a date for a public hearing is set, usually between 60-90 days after the receipt of the application. The same procedure is followed if an amendment of a certificate is desired. Such an amendment results from a substantial increase in environmental impacts or change in location of all or part of a proposed facility. Written or oral testimony concerning the proposed facility can be given by any person in attendance at the public hearing. Based on the filed application and the results of the public hearing, the Commission may either grant or deny the application for certification.

Certification is granted for a two-year operating period during which time the facility must operate in compliance with adopted standards and regulations pertaining to air pollution. If, however, compliance is not achieved during this period of initial operation (two years),

the facility then becomes subject to the jurisdiction of the Environmental Protection Agency and must comply with that agency's laws, regulations and standards pertaining to air pollution, water pollution and solid waste disposal.

The Commission will grant a certificate for the construction, operation and maintenance of a proposed or modified facility if:

- There is a definite and proven need for the facility.
- The nature of the probable environmental impacts is ascertained.
- The facility represents the best available technology of any of the various alternatives.
- The facility is consistent with the electrical grid in the interests of economy and reliability.
- The facility complies with environmental regulations and standards.
- The facility will serve the public interest, convenience and necessity.

The proposed retrofitting of the Acme Station is not likely to increase the capacity of the plant by more than the 50 MW electrical increase limit set forth in the Power Siting Commission's Rules and Regulations. If this is the case, application for a certificate will not be necessary. However, it is advisable to send a letter of intent to the PSC explaining the purpose of the project and its anticipated megawatt equivalent increase. This will allow the Power Siting Commission to clarify any jurisdictional questions it may have with respect to the proposed project. PSC-5-01A recommends that this

letter be written at least one year prior to the anticipated submission of an application for certification. The Commission will respond within 60 days to the letter of intent with a decision on whether it has jurisdiction over the proposed project. If the Commission decides it has no jurisdiction, then the project will face no impediments from the Power Siting Commission.

The Ohio Department of Energy

The Ohio Department of Energy was created by Section 121.02 of the Ohio Revised Code. The Department is charged, in ORC Section 1551.05, with a number of duties concerning the compilation of energy data and demand forecasts, the development of a State energy plan, the evaluation of energy laws and policies, and the provision of educational and technical assistance to individuals and organizations about energy-related matters. As a result of the aforementioned mandates, the Department has a vital interest in any project which promotes the use of energy sources not primarily dependent on natural gas or oil. Specifically, the Division of Information and Technology Transfer within the Department has an interest in and responsibility for the "...receiving, collecting, storing, and dissemination of energy-related data and information, undertaking to the extent practicable technology assessments, and administering technical assistance to local governments, other state agencies, and private individuals and organizations on energy-related matters." Furthermore, Section 1551.11 of the ORC says that the Director of the Department has the authority to sponsor research or pilot facilities and projects which would lead to the development and more efficient utilization of present, new or alternative energy sources in the State from funds appropriated by the General Assembly and by seeking out sources of grant money to foster such developments.

Thus, the Ohio Department of Energy has an expressed interest in the development of projects such as the one proposed by Toledo Edison, and State statutes provide encouragement for such developments. However, there are no official licenses or permit requirements from the Department to be fulfilled in connection with the proposed project. Rather, the Department's role will be of an advisory/review nature.

The Department performs two very important functions in relation to this proposed project. One is its evaluative role in the establishment of rates and prices for energy. Rates and prices are examined in the light of their effect on energy conservation and their ability to promote development and efficient use of energy sources. The Department makes recommendations to the PUCO and the General Assembly concerning changes in utility pricing policies, rate schedules and load management measures. The second important function of the Department is its analysis of the forecasts of loads and resources in relation to population growth estimates. The Department must then compare the results of this analysis with future development plans for the area and make recommendations which will help energy producers meet future demands.

The Ohio Department of Energy has also formed a committee, made up of members from various state departments and agencies, whose function is of an advisory nature with respect to this project. This group should be apprised of the proposed project's progress through its successive steps toward completion.

The Ohio Environmental Protection Agency

The Ohio Environmental Protection Agency (OEPA) is the chief agency administering environmental regulations within the State of Ohio. Working closely with officials from the U.S. Environmental Protection Agency Region V office in Chicago, Illinois, the OEPA

Offices of Air Pollution Control and Wastewater Pollution Control are responsible for granting permits to install equipment and operate industrial facilities (such as electric generating plants) which regularly discharge air and/or water pollutants as defined in terms of Federal and state air and water quality standards. Additionally, the OEPA will review the U.S. Army Corps of Engineers notice to issue a permit to install a pipeline across the Maumee River in relation to possible water quality impacts.

Air Quality

From an air quality perspective, the Toledo, Ohio metropolitan area is classified by the Federal government as a nonattainment area for carbon monoxide (CO), particulates, and sulfur dioxide (SO₂) emissions, and as a Class II area for prevention of significant deterioration of ambient air quality. Air quality criteria established in these regulations are presented in Tables 3 and 4 respectively.

Depending upon the specific engineering plans and the extent of modification required to retrofit existing boilers and turbines at the Acme Station to produce steam for the proposed district heating system, a permit to install for air emission offsets under provisions of the Federal Clean Air Act may be required from the Ohio EPA.*

If needed, the procedure for obtaining a permit to install will require the completion of an application form, OEPA 42G-2 and Appendix B, since fuel burning equipment is involved (see Appendix B of this report). This completed application for a permit to install must be submitted to the Toledo Pollution Control Agency, the local designated air pollution control agency, who will review the

* It is quite possible that a permit to install will not be required for the subject action. However, it is too premature for OEPA to make such a determination in Phase I of this program. Further discussions on this subject will be conducted in Phase II.

TABLE 2. CRITERIA FOR DETERMINING VIOLATIONS OF THE
AMBIENT AIR QUALITY STANDARDS

POLLUTANT	PRIMARY STANDARD	SECONDARY STANDARD
1. Total Suspended Particulate	<p>A. Every 24-hour sample other than the first greater than 260 micrograms per cubic meter is in violation of the standard.</p> <p>B. Annual Geometric Mean in excess of 75 micrograms per cubic meter.</p>	<p>A. Every 24-hour sample other than the first greater than 150 micrograms per cubic meter is in violation of the standard.</p> <p>B. Annual Geometric Mean in excess of 60 micrograms per cubic meter.</p>
2. Sulfur Dioxide	<p>A. Every 24-hour sample other than the first in excess of .14 parts per million is in violation of the standard. 365 ug/m³.</p> <p>B. Annual - 8 ug/m³.</p>	<p>A. For those non-overlapping 3-hour averages in excess of .5 parts per million each average after the first is in violation of the standard. 1300 ug/m³.</p>
3. Carbon Monoxide	<p>A. For those 8-hour averages in excess of 9 parts per million each non-overlapping average after the first is in violation of the standard.</p> <p>B. Each on-hour sample greater than 35 parts per million after the first is in violation of the standard.</p>	<p>A. Same as Primary standard.</p> <p>B. Same as Primary Standard.</p>
4. Photo-Chemical Oxidant:	<p>A. For those one-hour samples greater than 0.12 parts per million each sample after the first is in violation of the standard.</p>	<p>A. Same as Primary Standard.</p>
5. Non-Methane Hydrocarbons	<p>A. For those 6-9 a.m. averages greater than .24 parts per million each average after the first is in violation of the standard. 100 ug/m³.</p>	<p>A. Same as Primary Standard</p>
6. Nitrogen Dioxide	<p>A. Annual Arithmetic Mean in excess of .05 parts per million.</p>	<p>A. Same as Primary Standard.</p>

TABLE 3. PREVENTION OF SIGNIFICANT DETERIORATION

For any Class II area, the maximum allowable increase of sulfur dioxide and particulate matter over the baseline concentration of such pollutants shall not exceed the following amounts:

<u>POLLUTANTS</u>	<u>MAXIMUM ALLOWABLE INCREASE</u> <u>(in micrograms per cubic meter)</u>
Particulate Matter:	
Annual geometric mean	19
Twenty-four-hour maximum	37
Sulfur Dioxide	
Annual arithmetic mean	20
Twenty-four-hour maximum	91
Three-hour maximum	512

application and engineering plans to ensure completeness and to verify the accuracy of the required air pollutant dispersion models. With the recommendations of the Toledo Pollution Control Agency, the permit application is then forwarded to the Central Ohio EPA office in Columbus through the OEPA Northwest office in Bowling Green, Ohio. At the Central office of OEPA, the Division of Environmental Assessment within the Office of Air Pollution Control is responsible for issuing permits to install for sources of air pollution. After reviewing the application to ensure compliance with Federal and state air quality standards, as stated in the State Implementation Plan (SIP), this office will then issue a public notice of intent to issue the requested permit. This public notice will be printed in the local newspaper and sent to impacted agencies and interested individuals and organizations who will have a 30-day period to submit written comments to OEPA. Ohio EPA will subsequently issue a permit to install (retrofit the boilers and turbines, in this case) if no significant issues (generally public health and safety) have been raised by the public, and Federal and state air quality regulations will have been met. Upon approval of the permit, applicants for permits which involve air emissions or wastewater treatment facilities are required to pay a graduated fee ranging from \$0 to \$250, depending on the size of the proposed installation.

This permit to install application process requires three to four months to complete once a completed application has been received by the Toledo Pollution Control Agency. However, if revisions to Federal and state standards contained in the State Implementation Plan are required, if public hearings are required, if conditions established as part of the permit issuance are appealed to the Ohio Environmental Board of Review, or if judiciary procedures occur, the time required for obtaining a permit will be significantly extended.

Even if a permit to install is not required, the Ohio EPA Office of Air Pollution Control will review the project to assess the allowable increment of air pollutant increase that will likely

occur since the Toledo area is a Class II nonattainment area. This determination of air quality degradation will then serve as a basis for future air quality permits.

The present status of air quality operating permits for the Acme and Water Street facilities are discussed subsequently in the discussion of the Toledo Pollution Agency.

Presently, Ohio air quality standards are very complex, controversial and are undergoing modification, particularly with respect to the burning of Ohio high-sulfur coal. New emission offsets have recently been enacted by U.S. EPA (Federal Register, January 16, 1979). The present State Implementation Plan (SIP) for air quality is comprised of various State and Federal segments for various pollutants. Originally required to be completed by January, 1979, at least another six months and probably longer will be required before OEPA staff will be able to complete drafting of all segments for the various pollutants and obtain the approval of the new OEPA Director McAvoy before submitting the proposed regulations to the U.S. EPA Region V office for final approval. Additionally, OEPA is contemplating alternative regulations more stringent than the Federal regulations for certain pollutants. For example, under the proposed State standards for Lucas County, the Acme Plant would have to meet a standard of 1.2 lbs. SO₂ per million BTU as opposed to a Federal standard of 3.0 lbs. SO₂ per million BTU. The Ohio EPA maintains that their standard may require the burning of low sulfur coal and/or coal cleaning. However, the installation of scrubbers would not be required.

Destined to have significant impacts on all Ohio utilities, and possibly on the viability of the proposed district heating program, continued monitoring of air pollution program developments will be required in subsequent phases of the program, especially when detailed air emissions for the Acme retrofit scheme are finalized. A full-scale

environmental impact statement with detailed air quality modeling may be required for the proposed district heating project solely on the basis of potential air emissions.

Water Quality

In terms of water quality, in 1974 Toledo Edison filed an application for a National Pollutant Discharge Elimination System (NPDES) permit for the Acme plant as required under provisions of the Federal Water Pollution Control Act Amendments of 1972. Hearings have been held to resolve issues related to Section 316 A&B of the Federal legislation related to thermal discharges, and the effluent limitation on chlorine which is used as a cleansing agent in condensor tubes. The Acme plant is designated as a "non-major discharger", and the Ohio EPA Office of Wastewater Pollution Control anticipates issuance of the permit in 1979. Once the conditions of the NPDES permit have been finalized, the Ohio EPA will proceed with a public notice to interested organizations and individuals, as well as printing the draft permit subject to revision in the local newspaper. After a 30-day period for written comments, Ohio EPA will forward the permit application to the U.S. EPA Region V office for final approval.

Since the proposed retrofitting of the Acme plant will not involve installation of any new boilers, a modification to the permit that has already been applied for will not likely be required. Use of the steam from the boilers at Acme for the district heating system may even decrease the present thermal discharge. However, in the future, the U.S. EPA may require power plants to install Best Available Technology (BAT) for effluent discharges and BAT specifications for toxic pollutants may be instituted sometime in 1979.

Under conditions established in the NPDES permit, Toledo Edison will be required (as they have been doing voluntarily) to take

periodical water samples and submit the findings in a monthly report to the District Engineers in the Ohio EPA NW office in Bowling Green.

Ohio Department of Industrial Relations

The Ohio Department of Industrial Relations has two divisions that could potentially play a role in the proposed project. These divisions are:

- The Division of Pressure Piping
- The Division of Boiler Inspection.

Both of these divisions are discussed on the pages that follow.

Division of Pressure Piping

Chapter 4101 of the Ohio Revised Code (ORC) charges the Department of Industrial Relations (DIR) with the responsibility for and the authority to administer the intent of the laws which are concerned with "... protecting the life, health, safety and welfare" of employees in establishments under its jurisdiction. Specifically addressing pressure piping systems is Chapter 4101.8-3-01 of the Ohio Administrative Code (OAC). Section A includes the following: "Steam, water, hydraulic, air, instrument, and control piping as provided in ANSI B31.1-1973, titled 'Power Piping', with addendum B31.1b-1973." The scope of the regulations prescribes minimum requirements for the design, materials, fabrication, erection, test and "inspection of power piping systems for steam electric generating stations; industrial plants; central and district heating plants; district heating systems including those portions of the system both on the property of and within the buildings of industrial establishments." Subsections under A describe the systems to which ANSI B 31.1 apply. Of particular interest and applicability to the proposed

district heating project is subsection A2 which says the standards set forth in ANSI B 31.1 apply to "central and district heating systems for the distribution of steam and hot water away from the plant, whether underground or elsewhere."

Besides its concern for the type of materials used and the design and construction of district heating systems, the DIR's Division of Pressure Piping is also responsible for inspecting the pressure piping after it has been installed. Section 4101.08 and its subsections in the ORC address the certification of inspectors of pressure piping and charge the Board of Building Standards, created by ORC Chapter 3781.07, with formulating rules to govern the inspection of pressure piping systems. The Board of Building Standards is also empowered to certify municipal and county building departments to inspect power piping systems and adopt rules governing such certification. Section 4101:2-94-80 of the OAC certifies the Toledo, Ohio Building Department to enforce OAC Chapters 4101:8-1 to 4101-19 and they have taken over the duties of the State in regard to regulating all facets of the design, installation and inspection processes for pressure piping systems.

Before beginning installation of any pressure piping covered by the above regulations, the owner/operator must file with the Chief of the Division of Pressure Piping an application to install pressure piping and a fifty dollar fee. Two-tenths of one percent of the actual cost of the system or, in the case of negotiated contracts, the estimated cost of the system will serve as a basis for determining the inspection fee which must also be submitted to the Chief prior to the inspection. In order to meet the intent of the law, the installation of pressure piping systems must fulfill accepted engineering practices and accepted installation practices and workmanship. Therefore, the Division will not approve any plans submitted with application fee because approval for operation cannot be granted for something not yet constructed. However, after the installation of a

significant or operable portion of a pressure piping system, an inspection can be made at the request of the owner/operator. This request must have been made to the Chief four days in advance of the requested inspection, excluding Saturdays, Sundays and holidays. Inspections of all steam piping systems with pressure exceeding 15 psig and hot water piping systems with pressure exceeding 30 psig are under the jurisdiction of the above regulations.

Prior to the initial operation, pressure piping will be tested and inspected to the extent necessary to assure compliance with standards set forth in ANSI B 31.1. Nondestructive testing as well as visual tests are used to determine if the system complies with the accepted standards. Descriptions of the various tests performed are found in ANSI B31.1, Section 136.4 and parts of 137. Upon completion of the final inspection and the verified compliance of the pressure piping system by the inspector, the Chief issues to the owner/operator a certificate of inspection, which does not have to be renewed. Any alterations or extensions of less than fifty lineal feet of pipe in existing systems need not be inspected. Extensions greater than fifty feet must go through the traditional inspection-certification process.

Chapter 4101:8-5 of the AOC requires all new pressure piping to be designed, constructed and installed in accordance with accepted standards. Compliance with these standards will insure that no institutional impediments to the project arise. The Toledo Inspection Division, acting as agent for the State will have the responsibility for carrying out all Sections of OAC Chapter 4101:8.

Division of Boiler Inspection

Chapter 4101 of the Ohio Revised Code contains the general statutes which charge the Department of Industrial Relations with the responsibility for and the authority to administer boiler inspection

programs. These laws are concerned with "... protecting the life, health, safety, and welfare" of employees whose places of employment are under jurisdiction of the Department. Specifically, the Division of Boiler Inspection, as part of the Department of Industrial Relations, is required in Chapter 4104.02 of the Ohio Revised Code to formulate rules for the construction, installation, operation and inspection of boilers and unfired pressure vessels. Standards for materials used in boiler construction are set forth in ASME Section 1 and standards for welding and brazing of boilers are addressed in ASME Section 9.

The Ohio Administrative Code, Chapter 4101.4, outlines the procedures for boiler certification and inspection. Boilers are inspected upon installation and are not permitted to be operated until a certificate-inspection has been made and the initial certificate of operation fee has been paid to the Chief of the Division of Boiler Inspection. At the time of first inspection, State serial numbers are obtained from the Chief and affixed during the inspection to the boiler. Boilers are inspected both internally and externally. Internal inspection requires a 14-day advanced notice to the owner/operator. However, an external inspection does not require that a notice be given. If the boiler is being inspected for the first time, ASME's Long Form is used. It is also used when a boiler has been moved to a new location, when ownership has changed, or when the boiler has undergone major repair work. All subsequent inspections which are done on an annual basis, or by special permission biennially, use a Short Form.

Finally, upon receipt of the fee and approval of the inspection report by the Chief, the initial certificate of operation is issued. Each year thereafter or in some cases biennially, the certificate must be renewed. At least 30 days prior to certificate expiration, the Chief sends the owner/operator an application for renewal. The owner/operator completes the application and returns it with the fee to the Chief who then sends the renewed certificate to the owner/operator.

These procedures are currently being followed with the boilers already in place at the Acme and Water Street Stations to be affected by the proposed district heating system. At the present time, no new boilers are to be constructed in conjunction with the project. Thus, the Division of Boiler Inspection will not be concerned nor have jurisdiction over the project since alterations or new boiler construction will not result from it. Mr. Richard Jagger, Chief of the Division of Boiler Inspection, noted that altered turbines would require some reassessment for insurance purposes and that Toledo Edison's insurance company (with whom the turbines are insured) should be notified of this change. However, this is not under the jurisdiction of his Division.

The Public Utilities Commission of Ohio

The Public Utilities Commission of Ohio (PUCO), pursuant to the provisions of Title 49 of the Ohio Revised Code (ORC), has jurisdiction over public utilities in Ohio. The definition of "public utility", as specified in Section 4905.02 of the ORC includes "every corporation, person, or association, their lessees, trustees, or receivers ... including all telephone companies, but excepting such other public utilities as operate their utilities not for profit, such other public utilities as are owned or operated by any municipal corporation, and railroads...." Section 4905.03 of the ORC provides that any person, firm, copartnership, company or corporation, wherever organized or incorporated is "a heating or cooling company where engaged in the business of supplying water, steam, or air through pipes or tubing to consumers within this State for heating or cooling purposes."

The major powers exercised by PUCO in line with the definitions given above include:

- The fixing of tariffs
- The establishment of an acceptable system of accounts
- The requirement that any or all public utility contracts be filed with PUCO, reviewed and approved
- The granting of approval for the issuance of stocks, bonds or notes prior to issuance.

Each of these powers is discussed below.

Tariffs

Tariffs include the rules that describe the utility/customer obligations, as well as rates that specify service charges. Current steam tariffs in Ohio are relatively unsophisticated and will likely need to be reworked according to the PUCO staff interviewed (see Appendix C for list of contacts made). There is the potential for special contracts which identify a limited group of customers to take the bulk of the steam. In this case, a special tariff for each customer would be worked out within general tariff guidelines which are subject to PUCO approval.

As mentioned in Chapter 5, municipal ownership of the district heating system would diminish the role of PUCO with respect to tariffs. In such circumstances, the City of Toledo would have the option of setting rates which are still filed with PUCO for information purposes, but which do not require PUCO approval (unless there is a complaint, in which case, the burden of proof is heavily on PUCO in making any rate revisions). The rules portion of the tariff can be affected by PUCO, however, even though the rates are set relatively independently with

municipal ownership. In Ohio, steam heat companies do not need PUCO-certified service territories, but they cannot be discriminatory in their service policies.

Accounting System

Cash flows, tax effects and other fiscal details will eventually need to be characterized in detail, broken down by steam customers and electric customers in separate accounts. PUCO does not currently have formal accounting rules for district heating and cooling systems. Consequently, a continuing dialogue between the project team and PUCO staff in Phase II will be important in achieving a mutually agreeable set of accounting rules for such a project.

Public Utility Contracts

All public utility contracts must be filed, reviewed and approved by the PUCO before they are finalized as the basis for utility/customer relationships. PUCO concerns here are likely to include:

- An assessment of the way project risk is shared (relates directly to ownership options discussed in Chapter 5)
- Equity of the terms and conditions of the contract
- Provision for reliability of service
- Consistency with PUCO regulations and supporting policies.

Issuance of Stocks, Bonds or Notes

PUCO official involvement in the proposed district heating project will be minimal until a substantial front-end investment will have been made by Toledo Edison/U.S. Department of Energy. The Commission will have a significant role, however, when Toledo Edison (presuming they own the system) starts making financial commitments. PUCO regulates utility securities (the generation of long-term capital) and getting PUCO approval for such a financial transaction is a potential constraint. The need for additional capital must be justified using the proposed project as full or partial justification. It should be noted that security issuance has never been denied by PUCO, but it has been delayed and/or modified as a result of PUCO review in the past. Working with the PUCO staff in upcoming phases of this project will help to mitigate any such delay problems.

Other PUCO Considerations

Establishing a reliable supply of steam may also become an issue in project planning. There are currently no established rules for service reliability for district heating and cooling systems in Ohio. Again, such rules will need to be worked out jointly between Toledo Edison and the PUCO staff in subsequent phases of work. Similar discussions will need to be undertaken concerning the allocation of fuel costs between electric and district heating systems. The PUCO will also have responsibility for inspecting and approving the integrity of the steam distribution system according to current engineering standards.

In general, the PUCO staff is positively disposed to the application of district heating and cooling in Ohio. The importance of a continuing, more detailed discussion of the issues outlined herein with the PUCO cannot be understated as an element of the Phase II work.

LOCAL AGENCIES

This section summarizes the roles of a myriad of local agencies with respect to a potential district heating project in the study area. Because the most feasible service area for such a system is in the general vicinity of the existing steam distribution system, most of the agencies discussed here are Toledo municipal agencies. Fortunately for this analysis, no other local political subdivision is involved the way the project has emerged.

The local agencies discussed on the pages that follow include:

- Toledo Inspection Division
- Toledo Division of Engineering and Construction
- Toledo Division of Traffic Engineering
- Toledo Division of Streets, Bridges and Harbors
- Toledo Real Estate Department
- Toledo Pollution Control Agency
- Toledo-Lucas County Port Authority
- Toledo Metropolitan Area Council of Governments
- Toledo-Lucas County Plan Commission
- Toledo City Council.

Toledo Inspection Division

Established under Article XXIII of Chapter 3 of the Toledo Municipal Code, the Building Inspection Subdivision of the Division of Inspection in the Department of Community Development is responsible for inspecting pressure piping within the buildings using steam in quantities of 15 pounds or more per square inch, or hot water at 30

pounds or more per square inch. This Division has taken over the State inspection responsibility from the Ohio Industrial Relations Commission and follow and enforce the Ohio Building Pressure Piping Regulations which establish the types of pipe, etc., required (see Industrial Relations Commission). The jurisdiction of the Building Inspection Subdivision would include the portion of the new district heating system inside customer buildings, but not the distribution system itself.

A permit for application to install pressure piping is required from the Division of Inspection. A simple one-page form must be filed and a permit can be issued in the same day or within a day or two after filing of the application (see Figure 3). A graduated fee schedule ranging from \$20 to \$120 based on estimated installation cost is noted on the form. However, this schedule may be updated in the near future to be consistent with new State fees. After the pipes have been installed, the Division then conducts a pressure test to verify proper installation and issues a one-time-only certificate of compliance. There is no annual inspection thereafter. The Division issues approximately 300 pressure piping permits per year, only 10-15 of which are for steam pipes.

If the pressure of steam or hot water going to the buildings is less than 15 and 30 pounds respectively, a different permit will be required from the Subdivision of Plumbing Inspection of the Inspection Division (see Figure 4). Those regulations are specified in the Toledo Municipal Code under plumbing, Section 10.3.9.700, "Hydronic Heating and Air Conditioning." The City Code does not contain any specific pressure piping provisions related to fire prevention.

Assuming proper construction methods are used to install the new pressure piping within buildings, no institutional problems relating to the expansion of the present district steam heating system were identified.

FIGURE 3

CITY OF TOLEDO

DEPARTMENT OF COMMUNITY DEVELOPMENT

DIVISION OF INSPECTION

P.O. BOX 844
TOLEDO, OHIO
43696

APPLICATION TO INSTALL PRESSURE PIPING

DATE _____

IF APTS., MOTEL, HOSPITAL, OFFICE, ETC. STATE NO. OF UNITS. _____

JOB NAME AND LOCATION	ADDRESS	CITY	COUNTY
-----------------------	---------	------	--------

CONTRACTOR	ADDRESS	CITY	COUNTY	ZIP CODE
------------	---------	------	--------	----------

TYPE OF PIPING SYSTEM TO BE INSTALLED AND INSPECTED	OPERATING PRESSURE
---	--------------------

APPROXIMATE STARTING DATE _____

ACTUAL OR ESTIMATED COST OF INSTALLATIONS
(Labor and Material) _____CIRCLE TOTAL FEE APPLICABLE AND MAKE CHECK PAYABLE TO **CITY OF TOLEDO**FEE SCHEDULE FOR THE DIVISION OF PRESSURE PIPING

Minimum \$1,200 or less	\$ 20.00
\$1,201 to \$10,000 inclusive	\$ 30.00
\$10,001 to \$50,000 inclusive	\$ 35.00
\$50,001 to \$100,000 inclusive	\$ 45.00
\$100,001 to \$150,000 inclusive	\$ 60.00
\$150,001 to \$200,000 inclusive	\$ 80.00
\$200,001 and over	\$120.00

OWNER'S AGENT OR SUBMITTOR _____

TELEPHONE NUMBER _____

FIGURE 4

CITY OF TOLEDO, OHIO
APPLICATION FOR HEATING PERMIT

HOT WATER, STEAM HEATING, GAS UNIT HEATERS AND INFRA-RED HEATERS

TOLEDO, OHIO _____, 19____

THE UNDERSIGNED HEREBY MAKES APPLICATION FOR A PERMIT FOR THE INSTALLATION, REPLACEMENT OR ALTERATION OF A HEATING SYSTEM OR DEVICE AS HEREIN SPECIFIED, AGREEING TO DO ALL SUCH WORK IN ACCORDANCE WITH CITY AND STATE ORDINANCES AND TO SAVE THE CITY OF TOLEDO, OHIO, HARMLESS FROM ANY AND ALL DAMAGES.

LOCATION _____ CONTRACTOR-WET HEAT _____

OWNER _____ BUSINESS ADDRESS _____

DESCRIPTION OF WORK

TYPE OF HEATING SYSTEM _____ ESTIMATED COST _____

TYPE OF BOILER _____ BOILER B T U (P/Hr.) IN PUT _____

BREECHING SIZE _____ FLUE SIZE _____ FLUE HEIGHT _____

TYPE OF SAFETY DEVICES _____

BOILER LOCATION _____

TYPE OF FUEL _____ HOW FIRED _____

TYPE OF PIPING _____ METHOD OF CIRCULATION _____

TOTAL RADIATION _____ TOTAL HEATED AREA _____

CONSTRUCTION OF BUILDING _____ USE OF BUILDING _____ NEW _____ OLD _____

NUMBER OF CHARGEABLE UNITS _____ PERMIT FEE \$ _____

Distribution:

Blue - File White - Applicant
Pink - Auditor Tag - Inspector

SIGNED _____

Toledo Division of Engineering and Construction

The Division of Engineering and Construction within the Toledo Department of Public Services will be a key actor during the design and construction of the proposed district heating system. As discussed below, the agency works very closely with utility companies in locating and relocating utility lines.

The Division of Engineering and Construction must review and approve the detailed plans and specifications of the proposed project before the Toledo City Council will pass an ordinance authorizing the installation of distribution lines in the public right-of-way. Utilities are encouraged to consult with the Division during the design phase. However, the Division will only approve the final plant drawings. Two copies of the final plans are required (one for the records and one to be returned to the utility with any suggested modifications indicated). If the public utility intends to grant ownership and maintenance responsibility to the City once the system has been constructed, the Division may also specify the use of specific construction materials (size and type of pipe, etc.). The Division of Engineering and Construction will also review the Corps of Engineers permit notice to insure that the proposed Maumee River pipeline crossing will not interfere with existing sewer outfalls.

A permit form ULC-4 is required from the Utilities Section of the Division of Engineering and Construction. The purpose of this permit is to insure that other utilities have been made aware of the proposed action to avoid unexpected problems with other utility lines. (See Figure 5 for an example of a completed form ULC-4.) If the proposed construction is very complicated, detailed design plans may also be required to accompany the permit. This permit is normally approved by the Utilities Section within a day or two.

The Division of Engineering and Construction also issues "Street Opening Permits" in accordance with provisions established in

FIGURE 5

UTILITY WORK IN THE PUBLIC RIGHT OF WAY
FOR NEW CONSTRUCTION, RELOCATION, OR REPLACEMENT

DATE January 10, 1979

ORDER #Est. 5730

City of Toledo, Utilities Section
Division of Engineering and Construction
415 North St. Clair Street - Third Floor
Toledo, Ohio 43604

Dear Sir:

The Ohio Bell Telephone Company requests permission to
Relocate and Rebuild our Existing Underground and Aerial Plant as
required to Facilitate the "City of Toledo - Dorr Project"

This work is indicated on the attached prints 2 thru 14 and 21 thru 29
and will be performed under the following terms and conditions:

1. The Ohio Bell Telephone Company agrees to assume any and all liability in connection with this work and save the City of Toledo harmless from any and all claims for damages that may arise in connection therewith.
2. The work to be done under the supervision of your department and any request made in connection with the manner in which the work is carried on will be complied with. Whenever possible Traffic Engineering Division of the City of Toledo would be notified at least five (5) days in advance of construction operations with confirmation on the first working day preceding the actual beginning of work.
3. Traffic flow will be maintained with the least amount of inconvenience, excavated materials will be promptly hauled away, and special care will be taken to safeguard the traveling public.
4. Materials will not be stored in the streets without approval.
5. All City Ordinances governing openings in City streets will be rigidly observed and city specifications shall apply in this work.
6. Any existing structures will be carefully preserved, and any disturbed will be replaced. This refers particularly to utility lines.
7. Pavement will be replaced in accordance with current City of Toledo specifications (Utility Section, Division of Engineering and Construction). Backfill under the pavement and sidewalk shall meet the requirements of Section 310 of the current State of Ohio Department of Transportation Construction and Materials Specifications.
8. Work will proceed with the utmost speed.
9. Upon completion of work, charges for any street openings, as well as inspection, are to be billed to the Ohio Bell Telephone Company - Construction Dept. - 425 Jefferson Avenue - Toledo, Ohio - 43604.
10. Your office will be notified 24 hours in advance of actual construction.
11. The location of this work has been reviewed by:

CITY OF TOLEDO	NAME	PHONE	Pre-Const. Meeting REVIEWED At
Paving Section	William N. Shanbarger	247-6163	9-14-78 M.P.W.
Division of Water	Frank Hixson	247-6531	9-14-78 M.P.W.
Sanitary Sewer Section	Roy E. Schwanger	247-6162	9-14-78 M.P.W.
Storm Sewers and Drainage	Robert H. MacDonald	247-6179	9-14-78 M.P.W.
Traffic Engineering	Michael White	247-6431*	9-14-78 M.P.W.
Fire and Police Alarm	John Forshey	247-6590	9-14-78 M.P.W.
Forestry Division		247-6483**	9-14-78 M.P.W.
(**Trees involved only)			
(* Traffic lights involved or closing of sts.)			
PRIVATE UTILITIES			
Columbia Gas of Ohio Maps and Records		248-5035	9-14-78 M.P.W.
Ohio Bell Telephone Co. Engineering Dept.		247-7244, 7811	9-14-78 M.P.W.
Toledo Edison Co. Underground Engineer		259-5146	9-14-78 M.P.W.

BY Patricia A. Stiehn
Engineer Right-of-Way
Toledo-Findlay District
The Ohio Bell Telephone Co.

APPROVED

APPROVED: JAN 10 1979

APPROVED:

Engineering & Construction Division (Approval is necessary for Fire & Police Alarm
Toledo Edison & Ohio Bell Conduits and Aerials Only)

Chapter 7, Article 1 of the Toledo Municipal Code. This permit is required before any work can be performed within a public right-of-way or easement. A surety bond of \$1,000 is also required against potential damage and deficient restoration of pavement, etc. In general, the Construction and Material Specifications of the Ohio Department of Transportation apply to all construction and repair work. Other requirements relating to traffic maintenance, excavation, tunneling, etc., are established in Specifications Governing Openings in Public Ways issued by the Division of Engineering and Construction, June 13, 1978.

The Division conducts spot checks during construction operations to insure compliance with the engineering plans and construction specifications. Fees for conducting these inspection checks are assessed to the public utility. However, the Department does not inspect or test pressure pipes in the distribution system.

Since the downtown street/utility system is mostly established, physical space and clearances for new utility lines may be a constraint in some cases. Municipal sewer and water lines have precedence in public rights-of-way over public utilities because of gravity flow requirements for sewer line drainage (water lines are pressure lines). In a few isolated instances, a public utility has been required to relocate existing lines, and such may be the case with redesign and extensive downtown reconstruction associated with construction of the three new downtown buildings and the separation of existing combined storm/sanitary sewers in the area. This reconstruction area includes portions of Summit, Cherry and Jackson Streets (between Summit and Erie).

Toledo Division of Traffic Engineering

The Division of Traffic Engineering within the Toledo Department of Public Safety has the authority under Section 21-5-2 of the Toledo Municipal Code to place and maintain traffic control

signs, signals and devices and to facilitate the orderly flow of traffic during construction activities.

Other Federal (Federal Highway Administration) or State of Ohio (Department of Transportation) agencies will have have jurisdiction from a traffic perspective in the proposed project since no interstate highways are involved nor will any permanent changes in traffic patterns on a state highway result from construction activities required to install the proposed district heating program.

The Division of Traffic Engineering works closely with the Division of Engineering and Construction in approving street opening permits, and the Division may stipulate conditions governing the extent and timing of street openings in order to facilitate public safety and traffic maintenance on major downtown Toledo streets. The Division of Traffic Engineering has also prepared a Manual for Uniform Traffic Control for Construction and Maintenance as a supplement to the Ohio Manual of Uniform Traffic Control Devices for Streets and Highways, prepared by the Ohio Department of Transportation. This Manual for Uniform Traffic Control for Construction and Maintenance specifies proper construction contractor standards for signs, lighting, pedestrian movement, barricades and traffic controls which must also be adhered to facilitate public safety and maintain traffic flow.

Toledo Division of Streets, Bridges and Harbors

As specified in Chapter 22 of the Toledo Municipal Code, the Division of Streets, Bridges and Harbors is chiefly concerned with harbor operation policies and enforcement of harbor regulations as opposed to the Port Authority which is promotional and developmental oriented.

The Division of Streets, Bridges and Harbors' likely involvement in the proposed district heating project will include a review of

the Corps of Engineers' permit notice, specifically as related to possible interference with navigation. This Division does not issue any permits per se. However, according to Section 22-2-3 of the Toledo Municipal Code, construction projects in the harbor may not occur without a permit from the Inspection Division, who before issuing such a permit, must obtain the approval of the Commissioner of Bridges and Harbors who in turn, must submit the permit application to the Toledo-Lucas County Port Authority for their recommendations. Also, if the proposed dredging activity would involve the commercial sale of sand, gravel, etc., from the dredged materials (highly unlikely in the proposed location and size of the proposed pipeline installation), a commercial dredging license would be required pursuant to Section 25-26-1 of the Toledo Municipal Code. This Division does not inspect construction sites unless there is a public complaint or flagrant violation.

The Division of Streets, Bridges and Harbors is also responsible for preventing the harbor from becoming unnecessarily congested and can regulate the places where, and the circumstances under which, vessels may be moored or stored during the winter season or when they are not engaged in navigation.

Presently, ConRail is suing the Division of Streets, Bridges and Harbors regarding the Division's enforcement powers over navigable waterways claiming that only the Corps of Engineers has this authority. Regardless of the outcome, either the Division or the Corps will have jurisdiction.

Toledo Real Estate Department

The expansion of the present district steam heating system to other areas of the city and for the Acme-Water Street connection will require the securing of rights-of-way. In all likelihood, existing street utility corridors will have to be used for extending

the system into new downtown buildings as there are very few buildings set back from the property lot lines and streets in the downtown area, and there are several subbasements under the sidewalks. Within the City of Toledo, the Real Estate Department is the agency responsible for preparing the necessary paperwork granting new or extending existing easements or franchises which then must be finally approved by the Toledo City Council in the form of an ordinance.

After approval by the Department of Engineering and Construction (and perhaps by the Division of Streets, Bridges and Harbors depending upon the nature of the proposed project), the detailed engineering plans and legal descriptions of the affected properties are then submitted to the Real Estate Department who prepares the necessary paperwork for Council approval. Assuming that all of the necessary information has been submitted, approximately six to nine months are normally required for the Real Estate Department to complete the titlework, appraisals, negotiations, etc., for a right-of-way involving 50-60 easements.

The right to use land by the public utility or the municipality for the proposed district heating system could most easily be secured or granted if the system can use existing rights-of-way by amending existing contracts.

Generally, where possible, the City prefers amendments to existing franchises rather than issuance of easements for right-of-way since easements normally encumber the land for long periods of time, even if the system is later abandoned. Also, there is no "quick take" condemnation and appropriation provision in Ohio Statutes to take land for public purposes (except highways). However, hearings on disputed cases must occur within a six-month period. In essence, the absence of a quick-take provision is an incentive to use existing right-of-way corridors to avoid delays and costs associated with court actions. Accordingly, the City of Toledo prefers to negotiate

rather than go to court to secure rights-of-way in dispute. This negotiation period varies in length depending upon the complexity of the issues involved.

Toledo Pollution Control Agency

Under Article 3-60 of the Toledo Municipal Code, the Pollution Control Agency is responsible for the enforcement of all laws pertaining to pollution control, the preparation of long-range plans for pollution control, and inventory and maintaining data on the conditions of the environment. Accordingly, this local governmental agency will be mostly concerned with changes in air and water emissions associated with the proposed district heating project.

The Toledo Pollution Control Agency will also review the Corps of Engineers notice to issue a permit for the Maumee River pipeline crossing, primarily in regard to the proposed dredging operations and disposal of dredged materials.

The Toledo Pollution Control Agency is the designated air quality agency for Lucas County and issues the air quality permits for installation (and/or modification) and operation of boilers, etc. Of the approximately 900 air quality permits granted by the Toledo Pollution Control Agency, the Ohio EPA has only disapproved approximately three of the permits. Air quality operating permits must be renewed once every three years. However, since 1977 the Ohio EPA has placed a moratorium on the issuance of new permits pending the completion and U.S. EPA approval of the State Implementation Plan (SIP) for Ohio. New permits issued under the State Implementation Plan are likely to specify a compliance time schedule limiting emissions. Thus, the procedure and time requirements for securing necessary air quality permits to operate the retrofited boiler units at Acme cannot be determined at this time. Toledo Edison's air quality operating

permits for their twelve oil-fired units at the Acme and Water Street facilities expired in 1977, and their applications for operating permits for their coal-fired units at the Acme facility were denied in 1972 with subsequent court litigation occurring since that time.

The following solutions have been identified to bring Acme Station into compliance. Precipitators are presently being installed on three Acme boilers which will bring the plant into compliance by the deadline established for particulates of April 15, 1980. By using low (1.25-1.50%) sulfur coal, Acme will be in compliance with the SO₂ regulations by October 19, 1979. The issuance of permits will depend on the approval of a State Implementation Plan by the U.S. EPA.

The Toledo Pollution Control Agency also conducts visual spot checks or a monitoring program at locations where a water quality problem is apparent and has the authority to take whatever corrective measures are necessary to solve the problem. However, in terms of power plant operations, the Ohio EPA Northwest District office in Bowling Green, Ohio is responsible for issuing NPDES permits, and Toledo Edison submits monthly water quality reports of operations at their Acme and Water Street Plants to this agency.

Toledo-Lucas County Port Authority

The Toledo-Lucas County Port Authority is likely to have minimal involvement in the Maumee River pipeline crossing segment of the proposed district heating system. Although vested with eminent domain and zoning powers along the Maumee River and Toledo Harbor under the Ohio Port Authority Act (Section 4582 of the Ohio Revised Code), the Toledo-Lucas County Port Authority has yet to exercise these powers. Instead, they have acted as a development agency, primarily by constructing and operating two overseas docks in the Toledo Harbor and by promoting private industrial development. The Port Authority will review the U.S. Army Corps of Engineers' notice to issue a permit for

the Maumee River pipeline crossing and will likely comment only if the proposed construction is anticipated to cause significant disruption to commercial shipping. Also, the Port Authority may subsequently become involved in the proposed project should dredged materials from the pipeline installation be required to be deposited in a dredge disposal containment area. Presently, Toledo Edison has a contract with the Port Authority to dispose of ash and channel maintenance materials from the Bay Shore Plant at the Port Authority's dredge disposal containment area located in the Toledo Harbor. It is conceivable that this same area will be allowed to accommodate dredged material from the pipeline channel excavation.

Toledo Metropolitan Area Council of Governments

As a regional planning and A-95 review agency, the Toledo Metropolitan Area Council of Governments (TMACOG) advises its constituent governmental agencies (municipalities in five counties) on a wide range of matters, including long-range energy planning. As a member of the District Heating and Cooling Project Demonstration Team, TMACOG has been involved in the project's development by serving as a catalyst, by bringing together key actors having interests in the project, and by reflecting the attitudes of local government relative to the project. As a coordinating, areawide and comprehensive planning organization, TMACOG has also contributed land use, demographic, economic and environmental data to the other members of the project demonstration team.

Other current TMACOG energy planning studies which relate to the proposed District Heating and Cooling Demonstration Project include a recently funded Comprehensive Energy Conservation Planning Program and a proposed resource recovery facility study. An Energy Guidance Group of elected and appointed officials and professional resource people will meet each month to monitor the comprehensive energy conservation program.

As the District Heating and Cooling Demonstration Program advances into successive phases, TMACOG's anticipated role will include working closely with environmental groups to obtain endorsements for the project and providing a forum for local community involvement.

Toledo-Lucas County Planning Commission

This agency is involved with various planning activities for their Toledo-Lucas County jurisdiction. While they will likely have no formal approval authority over the proposed district heating system, they should be consulted as the project planning effort proceeds. One reason for such consultation is that the Planning Commission is intimately involved with downtown redevelopment efforts which could influence the development of future markets for any district heating system. In addition, the Planning Commission commonly reviews and comments upon easement requests. Such requests could be involved in the proposed project, and therefore, coordination with this agency on such matters could help avoid troublesome and unnecessary delays as implementation proceeds.

Depending upon the final configuration of the district heating system, there may be the need for a small building to house a pressure reduction station and other auxiliary equipment. There appears to be sufficient flexibility in the choice of a site for this facility that anticipated zoning problems are minimal. Clearly, opposition to the selected site would delay zoning approval. The Toledo-Lucas County Planning Commission will review and make recommendations to City Council on any such zoning requests.

Toledo City Council

Once all the proposed construction plans have been preliminarily approved by the Toledo Division of Engineering and Construction and

the paperwork for securing rights-of-way has been completed by the Toledo Real Estate Department, the Toledo City Council will finally approve the project by passing an ordinance authorizing the installation of the utility distribution lines within the public right-of-way. A \$25 fee is assessed for preparing the ordinance.

The Toledo City Council also normally attaches the following types of conditions to such ordinances:

- . The construction shall be in accordance with plans approved by the Division of Engineering and Construction with the design meeting standards and specifications of the City of Toledo.
- . Construction shall be subject to inspection by the Division of Engineering and Construction.
- . The owner shall reimburse the City of Toledo for the cost of plan review and construction inspection, plus a 35 percent surcharge for overhead costs associated with plan review and construction inspection.
- . The work shall be performed by a competent contractor acceptable to the Engineering and Construction Division.
- . The owner shall indemnify the City of Toledo, its officials, agents or employees, from any and all claims, demands, cause of actions, suits or liability in connection with the performance of any and all acts authorized or permitted under the ordinance. Said indemnification shall be kept in permanent file of the Clerk of Council.

A Maintenance Bond shall be obtained in the amount of 50 percent of the construction cost upon completion of all construction for a period of one (1) year. (This Bond normally is required only for those systems which are to be turned over to the municipality for operation after construction.)

Once the proposed project has been approved by the City Departments, the Toledo City Council very rarely disapproves any staff recommendations.

CHAPTER 8. SUMMARY AND CONCLUSIONS

This report has outlined the results of Battelle's Phase I, Task 5 responsibilities to conduct an assessment of potential institutional constraints or impediments to the implementation of a district heating program in the Toledo Edison service area. In doing so, the following major topics have been discussed:

- Alternative ownership/financing options
- Potentially relevant tax considerations
- Roles of Federal, state and local agencies with possible jurisdiction over the proposed project.

This Chapter provides an overview of the significant findings or conclusions of this Phase I work.

OWNERSHIP/FINANCING OPTIONS

The following ownership/financing options were evaluated in this Phase I effort in order to narrow the scope of the Phase II investigation:

- Public utility ownership
- Utility subsidiary ownership
- Municipal ownership
- Joint venture ownership (public utility/municipality)

- Joint venture ownership (public utility/private sector)
- Nonprofit corporation ownership
- Customer ownership.

While each of the above alternatives has specific advantages and disadvantages associated with it, the evaluation led to two options being recommended for more focused analysis in Phase II. They are public utility ownership and municipal ownership.

Public utility ownership (specifically Toledo Edison ownership) is considered to be the most likely alternative. This option is essentially the status quo arrangement whereby Toledo Edison would own, operate and maintain the entire steam production and distribution system. Advantages of utility ownership include:

- It is the least complicated alternative and administrative/transaction costs would likely be minimized.
- Because Toledo Edison is already engaged in financing a large capital construction program, special financing may not be required for this project.
- While the operation of the district heating system is marginally riskier than Toledo Edison's other operations, it is not likely to affect the company's overall financial standing.
- As a major utility, Toledo Edison is able to obtain capital at a lower cost than most industrial firms.
- Toledo Edison is thoroughly familiar with the regulations and procedures of the Public Utilities Commission of Ohio.

Municipal ownership is potentially the least cost ownership option. If the City of Toledo were to acquire ownership, issuance of revenue bonds would be the preferred financing method. Advantages of municipal ownership include:

- A municipally owned system would enjoy tax exempt status.
- The City would be able to obtain a lower interest rate on a bond issue to finance the purchase.
- Municipal ownership would lead to virtual exclusion from Public Utility Commission regulation.

Both of these options are recommended for more detailed examination in Phase II of this study.

TAX CONSIDERATIONS

Tax considerations, at this point in the analysis, do not appear to be a constraint to further consideration of a district heating project in Toledo. In fact, recent Federal and state legislation includes several tax incentives available to a public utility for an investment in district heating and cooling. Available incentives include those provided by:

- Ohio Am.Sub.H.B. 467
- Federal Public Law 95-600.

KEY AGENCY ROLES

This report has explored the potential roles of key agencies at the Federal, state and local levels with respect to the proposed district heating system. Figures 6, 7 and 8 summarize those agencies that have potential approval/permit responsibilities in the implementation of a district heating project in the Toledo metropolitan area. This figure also provides an estimate of the timing of each anticipated approval or permit, in general terms. The priorities and timing considerations reflected in this figure will be refined in Phase II as the project team talks with relevant agencies in more specific terms about the proposed project.

There are three Federal agencies with a potentially significant role to play in the proposed project, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, and the U.S. Coast Guard. The Corps of Engineers' role relates to the agency's responsibility for issuing permits authorizing structures (e.g. steam lines) and work in or affecting navigable waters of the United States, and the discharge of dredge or fill material into the waters of the United States. The U.S. Environmental Protection Agency responsibilities relate to their review of the provisions (air and water quality related) of a "permit to install", should such a permit be required. The Coast Guard role relates primarily to the maintenance of port and vessel safety during the construction of the required steam pipeline across the lower Maumee River.

There are also three major state agencies with approval/permit responsibility for the proposed project as it is currently conceived. These are the Ohio Environmental Protection Agency (OEPA), the Ohio Department of Industrial Relations (DIR) and the Public Utilities Commission of Ohio (PUCO). OEPA must grant a "permit to install" for major actions with significant air emissions and/or water effluents. At this time, OEPA staff anticipate that such a permit

FIGURE 6. PRELIMINARY SCHEDULE OF PERMITS/APPROVALS* - FEDERAL AGENCIES

* This schedule is simply a first approximation of the time required to secure appropriate permits and approvals. It gives an indication of priorities and the range of time frames likely to be required to obtain necessary permits and approvals.

** Both the NPDES and air quality permits are being pursued by Toledo Edison independent of the proposed project. In addition, it appears quite likely that a permit to install will not be required because of the minor effect of the project on residual emissions at Acme Station. This cannot be confirmed until more details are submitted to OEPA/USEPA for review in Phase II. Consequently, the above schedule is an estimate of the time requirements should the permit to install be required.

FIGURE 7. PRELIMINARY SCHEDULE OF PERMITS/APPROVALS* - STATE AGENCIES

* This schedule is simply a first approximation of the time required to secure appropriate permits and approvals. It gives an indication of priorities and range of time frames likely to be required to obtain necessary permits and approvals.

** It now appears likely that a permit to install will not be required because of the minor effect of the proposed project on residual emissions at Acme Station. This, however, cannot be confirmed until more details are submitted to OEPA/USEPA for review in Phase II. Consequently, the above schedule is an estimate of the time requirements should the permit to install be required.

FIGURE 8. PRELIMINARY SCHEDULE OF PERMITS/APPROVALS* - LOCAL AGENCIES

* This schedule is simply a first approximation of the time required to secure appropriate permits and approvals. It gives an indication of priorities and range of time frames likely to be required to obtain necessary permits and approvals.

** It now appears likely that a permit to install will not be required because of the minor effect of the proposed project on residual emissions at Acme Station. This, however, cannot be confirmed until more details are submitted to OEPA/USEPA for review in Phase II. Consequently, the above schedule is an estimate of the time requirements should the permit to install be required.

will not be required for the proposed action because it involves a retrofit of existing facilities with minimal impact upon plant residuals. A final determination on this matter must be deferred to Phase II when more details on the project will be available.

The Department of Industrial Relations' responsibilities revolve around assuring the use of established material and design standards in district heating systems. Their jurisdiction includes the approval of applications to install pressure piping in buildings served by a district heating system. They also have statutory responsibility to inspect such pressure piping systems before operation is authorized. The Toledo Inspection Division has been delegated these duties by the State for the proposed study area. Consequently, the Department of Industrial Relations is likely to be only peripherally involved with the proposed project.

The Public Utilities Commission of Ohio has well-established regulatory authority over the proposed district heating system. This authority relates to the fixing of tariffs; to the establishment of appropriate accounting rules; to the approval of all public utility contracts; and to the granting of approval for the issuance of stocks, bonds or notes. A continuing dialogue with PUCO on these and related matters will be an important part of the Phase II institutional analysis.

Numerous local agencies will also play a role in the implementation of a district heating project in the Toledo metropolitan area. These agencies and a brief description of their role in project approval are as follows:

- Toledo Inspection Division - authorizes permits to install pressure piping in buildings using steam at 15 pounds or more per square inch or hot water at 30 pounds or more per square inch.

- Toledo Division of Engineering and Construction - must review and approve the detailed plans and specifications of the proposed project before Toledo City Council will authorize the installation of distribution lines in the public right-of-way.
- Toledo Division of Traffic Engineering - has the authority to stipulate conditions governing the extent and timing of street openings in order to facilitate public safety and traffic maintenance.
- Toledo Division of Streets, Bridges and Harbors - concerned with developing harbor operation policies and enforcing harbor regulations.
- Toledo Real Estate Department - responsible for preparing the necessary paperwork granting new or extending existing easements or franchises for Toledo City Council approval.
- Toledo Pollution Control Agency - the designated air quality agency for Lucas County which issues air quality permits for installation (and modification) and operation of boilers, etc.

The Phase I institutional analysis has identified no constraints that could be taken to be serious enough to jeopardize the viability of the proposed district heating system. While the number of approvals required will make implementation of such a system complex, continued dialogue with appropriate agencies in subsequent phases will help minimize unnecessary delays should the project proceed to completion.

APPENDIX A

PRIVATE FINANCING

To determine the overall cost of the project, the principal variables that have an impact on the cost of capital must be identified and evaluated. In the private sector, determining whether a particular financial plan will help to lower the capital costs will depend on the plan's ability to:

- (a) Utilize the benefits of investment tax credits
- (b) Utilize the tax benefits of accelerated depreciation
- (c) Exempt the bulk of operating income from corporate income taxes
- (d) Exempt the interest and dividends from individual income taxes
- (e) Obtain exemption from the sales, gross receipts, fuel, property and other taxes associated with the projects
- (f) Obtain exemption from recapture taxes, should ownership change at a later period
- (g) Use the credit of others as a backing for financial instruments
- (h) Utilize existing government programs as a source of venture capital
- (i) Obtain firm commitments for the purchase of steam
- (j) Utilize the benefits of financial leverage in the capitalization structure.

A good financial plan will compare the alternatives as they relate to the items listed above.

Conventional Debit and Equity Financing

Conventional capital sources consist of common stock, preferred stock and debt (bonds, notes, loans). These are listed in order of decreasing risk to the holder. The percentage return to each roughly corresponds to its riskiness. From a purely financial standpoint, therefore, the higher the proportion of a debt utilized, the lower the overall cost of capital. However, debt is a fixed obligation instrument which increases the firm's periodic expenses. Because revenues fluctuate according to various business cycles, a high debt/equity ratio increases the possibility that revenues may not be sufficient to cover expenses at a particular point in time. Thus, greater use of debt increases the overall risk of a business and will tend to raise the cost of capital. For every company, then, the optimal proportion of debt and equity financing will ultimately depend upon the inherent riskiness of the business. (The overall supply and demand for capital funds in the capital market and the rate of inflation also play a major role in determining the cost of capital. These macro factors are beyond the limits of this discussion.)

Toledo Edison currently utilizes approximately 35 percent common stock, 15 percent preferred stock and 50 percent debt. This capitalization structure is typical of most electric utilities. The proportion of fixed and semi-fixed obligation instruments is much larger than is found in most industrial companies. It is made possible by the relatively low-risk nature of the electric utility business. Obviously, this permits a comparatively low overall cost of capital to be obtained.

Income Bonds

An income bond can be used as an alternative means of increasing the proportion of debt in the capitalization structure and thereby reducing the cost of capital. The payment of the interest on income bonds is subordinated to the full satisfaction of claims by senior debt holders. To the extent that the existence of income bonds minimizes corporate income tax liability, the security of interest payments on the debentures and bonds would be increased. The same ranking of claims, as to the income bond holders and senior debt holders, would take place in the event of a liquidation of the company. An income bond thus is a junior security to mortgage bonds and debentures in all material respect. Failure to pay interest on income bonds would not lead to a default and insolvency of the company. Interest would be paid on income bonds only after all claims by senior debt holders had been fully satisfied and then only to the extent of realized income.

Corporate stock holders can be expected to favor income bonds to the extent that the capital structure is positively leveraged, and the addition of income bonds results in higher earnings per share of common stock.

The advantages of income bonds are:

- (1) Interest on income bonds paid out to investors is not subject to corporate income taxes.
- (2) The company is obligated by the terms of bond indenture to pay interest to investors only if sufficient income is generated.
- (3) The income bond issue is normally any outside debt indenture covenants restricting the amount of new debt.

- (4) The issuance of income bonds causes no dilution in the common stock.
- (5) The company's borrowing power is preserved for other uses.
- (6) Income bonds, if issued in place of a common or preferred stock, help to reduce the overall costs of capital.

Income bonds fall between mortgage bonds and preferred stock and may be substituted for either one. While interest payments on the bonds are a semi-fixed obligation, regular payments must be maintained or they may be treated as equity rather than debt for tax purposes. Because they are subordinate to mortgage bonds and dependent upon the issuer earning income, income bonds earn a higher interest rate than mortgage bonds. Therefore, they would not normally be used unless issuance of mortgage bonds is restricted.

Special Project Financing

This type of financing takes advantage of any segmentation the company might have in terms of projects, product lines or services, and limits risk exposure to each individual item. Financing may be carried out separately for each project, and the investors have a recourse on their claims only to the extent of that one project, instead of to the overall company's credit.

In the event of default, the company stands to lose only one project, with all other activities remaining intact. Because of this exposure limitation, the company may rely much more heavily on debt financing, and this will help to reduce the cost of capital.

Limiting potential loss to a single project is recognized by the investor as a factor diminishing the safety of his investment. As a result, a debt instrument backed only by the revenues and assets of a specific project normally commands a higher coupon rate than a similar instrument issued on behalf of an entire company. However, the higher cost of capital under these conditions can be offset by government guarantees. This is discussed in a later section.

Leasing

Financial Lease

The financial lease provides for use of the asset for its entire life. In a true lease, the lessor holds legal title to the facility throughout the term of the lease agreement. The lessor also claims the tax benefits of ownership.

Conditional Sales Contract

There is a second type of financial lease which is regarded as a conditional sales contract. In this type, the lessee obtains an option from the seller to purchase the leased property at a minimal price upon expiration of the lease. The lessee is then the one who claims depreciation and the investment tax credit, but can deduct, as his business expense, only the interest portion of his lease payment.

There are several unique advantages of leasing over conventional debt and equity. First, by separating the user of the leased facility from ownership and permitting another party to claim the tax advantages, the resulting saving can be reflected on lower lease payments. Second, the lessee is freed from an obligation to meet a fixed debt service

regardless of the project's revenue and can instead negotiate variable lease payments to correspond with the timing of the expected project's revenue. Finally, the lessee preserves his borrowing power for other uses.

Whether the operator owns or leases the system, funds to finance the project must be raised, debt must be retired, and the project must be operated profitably. Therefore, the benefits of leasing can be realized only if these tasks can be accomplished in a mutually advantageous manner. This may result under any of three conditions: (1) the lessor can raise capital more easily than the lessee; (2) the lessor can raise capital at a lower cost than the lessee (e.g. tax-free bonds); and (3) the lessor can take better advantages of the tax benefits of ownership (e.g. investment credit and depreciation). Finally, a successful lease requires careful, and perhaps costly, negotiations between the parties to ensure that the interest of each is upheld.

In another type of specialized lease called a leveraged lease, the lessor is the owner of the district heating distribution facilities and is entitled to all tax benefits relating to ownership. These tax benefits are depreciation and investment tax credits. The lessor is assumed to provide only a small percentage (20-40 percent) of the necessary capital. The remainder of the capital is borrowed from institutional investors on a non-recourse basis to the lessor. This loan is secured by:

- (a) The credit of energy users (through take-or-pay contracts)
- (b) A first lien on the heating system facilities.

As the lessor can claim all tax benefits incidental to ownership of the asset while only providing 20-40 percent of the capital requirements, the leveraged lease rate can be appreciably reduced. Another

advantage is that the leveraged lease provides a uniform capital charge component of energy price for the term of the lease.

Because this type of leasing is 100 percent supported from project revenues and more than a financial institution would normally lend to a project, the energy user group (the customer) will be required to sign take-or-pay contracts to make certain minimum payments for lease rental, maintenance, insurance and taxes for the term of the lease.

In addition, leverage leases are often complex from a legal and tax viewpoint. Obtaining various regulatory approvals and IRS tax rulings are necessary before the lease can be closed. Therefore, putting together a leveraged lease package may be very time-consuming and costly.

PUBLIC FINANCING AND SUPPORT OF PRIVATE ENTERPRISE

Governmental funding is another mechanism for financing the ownership of district heating system facilities. Three government financing mechanisms are reviewed. They are:

- (1) Municipal general obligation bonds
- (2) Municipal revenue bonds
- (3) Tax exempt industrial revenue bonds.

Municipal General Obligation Bonds

Financing through municipal general obligation bonds, a municipality guarantees repayment in the most fundamental way it can, by backing up its bond obligations with its tax base.

Municipal bonds are tax exempt, and therefore, attractive to investors. These types of bonds are also rated according to the financial condition of the municipality and not by the uncertainty of the specific projects being bonded.

One of the major disadvantages is that the City's revenues are subject to potential diversion if the project is a financial failure. Because general obligation bonds represent such a high potential risk to the community, there are usually tight restrictions governing their issuance. The size of a general obligation bond that can be issued without voter approval through a referendum is limited.

In Ohio, the net indebtedness incurred by a municipality without a vote of the electors may not exceed 5.5 percent of the total assessed value of all taxable property within the municipality. Furthermore, there is an indirect limit. The bond payments on general obligation bonds cannot exceed the revenues received from a ten mill property tax assessment. Moreover, the outstanding unvoted indebtedness of all overlapping political subdivisions must be included in computing whether the proposed bond issue will fall within the ten mill limit. General obligation bond issues generally are used to fund routine public improvements. If a referendum is required, it takes money to put on an informational campaign for passage, which consumes time and adds uncertainty.

Revenue Bonds

Revenue bonds are a method for financing in which the bond holders' guarantee of repayment rests on the project's ability to generate revenue. Bond holders cannot rely on the assets of the municipality to secure debt. Thus, the costs, prices and types of contracts for the sale of products or services from the project become a central concern to the potential investor. Contracts

negotiated by the municipality with both customers and suppliers are major sources of confidence to prospective investors. An establishment of firm, long-term contracts before the bond prospectus is issued is desirable under any financing plan, but it is the essential guarantee when revenue bond financing is used.

Customers with whom the municipality must have early and secure contracts are typically the large commercial and/or industrial establishments. Contracts with government buildings also are a helpful guarantee to investors in revenue bond-financed system. The contracts initially secured need not approach full utilization of the system's capacity. For example, a Nashville, Tennessee facility began in 1974 with only 50 percent of its capacity contracted. The primary reason for this situation was U.S. Environmental Protection Agency restriction on air pollution emissions.

Industrial Development Bonds

Industrial Development (Revenue) Bonds are issued by a state, county or municipality on behalf of a private firm. The firm is owner or lessee of the facility and is eligible for whatever investment tax credits and depreciation methods apply. Although the firm is not the bond issuer, it is the party responsible for debt service and repayment of principal.

The major attraction of industrial development bonds is that they are tax exempt. This includes exemption of interest payments from Federal income taxes and normally state income taxes, and perhaps exemption from the intangibles tax. As a result, industrial revenue bonds are a lower cost method of financing a facility than conventional private financing.

In Ohio, industrial development bonds are issued through a local Community Improvement Corporation or the Ohio Development Financing Commission. The authority for these organizations can be

found in Chapter 1724 and Chapter 122, Sections 27 to 62 of the Ohio Revised Code (ORC). A typical statement of their purpose is found in ORC Chapter 122, Section 41 ... "to promote the welfare of the people of the state, to stabilize the economy, to provide employment, to assist in the development within the state of industrial, commercial, distribution and research activities required for the people of the state, and for their gainful employment, or otherwise to create or preserve jobs and employment opportunities, or improve the economic welfare of the people of the state..."

The employment/economic development requirement stated above is rather broad, and so has it been historically interpreted and implemented. The requirement that the bonds be issued for development of "industrial, commercial, distribution and research activities" may prevent their use for public utilities. This same restriction is found in the Ohio Constitution, Article VIII, Section 13. This section also states that "no guarantees on loans and no lending of aid or credit shall be made ... for facilities to be constructed for the purpose of providing electric or gas utility service to the public." The use of bonds for steam heating facilities is not expressly prohibited, but its legality is certainly in doubt. Thorough legal research will have to be done before a definite determination can be made.*

If the district heating system is eligible for financing through industrial development bonds, various methods for utilizing them are available. The bonds can be issued at the state or the local level. The funded facility may be owned or leased by the Company. In addition, the Ohio Development Financing Commission has direct loan and loan guarantee programs. A \$10 million limit is placed upon the cost of the project to be financed, except for pollution control equipment which is exempt for this limit. Various other Federal and state restrictions may also apply depending upon the exact nature of a particular project.

* The conduct of such legal research is beyond the scope of Battelle's Task 5 activities.

APPENDIX B

OHIO ENVIRONMENTAL PROTECTION AGENCY
APPLICATION FOR PERMIT TO INSTALL

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For Office Use Only
Check Appropriate Box(es)

- ☐ Air Discharge
- ☐ Water Discharge to New
Source Treatment Works
- ☐ Solid Waste Disposal Facility

B-1

For Office Use Only

Application No. _____

Date Received _____

OHIO ENVIRONMENTAL PROTECTION AGENCY
Application for Permit to Install

Applicant's Name _____

Mailing Address _____

City _____ County _____ State _____ Telephone Number _____

Person to contact (Name and Title and Telephone Number) _____

Location of Proposed Facility (State the location as completely and precisely as possible)* _____

City or Township _____

County _____

DIRECTIONS: A Permit to Install is required under the provisions of OAC Rule 3745-31. Complete each item on this application form. An application cannot be considered unless all questions are answered and required supplemental information submitted. If any of the information requested does not apply to your situation, then state the reasons why it does not apply. This application must be signed as provided for in OAC Rule 3745-31-04(B) or it will not be accepted. Applicants for permits which involve air emissions or wastewater treatment facilities are advised they will be required to pay a fee upon approval of their applications as provided for in OAC Rule 3745-45-02.

1. Name of Source: _____
2. Product or Use of Source: _____
3. Will the proposed source involve any of the following: Check all that apply.
 - A. ☐ Air Discharge
 - B. ☐ Waste Water Treatment Works
 - C. ☐ Solid Waste Disposal Facility

*EXAMPLE: "The source will be constructed on a 20 Acre plot to be located on Franklin Township Road No. 17, approximately 1 1/4 miles north of the intersection of State Route 99 and Franklin Township Road No. 17."

4. Equipment Description (boiler, incinerator, etc.):

5. Your Identification for Source:

6. Manufacturer: _____

7. Make or Model No.: _____

8. Operating Schedule: Hours/Day _____ Days/Week _____ Days/Year _____

9. Percentage of Total Use by Season:

Winter _____ Spring _____ Summer _____ Fall _____

10. Type of Process:

Continuous _____ Batch _____

11. Does process involve the use of (check all applicable):

Lead _____ Asbestos _____ Beryllium _____ Mercury _____

The following information must be submitted on a separate piece of paper and attached to this application. Each and every item must be completed, labeled, and listed in the order stated.

12. Describe the product or service to be produced by the applicant along with a description of the proposed source.

13. List the name and quantity of all materials and chemicals; dry, wet, or gaseous that will be used or produced by the source.

14. State the anticipated quality of all types of environmental pollutants to be emitted by the source. (This includes all wastewater discharges, all air emissions and solid waste regardless of disposal method.)

15. State in detail the method for disposal of all environmental pollutants listed in response to Question 14. (This should include a complete description of any control equipment to be employed.)

16. (a) If wastewater is an anticipated waste and it is to be discharged to a surface water, state the anticipated concentration (mg/l) and loading (lbs/day) in the discharge and the effect this discharge will have on the surface water under critical conditions.

(b) If wastewater is an anticipated waste and it is to be discharged to the groundwater, state the anticipated concentration (mg/l) and loading (lbs/day) in the wastewater and the effect this wastewater will have on the groundwater.

17. If wastewater is to be discharged to a sewerage system, what will be the effect on the sewerage system and wastewater treatment system.

18. If air contaminant emissions are an anticipated waste, state the anticipated emissions in lbs/day and the effect of this discharge on environmental surroundings.

19. Describe any proposed monitoring devices to be installed by the applicant.
20. State the local zoning requirements.
21. Will the proposed source comply with all laws, rules and regulations of the Ohio EPA and U.S. EPA?
22. Will the proposed source employ the best available technology and not cause significant degradation of any air or water which at the time of installation meets or is better than applicable air or water standards?
23. Will the proposed source conform with area-wide waste management plans for wastewater treatment and solid waste?
24. If the proposed source is a wastewater treatment facility submit general plans for approval for the proposed source in conformity with the requirements of OAC Rule 3745-31-05.
25. With regard to the source described in Question No. 1 of this application, has a previous plan submission or OEPA application of any type been filed prior to the submission of the present Permit to Install application? If so, state the date and type of this application previously submitted.
26. If the proposed source is a Process, complete Appendix A.
 If the proposed source is a Fuel-fired Indirect Heat Exchanger (boiler), complete Appendix B.
 If the proposed source is an Incinerator, complete Appendix C.
 If the proposed source is a Spray Booth, complete Appendix D.
 If the proposed source is a Storage Tank, complete Appendix E.
 If the proposed source is a Solid Waste Disposal Facility, complete Appendix F.

Signature of Applicant

Title

Address

Signature of General Contractor or Agent
 Performing installation, if selected.
 (See OAC Rule 3745-31-04(B))

Company

Address

Premise No. / / /
Source No. / /
Application No. /

APPENDIX B;

(Boilers, Heaters, and Steam Generators)

1. Manufacturer _____ Model No. _____
2. Your identification _____ Year Installed _____
3. Input capacities (10⁶ BTU/hr.): Rated _____ Max. _____ Normal _____
Output capacities (lbs.-steam/hr.): Rated _____ Max. _____ Normal _____
Note: Indicate units if different than above.
4. Percent used for: Space heat _____% Process _____% Power _____%
5. Normal Operating schedule: _____ hrs./day, _____ days/wk., _____ wks./year
6. Type of fuels fired: ☐ Coal ☐ Oil ☐ Natural gas
☐ Wood ☐ LPG ☐ Other, specify _____
7. Type of draft: ☐ Natural ☐ Induced ☐ Forced
8. Combustion Monitoring: ☐ Fuel/air ratio ☐ O₂ ☐ Smoke
☐ Other, specify _____

9. Type of firing: ☐ Hand-fired ☐ Underfeed stoker ☐ Traveling grate
☐ Chain grate ☐ Spreader stoker ☐ Cyclones
☐ Pulverized-dry bottom
☐ Pulverized-wet bottom
☐ Other, specify _____

10. Fly ash reinjection: ☐ Yes ☐ No

11. Type of oil: ☐ No. 2 ☐ No. 6 ☐ Other, specify _____

12. Atomization: ☐ Oil pressure ☐ Steam pressure ☐ Compressed air
☐ Rotary cup ☐ Other, specify _____

13. Oil preheater: ☐ Yes, Temp. _____ °F. ☐ No

FUEL DATA

14. Complete the following tables for each type of fuel*:

Type of Fuel	Heat Content (BTU/Unit)	Percent		Quantity of Fuel Used		
		Ash	Sulfur	Per Year	Normal/hr.	Maximum/hr.
Coal	BTU/pound			tons	lbs.	lbs.
Oil	BTU/gallon			gals.	gal.	gal.
Gas	BTU/cu.ft.			cu.ft.	cu.ft.	cu.ft.
Wood	BTU/pound			tons	lbs.	lbs.
LPG	BTU/gallon			gal.	gal.	gal.
Other						

Type of Fuel	Percent Annual Use			
	Winter	Spring	Summer	Fall
Coal				
Oil				
Gas				
Wood				
LPG				
Other				

* Obtain fuel analysis from vendor(s) and report on an as-received basis. Use weighted annual averages.

CONTROL EQUIPMENT

Control Equipment Code:

- (A) Settling Chamber
 (B) Cyclone
 (C) Multiple cyclone
 (D) Electrostatic precipitator

- (D) Spray Chamber
 (F) Cyclonic Scrubber
 (G) Packed tower
 (H) Venturi
 (I) Other

15. Control Equipment data:

Item	Primary Collector	Secondary Collector
(a) Type (See above code)		
(b) Manufacturer		
(c) Model No.		
(d) Year installed		
(e) Your identification		
(f) Pollutant Controlled		
(g) Controlled Pollutant emission rate (if known)		
(h) Pressure drop		
(i) Design efficiency		
(j) Operating efficiency		

STACK DATA

16. Your stack identification _____
17. Are other sources vented to this stack? ☐ Yes ☐ No
If yes, identify sources _____
18. Type: Round, top inside diameter dimension _____
Rectangular, top inside dimensions (L) _____ x (W) _____
19. Height: Above roof _____ ft., above ground _____ ft.
20. Exit gas: Temp. _____ °F, Volume _____ ACFM, Velocity _____ ft./min.
21. Continuous monitoring equipment ☐ Yes ☐ No
If yes, indicate Type _____, Manufacturer _____
Make or Model _____, Pollutant(s) monitored _____
22. Emission data: Emissions from this source have been determined and such data is included with this appendix: ☐ Yes ☐ No
If yes, check method: ☐ Stack Test ☐ Emission factor

Completed by _____, Date _____

INSTRUCTIONS FOR APPENDIX B -
FUEL BURNING EQUIPMENT

Appendix B is a technical information form for fuel burning equipment.

Regulation EP-11-01 (A) defines "fuel-burning equipment" as "... any furnace, boiler, apparatus, and all appurtenances thereto, used in the process of burning fuel for the primary purpose of producing heat or power by indirect heat transfer."

General Instructions: Answer or complete all items. If the item does not apply to the fuel burning equipment write in "not applicable" or "NA". If the answer is not known write in "not known" or "NK". The appendix form may be returned if all items are not completed or answered.

Specific Instructions:

Item Items (1) thru (8) refer to general information about the fuel burning equipment.

- (1) Complete the manufacturer and model number of the fuel burning equipment.
- (2) Complete the company's identification number for the equipment (e.g. boiler #1) and the year it was or will be installed.
- (3) Specify the input capacity in one million BTU's per hour (10^6 BTU/hr) and/or the output capacity in pounds of steam per hour (lbs. - steam/hr). "Rated" refers to the continuous rating of the heat exchanger. "Maximum" refers to the maximum peak rating of the heat exchanger. "Normal" refers to the normal operating capacity of the heat exchanger. If the heat exchanger has separate ratings for each fuel used, specify the input and/or output capacities for each fuel used on a separate attachment.
- (4) Complete the percent of use for space heat, process and power. Total is 100%.
- (5) Complete the fuel burning equipment's normal operating schedule in hours per day, days per week, and weeks per year.
- (6) Check the type of fuels fired.
- (7) Check the type of draft.
- (8) Check the method of combustion monitoring.

Coal Fired Units: Items (9) and (10) refer only to coal fired units.

- (9) Check the method of coal firing.
- (10) Indicate whether or not there is fly ash reinjection from a fly ash collector.

Oil Fired Units: Items (11) thru (13) refer only to oil fired units.

- (11) Check the type of fuel oil used.
- (12) Check the type of fuel atomization employed.
- (13) Indicate if an oil preheater is used and if so specify the temperature of the heated oil.

Item Fuel Data: Item (14) refers to fuel data for this source. A fuel analysis can be obtained from the supplier.

- (14) Specify the heat content, ash content, sulfur content, and the quantity used per year and per hour (normal amount and maximum amount) for each fuel used. Use units provided on the form. Also complete the percent annual use by season for each fuel used. The months within each season are: Winter (December - February), Spring (March - May), Summer (June - August), and Fall (September - November).

Control Equipment: Items (15) (a) thru (j) refer to the control equipment information.

- (15) Complete items (a) thru (j) for any air pollution control device or equipment related to the fuel burning equipment of this appendix. The primary collector and secondary collector refer to separate control devices or equipment for collecting similar or different air pollutants. If there is a third collector complete the same data for that collector on a separate sheet. Additional information (e.g. drawings, design data, etc.) may be attached to this appendix.
- (a) Insert the control equipment code letter.
 - (b) Name the manufacturer of the control equipment.
 - (c) Name the manufacturer's model number (if any).
 - (d) Fill in the year the control was or will be installed.
 - (e) Fill in the company's identifying name or number for the control device or equipment.
 - (f) Specify only the pollutant (air contaminant) controlled.
 - (g) Specify the controlled pollutant emission rate if known or measured, in pounds per hour (lbs/hr) or grains per standard cubic foot dry (g/scfd) or other appropriate units. Specify units.
 - (h) Specify the pressure drop, in inches H₂O, across the collector.
 - (i) Specify the design collection or removal efficiency of the collector for the controlled pollutant.
 - (j) Specify the operating collection or removal efficiency of the collector for the controlled pollutant. The operating efficiency is normally determined from a stack test.

Stack Data: Items (16) thru (22) refer to information for the stack or exhaust of this fuel burning equipment.

- (16) Indicate the company's identification for the stack or exhaust.
- (17) If other sources are also vented to this same stack or exhaust indicate so and identify those sources.
- (18) Specify the inside dimensions of the stack or exhaust at the outlet to the atmosphere.
- (19) Specify the stack's or exhaust's height, in feet (ft.), above ground and above the attached roof.
- (20) For the stack's or exhaust's exit gas complete the temperature in degrees Fahrenheit (°F), the volume flow rate in actual cubic feet per minute (ACFM), and the velocity in feet per minute (ft/min). If the properties of the exit gas vary use the average values.
- (21) Indicate if the stack or exhaust is equipped with air pollution monitoring equipment and if so specify the type, manufacturer, make or model, and the pollutant or pollutants monitored.

Item

- (22) If air pollution emissions from this fuel burning equipment have been determined and the data is included with (attached to) this appendix indicate so and check the method of determination (i.e. stack test or emission factor). The stack test may be from either this reported fuel burning equipment or a similar one located elsewhere. The emission factor calculation and determination should include a reference to the process emission factor and data relative to the collection or removal efficiency of any air pollution control equipment.

Completed by and Date: Write in the name of the person completing this form and the date.

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APPENDIX C

CONTACTS

This appendix provides the names, addresses and telephone numbers of officials of key governmental agencies and other organizations who were interviewed during this study, and who will likely participate in subsequent phases of the proposed district heating and cooling project.

Federal Agencies

U.S. Environmental Protection Agency
Region V Office
230 South Dearborn Street
Chicago, IL 60604

Linda Szempruck
Air Quality Branch
(312) 353-2090
Robert Robishaud
Water Permits Branch
(312) 353-3105

U.S. Army Corps of Engineers
Buffalo District
1776 Niagara Street
Buffalo, NY 14207

Walter Fray
Regulatory and Permits
Branch
(616) 876-5454, ext. 2313

U.S. Coast Guard
9th U.S. Coast Guard District Office
1240 East 9th Street
Cleveland, OH 44149

Jay P. Olms
EIS Coordinator
(216) 522-3919

U.S. Coast Guard
Toledo Port Office
Federal Building, Room 504
234 Summit Street
Toledo, OH 43604

Captain Jerry P. Foley
Captain of the Toledo Port
(419) 259-7558

State Agencies

Ohio Environmental Protection Agency
361 East Broad Street
Columbus, OH 43215

Robert Hodanbosi
Chief, Environmental
Assessment
(614) 466-6116

Robert E. Phelps
Chief, Division of
Industrial Wastewater
(614) 466-2390

Northwest Office
1035 Devlac Grove Drive
Bowling Green, OH 43402

Charles Hull
Chief, NW District
Air Section
(419) 352-8461

Ohio Department of Energy
30 East Broad Street, 34th Floor
Columbus, OH 43215

Robert S. Ryan
Director
(614) 466-8277

Ohio Power Siting Commission
361 East Broad Street
Columbus, OH 43215

Harold W. Kohn
Staff Scientist
(614) 466-8866

Public Utilities Commission
of Ohio
180 East Broad Street
Columbus, OH 43215

John D. Borrows
Director
Department of Utilities
(614) 466-3292

Ohio Industrial Relations Dept.
2323 West Fifth Avenue
Columbus, OH 43204

Robert Cullins
Division of Pressure Piping
(614) 466-2675

Richard Jagger
Division of Boiler Inspection
(614) 466-2743

Regional and Local Agencies

Toledo Metropolitan Area Council
of Governments (TMACOG)
420 Madison Avenue, Room 725
Toledo, OH 43652

June Brown
Director of Energy Programs
(419) 241-9155

Toledo Planning Commission
415 North St. Clair Street
Toledo, OH 43604

Barry Hersch
(419) 247-6281

Toledo-Lucas County Port Authority
241 Superior Street
Toledo, OH 43604

Gary Failor
Director of Administration
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DISTRICT HEATING AND COOLING SYSTEMS FOR COMMUNITIES
THROUGH POWER PLANT RETROFIT AND DISTRIBUTION NETWORK

Task 6
Economic Analysis

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3.6 TASK 6 - PRELIMINARY ECONOMIC ANALYSIS

ABSTRACT

Battelle Columbus Laboratories (BCL) is a member of the Demonstration Team employed as a subcontractor by Toledo Edison to complete the preliminary economic analysis. Toledo Edison and Battelle worked closely on this task to prepare an economic analysis. This evaluation incorporates accurate input parameters applicable to utility ownership of the proposed district heating system.

The following summary explains the methodology used in the economic analysis, lists the assumptions and briefly reviews the results. The detailed results of Task 6 may be found in the text of the Battelle report.

3.6 Task Deliverables

Explain all assumptions, document all sources used to develop costs, and supply underlying methodology and calculations required.

Supply a complete explanation of all assumptions and document sources of information in developing evaluation required in this subtask.

3.6 Task Summary

Methodology

Life cycle savings was chosen as the evaluation parameter to determine the economic viability of the proposed district heating system. Each of

four possible retrofits was analyzed using this method. A base case was developed to determine the net present value of the savings possible over the 25-year life of the investment. Cost of service pricing was used to reflect the regulatory environment in which the system is assumed to operate.

The system owner will recover operating expenses and a fair return on his investment. The economic benefits of operating the proposed district heating system accrue to the customers in the form of decreased energy costs--the price of steam being lower than the price of the customer's present energy source. An after-tax discounted cash flow approach is used to evaluate these benefits.

Assumptions

The parameter values and assumptions which remain constant throughout both the base case analysis and subsequent sensitivity analyses are as follows:

- . All costs except fuel cost escalate at the assumed inflation rate of 7%.
- . Present district heating customers remain as steam customers under each of the retrofit alternatives.
- . Present and potential new customers of the district heating system will use energy in accordance with historical use patterns and consumption levels.
- . Potential new customers are included in the district heating system even if their economic benefits are negative. The sensitivity analysis shows that the impact of this assumption is minimal.
- . Capacity and energy costs associated with the electric losses due to the retrofit of Acme generating plant were not considered in the preliminary analysis.

- Changes in O&M expenses at potential new customers were omitted.
- Expenses that may be required to improve the reliability of the proposed retrofit scheme were omitted. The additional investment will change the total capital investment by only a few percentage points.
- Expenses to acquire permits and approvals were not explicitly included.

Base Case Parameters

The base case employed the following values as inputs for the primary parameters of the economic analysis:

- Utility cost of capital = 12%
50% debt at 10.4%
15% preferred stock at 10.4%
35% common stock at 15%
- Annual fuel escalation rates in real terms:

	<u>Base Case*</u>	<u>Range</u>
Natural gas and oil	6.5%	3-10%
Coal	3.5%	0-7%
Electricity	5.5%	4-7%

- * These are midpoints in the ranges specified in the DOE contract for this project.

- 1985 system start date
- User cost of capital or discount rate = 15%

The base case evaluates the net present value for fuel escalation rates at the midpoints of the ranges indicated in the DOE contract for this project. The differential escalation rate for scarce fuels is 6.5%, for coal is 3.5% and for electricity is 5.5%. These escalation rates are substantial since inflation is considered to be 7%. Under these conditions the four retrofits generated life cycle savings of \$21.7 million for Retrofit 1, \$24.9 million for Retrofit 2, \$23.4 million for Retrofit 3 and \$26.4 million for Retrofit 4. These dollar amounts are in 1979 dollars and represent the present value of savings accumulated during the 25-year life from 1985 to 2009.

The life cycle cost for the user retrofit to use district heating steam amounts to less than \$0.10 per million BTU consumed during the 25-year life. Therefore, the fuel escalation used is the critical factor which determines the magnitude of the life cycle savings. Figure 1 shows the price trajectories for the end user fuels and district heating steam for Retrofit 1. On the average, the analysis shows that the price of the present fuel source exceeds the projected district heating steam price in the year 2000 for coal, by 1990 for natural gas and oil, and by 1985 for electric and existing steam.

Other results from the base case analysis include the following:

- . There is no economy of scale for the four retrofits considered. Even though the largest retrofit is three times the size of the smallest retrofit, the additional capital cost cancels any savings associated with increased system size.
- . The existing district heating customers accrue the greatest proportion of the total system savings. On a per million BTU basis the present electric customers realize the largest savings per million BTU consumed. The coal customer realizes a negative savings on a per million BTU basis.
- . The proportion of the revenue requirement attributable to capital costs drops from over 50% in the first years of the project to less than 10% in the final years of the project. Figure 14 shows how fuel price escalation dominates the cost over time as depreciation reduces the capital requirements.
- . The impact of the proposed district heating system on present energy suppliers is expected to be minimal. Since the fuels displaced are defined to be scarce, other markets will absorb the supplies no longer required for space heating.

Sensitivity Analyses

The most significant result of the various sensitivity analyses is that for the parameter ranges studied, none had sufficient impact to alter the basic conclusion that the proposed district heating system is an economically viable project. Other results are summarized as follows:

- . The scarce fuel price escalation rate has a large impact on the magnitude of life cycle savings of the proposed district heating system. Life cycle savings for Retrofits 1 & 2 at 3% scarce fuel differential escalation rate are one half what they are at 6.5% and only one fourth of what they are at 10%. For Retrofits 3 & 4 the change from 3 - 6.5% increases the life cycle savings by 4 to 5 times. Similarly, a change from 3-10% increases the life cycle savings by 11-13 fold. Figures 18 & 21 clearly show this sensitivity to scarce fuel prices.
- . Life cycle savings are positive for Retrofits 1 & 2 assuming a zero differential escalation rate for all fuels.
- . Financing the entire project with 100% debt financing at the lowest possible rate results in a 10% and 12% increase in life cycle savings for Retrofits 1 & 2 respectively. For Retrofits 3 & 4 the life cycle savings increase 29% and 27% respectively.
- . Delaying the system start up date does not alter the economic viability substantially for Retrofits 1 & 2. The five year delay would increase the life cycle savings for Retrofits 3 & 4 by 20%.
- . An increase or decrease of 25% in the total capital cost of the system results in a variation of 15% and 18% in life cycle savings for Retrofits 1 & 2. For Retrofits 3 & 4 the same change in capital cost results in a 45% variation in life cycle savings.
- . Variation in the consumption by 10% results in changes in the life cycle savings of 14% for Retrofits 1 & 2 and 20% for Retrofits 3 & 4.
- . The user discount rate represents the rate at which customer savings occurring over time are equated or collapsed into a single net present value. Decreasing the user discount rate from 15% to 10% results in nearly a three fold increase in life cycle savings. Increasing the user discount rate to 20% cuts the life cycle savings by 54% for Retrofit 1 & 2 and 63% for Retrofits 3 & 4. Savings still occur even when the user discount rate is as high as 25%.

Figure 1: PROJECTED ENERGY PRICE IN CURRENT DOLLARS*
 RETROFIT ALTERNATIVE #1 (A_3f_1)
 BASE CASE

Figure 14: Breakdown of Projected District Heating Costs
Retrofit Alternative #1 (A3f1)
Current Year Dollars

Figure 18. Life Cycle Savings for All Customers (existing and new)

Retrofit Alternative #1 (A_3f_1)

Figure 21:: Life Cycle Savings for all Customers (existing and new)

Retrofit Alternative #4 (A_3g_2)

Energy Costs and Capacity Penalties Associated with Cogeneration

To provide steam for district heating, the electrical production is reduced for the generator connected to the turbine operating in the cogeneration scheme. This capacity reduction implies that if the kilowatthours normally generated during this time period were indeed required to serve the electrical energy requirements, then the kilowatthours must have been generated by another machine. Since the cogeneration machine is a base loaded or intermediate loaded machine, the displaced kilowatthours were probably made up by a less efficient and therefore, a more expensive power production unit. This additional cost would be treated as a penalty cost against the district heating system. This cost has not been incorporated into the economic analysis because the magnitude of this expense is unknown.

During light electric load periods the generator attached to the cogeneration turbine may run solely because of the steam requirements for district heating. The kilowatthours being produced may be more costly than necessary. A case could result which would mean that base load capacity would be displaced by the cogenerated capacity. This additional cost is once again a penalty to the district heating system. The magnitude of this cost is also unknown.

Penalty costs during peak load and light load periods can be calculated once the hour by hour use patterns of steam and electricity are forecast for the time period when both systems will operate. Comparisons could then be made to determine the match between electrical demand and steam demand. The kilowatthours foregone during peak load periods would then be known and a penalty cost could be estimated. Likewise, during light

load periods the kilowatthours displaced from base loaded machines would be known and the penalty cost could be estimated.

While this methodology sounds precise, it would be very speculative. Estimating the hour by hour use patterns for a 25-year life cycle study and determining the economic dispatch during this period would at best be speculative. The assumption also includes that the load forecast is accurate during this time period. Finally, the base load capacity in nuclear and fossil units would have to be accurate so the cost differentials could be calculated.

Because of the uncertainty associated with the analysis we may be advised to look at our existing economic analysis for the sensitivity to total system cost. We found that a 25% variance in total system cost still resulted in a positive net present value. Therefore, if we include some penalty costs as part of this variance, we still have an economically viable district heating system.

If the operation of a district heating system reduced the utility's generating capacity at the time of system peak, then this capacity has to be replaced eventually. Power pool purchase power agreements are also based on the capacity available at the time of system peak. Projecting a summer peak relieves Toledo Edison to a large extent since the full electrical capacity would not be diminished as a result of the proposed retrofit. The minimal steam requirements in the summer could be served by heat only boilers or by boiler capacity at certain customer locations.

The installation of heat only boiler capacity is the most reasonable approach to this problem because purchase power commitments are very expensive. Once again we can look at this expense as part of the variance used in the sensitivity analysis. Detailed study of the retrofit options during Phase 2 will investigate heat-only boiler capacity as a means to improve reliability and assist in solving the capacity problem.

Finally, we must remember that the success of the district heating project depends upon the cost of scarce fuels in future years. The electrical capacity penalties are a much smaller portion of the overall economics. While we intend to determine the relative magnitude of the electrical penalties in Phase 2, further study regarding the future prices of oil and gas is even more important.

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I. METHODOLOGY AND ASSUMPTIONS

This report presents a preliminary analysis of the overall economic viability of the proposed district heating system for the Toledo area. At present there are four retrofit alternatives under consideration. The estimated capital costs of Retrofits #1 - #4 in millions of 1979 \$'s are \$11.1, \$14.0, \$32.5, and \$34.4 respectively. The projected annual steam consumptions for Retrofits #1 - #4 in billions of Btu's are 491, 581, 1369, and 1496 respectively. The methodology and assumptions employed in the economic analysis of the retrofits are discussed below.

Since the operation of a district heating system will be regulated by some form of public agency, the price at which system customers will be able to purchase steam is calculated by applying the standard regulatory economics framework-i.e., cost of service pricing. The system owner will recover operating expenses and a fair return on its investment. The economic benefits of the proposed project accrue to the customers of the district heating system in the form of decreased energy costs - the price of steam being lower than the price of the customer's present energy source. An after-tax discounted cash flow approach is used to evaluate these benefits.

The economic analysis can be divided into two parts. The first is designated as the Base Case Analysis. In this evaluation of each of the four possible retrofits, the parameters and assumptions used in the analysis are assumed to take on reasonable values derived from other Tasks in the Phase I study.

At this early stage of the proposed project, significant uncertainties are to be expected in many of the parameters chosen for the base case. To fully assess the potential impact or risk of these uncertainties on the economic viability of the proposed district heating system, sensitivity analysis have been prepared for seven different parameters:

- Fuel prices
- Financing assumptions
- System start-up date
- Cost of service
- Changes in consumption
- User discount rates
- Retrofit alternatives.

The analysis of these parameters constitutes the second part of the report - Sensitivity Analyses on the Base Case.

Parameter values and assumptions which remain constant throughout both the base case analysis and sensitivity analysis include:

- All costs except for fuels are escalated at the assumed rate of inflation - 7%.
- Present customers of the existing steam distribution system will remain as steam customers under each of the retrofit alternatives.
- Present and potential new customers of the steam system will continue in the same patterns and magnitudes of energy consumption.
- The project lifetime is set at 25 years for both the revenue requirement calculation and the economic analysis.
- All of the energy savings associated with the cogeneration concept and with the improved thermal efficiencies of the Acme system are credited to the generation of steam. These savings are determined by subtracting the estimated fuel input for the cogeneration system from the total heat input required to generate the steam and electric power under separate systems. Refer to Section 7.2 of the Task 4 report for additional explanation.
- Potential new customers are included on the district heating system even if their benefits are negative. The sensitivity analysis shows that the impact of this assumption is minimal.
- All customers join the system in its first year of operation.
- The federal income tax rate for corporations is set at 48%. Recent legislation has changed the rate to 46%. The impact of the lower rate will be to increase life cycle savings by roughly 3%.

- No property taxes are included in the new system. This assumption is based on conclusions drawn in Task 5 concerning the new state law exempting all property taxes on those investments in the area of scarce fuel conservation.
- The analysis does not give cost considerations to:
 - capability penalties associated with electric losses due to the retrofit of the Acme generating plant - (Losses of electrical generation based on the maximum hourly steam output are given in Table 2-B of Appendix B. It should be pointed out in regard to Table 2-B that the steam and electric peaks are not coincident.)
 - expenses that may be required to upgrade the reliability of the retrofit system (expected to be less than 1% of the total capital cost)
 - expenses in acquiring permits, approvals, etc., as noted in Task 5.

A description of the economic model developed to evaluate the overall economic viability of the proposed district heating system is provided in Appendix A. The detailed assumptions that are not listed in this section are included in the appendix along with their documentation. Cost estimate details are provided by Stone and Webster in Appendix B.

II. BASE CASE ANALYSIS

Introduction

The purpose of a base case analysis is to establish initial estimates of benchmarks of the overall viability of the project. The parameters and assumptions used in the analysis are assumed to take on reasonable values derived from other Tasks in the Phase I study. The chapter on sensitivity analysis will assess the potential impact of any uncertainties that might be associated with these parameters or assumptions. This chapter is organized into five sections:

- Base Case Life Cycle Savings
- Projected Energy Prices
- Sources of Life Cycle Savings
- Cost Components and Income and Balance Sheet Data
- Impacts on Energy Suppliers.

Base Case Life Cycle Savings

The base case parameters or assumptions for which sensitivity analyses have been prepared are:

- Annual fuel escalation rates (D.E.R.'s) in real terms:

Scarce Fuel	6.5%
Coal	3.5%
Electricity	5.5%
- Utility ownership and financing
- Utility cost of capital = 12%:
 - 50% debt at 10.4%
 - 15% preferred stock at 10.4%
 - 35% common stock at 15%
- 1985 system start
- User cost of capital or discount rate = 15%
- Potential new customers consumption included in the analysis
- No changes in consumption over time included in the analysis.

Life cycle savings for existing and new customers are presented for the base case in Table 1. The savings that accumulate over the lifetime of the system (1985-2009) are expressed in terms of net present values. This means that the after-tax savings, which occur each year as a result of lower energy costs, are discounted back to the present time (1979) by the appropriate user discount rate.

TABLE 1. BASE CASE LIFE CYCLE SAVINGS OF
NEW AND EXISTING CUSTOMERS
(Millions of 1979 \$'s)

	Retrofit 1	Retrofit 2	Retrofit 3	Retrofit 4
Base Case	21.7	24.9	23.4	26.4

Table 1 indicates that for the assumptions used in the base case each of retrofit alternatives are an economically viable option. The life cycle savings for a Retrofit 1 system serving only existing customers is \$16.1 million (1979 \$'s). The savings would be even greater if the capital investment for Retrofit #1 were scaled down to reflect the smaller system that would be required.

A second measure of the economic viability of the project is to determine the period of time required for the net present value of the early losses to be balanced by the net present value of later savings—i.e., a break-even period. For Retrofits #1 and #2 and for the Retrofit #1 system serving only existing customers, the break-even point is achieved in the first year. For Retrofits #3 and #4, the break-even point is achieved in the eighth year.

A third measure of the economic viability of the project is the cost-benefit ratio which is the life cycle savings divided by the required capital investment. The ratio for each of the four retrofits is 1.90, 1.78, .72, and .77 respectively. The larger the ratio, the higher the return on investment.

The primary cost relationship that is producing the large life cycle savings for each of the retrofits is the comparison between the projected steam price under the new Acme Retrofit Systems and the projected steam price under the existing Water Street System. In 1985, the first year of system operation, the price under the existing system is projected to be roughly \$1.00 (1985\$) more than the price under the new system. In addition, the price under the existing system is expected to escalate at a

rate of roughly 6% more than the rate for the new system.

The economics of the entire project can be looked at in terms of this Acme vs. Water Street comparison. That is, assume in a hypothetical situation that a Retrofit #1 system serving only existing customers could be put into operation as of January, 1979. Using 1979 fuel prices, the savings in fuel costs alone nearly compensate for the capital costs associated with the retrofit. Additional benefits, such as the lower O&M costs at Acme, the net escalation rate in scarce fuel prices over coal prices, and the revenues from potential new customers, make the hypothetical investment appear even more favorable.

Present steam consumption amounts to 433,000 million Btu's per year.* The existing Water Street System can deliver 1 Btu of steam for every 1.76 Btu's of #6 fuel oil burned at the plant. On the other hand, the proposed Acme System can deliver 1 Btu of steam for every .994 Btu's of utility coal chargeable to steam production. With 1979 fuel prices at \$2.47 per million Btu's for #6 oil and \$1.50 per million Btu's for utility coal, the resulting annual fuel costs for Acme and Water Street are \$645,603 and \$1,882,338 respectively. The difference represents an annual fuel savings of \$1,236,734 or 66% of the original fuel cost at Water Street. This annual savings can then be compared to the capital cost of Retrofit #1, which is \$11,100,000. Assuming a cost of capital equal to 12% and an investment life of twenty-five years, the net present value of the fuel savings totals \$9,699,704 which is close to the capital cost of \$11,100,000. Another way of measuring the trade-off between capital costs and annual fuel savings is to calculate a payback period defined as the cost of the investment divided by the savings per period. The payback period of this hypothetical investment is less than nine years.

It is now easier to understand how the large life cycle savings for each retrofit alternative are possible. The majority of the fuel savings under the Acme System result from the benefits of cogeneration and the switch from a petroleum-based plant to a coal-based plant. Smaller savings result from the advantages of the better system efficiencies associated with Acme.

* All numbers documented in Appendix A.

Toledo Edison records indicate that the 1977 O&M costs at Water Street were \$679,810. Inflating the figures by an annual inflation rate of 7% to 1979 results in a projected cost of \$778,314. Stone & Webster estimate the O&M costs chargeable to steam production at Acme to be \$364,489. If the projected annual O&M savings of \$413,825 are included with the previous energy savings, the hypothetical investment has a positive net present value of nearly two million dollars and the payback period decreases to less than seven years.

Projected Energy Prices

The annual fuel escalation rates (D.E.R.'s) that have been employed in the base case analysis are in real terms: 6.5% for scarce fuels, 3.5% for coal, and 5.5% for electricity. Compounded with an inflation rate of 7% means that the nominal price of scarce fuels will be doubling every 6 years; the nominal price of coal, every 10 years; the nominal price of electricity, every 6 years. These energy price trajectories, along with the projected steam prices for each of the retrofits and for the existing steam system, are depicted in Figures 1-5. Figure 2 is a close-up of Figure 1 and shows the price trajectories for only the 1985-1995 period. Table 2 is a supporting table containing the raw data on which Figures 1-5 are based.

Typical user retrofit costs amount to less than \$.10 per million Btu's consumed during the lifetime of the system. Therefore, the critical factor in determining whether an individual customer saves by switching to the new system is the difference between the price of steam and the price of the customer's present fuel source. Results indicate customers should switch to the proposed district heating system if the price of steam in 1985 is slightly higher than the 1985 price of their present fuel. This is because the price of their present fuel will rise faster than the price of steam. On average the analysis shows that the price of the present fuel source exceeds the projected steam price in the year 2000 for coal customers, by 1988 for natural gas and oil customers, and by 1985 for electric and existing steam customers.

Table 2 illustrates one of the more surprising conclusions of the preliminary economic analysis task: the steam price for the proposed district heating system does not vary significantly between the four retrofit alternatives. This indicates that there are no significant system economies of scale associated with the larger Retrofits #3 and #4. The main reason for this result is that additional costs of transmission lines out to the potential new customers negate the economies of scale that are attained within the plant itself. From a cost standpoint, the ratio of customer steam consumption to transmission capital costs should probably be increased before the larger retrofits can become cost effective.

The projected price of steam from the new system more or less tracks the price of coal. The steam price increases at a slower rate than coal because of the capital cost component in the steam price which is decreasing over time.

It should be pointed out that although the projected energy prices attain extremely high levels in the last half of the study period, they do not have an abnormally large impact on the analysis. This is because any savings accrued in the latter years are discounted back to the present by the user interest rate of 15%. The life cycle savings for each of the retrofit alternatives accumulate over the project lifetime at a fairly uniform rate.

Figure 1 : PROJECTED ENERGY PRICE IN CURRENT DOLLARS*
 RETROFIT ALTERNATIVE #1 (A_{3f1})
 BASE CASE

Figure 2: PROJECTED ENERGY PRICE IN CURRENT DOLLARS*

RETROFIT ALTERNATIVE # 1 (A_{3f1})BASE CASE
(1985-1995)

PROPOSED DISTRICT HEATING SYSTEM

--- (Existing and New Customers)

Figure 3: PROJECTED ENERGY PRICE IN CURRENT DOLLARS*
 RETROFIT ALTERNATIVE #2 (A_{3f2})
 BASE CASE

Figure 4: PROJECTED ENERGY PRICE IN CURRENT DOLLARS*
 RETROFIT ALTERNATIVE #3 (A₃₉₁)
 BASE CASE

Figure 5: PROJECTED ENERGY PRICE IN CURRENT DOLLARS*
 RETROFIT ALTERNATIVE #4 (A₃₉₂)
 BASE CASE

Table 2. BASE CASE ENERGY PRICE FORECASTS
CURRENT YEAR DOLLARS*
(\$/10⁶ Btu)

Year	New System Steam Price				Retrofit 1 (Existing Customers Only)	Current Energy Source Prices				
	Retrofit 1	Retrofit 2	Retrofit 3	Retrofit 4		Gas	Oil	Coal	Electric	Existing System
1985	11.69	12.20	12.38	12.19	12.88	9.26	8.417	4.61	32.23	13.12
1986	11.82	12.32	12.52	12.35	12.99	10.56	9.59	5.10	36.39	14.71
1987	11.99	12.47	12.71	12.55	13.13	12.04	10.93	5.65	41.07	16.52
1988	12.20	12.66	12.95	12.80	13.32	13.71	12.45	6.26	46.37	18.55
1989	12.45	12.90	13.23	13.10	13.55	15.64	14.19	6.93	52.35	20.86
1990	12.76	13.19	13.57	13.46	13.84	17.80	16.17	7.67	59.09	23.46
1991	13.13	13.54	13.97	13.88	14.19	20.29	18.43	8.50	66.70	26.41
1992	13.56	13.95	14.44	14.37	14.60	23.12	21.00	9.42	75.30	29.74
1993	14.06	14.44	14.99	14.94	15.08	26.35	23.93	10.43	85.00	33.52
1994	14.63	14.99	15.61	15.58	15.64	30.04	27.27	11.54	95.95	37.79
1995	15.30	15.64	16.33	16.33	16.28	34.23	31.08	12.78	108.30	42.63
1996	16.05	16.37	17.15	17.18	17.02	39.01	35.42	14.17	122.25	48.13
1997	16.90	17.21	18.08	18.13	17.87	44.45	40.36	15.70	138.00	54.35
1998	17.87	18.16	19.13	19.22	18.83	50.65	46.00	17.37	155.77	61.41
1999	18.97	19.24	20.33	20.44	19.92	57.72	52.41	19.24	175.83	69.42
2000	20.20	20.46	21.66	21.81	21.14	65.78	59.72	21.70	198.47	78.50
2001	21.59	21.83	23.16	23.35	22.52	74.96	68.06	23.60	224.04	88.81
2002	23.14	23.37	24.85	25.07	24.08	85.42	77.56	26.14	252.89	100.51
2003	24.89	25.09	26.74	27.00	25.82	97.34	88.38	28.94	285.46	113.80
2004	26.83	27.02	28.84	29.15	27.76	110.92	100.71	32.07	322.22	128.89
2005	29.01	29.17	31.20	31.55	29.94	126.40	114.77	35.50	363.72	146.03
2006	31.43	31.58	33.82	34.22	32.38	144.04	130.79	39.31	410.57	165.50
2007	34.13	34.26	36.74	37.20	35.09	164.14	149.04	43.49	463.44	187.64
2008	37.14	37.25	40.00	40.52	38.11	187.06	169.83	48.23	523.13	212.79
2009	40.48	40.58	43.60	44.20	41.47	213.17	193.56	53.41	590.50	241.37

* Assumed energy efficiencies: gas .77, oil .77, coal .70, electric .95

Sources of Life Cycle Savings

Figures 6 through 13 illustrate the Net Present Value and the Net Present Value per 10^6 Btu by the present fuel type for each retrofit alternative. Table 3 is a supporting table containing the raw data on which Figures 6-13 are based.

On a total net present value basis the existing district heating customers realize the largest savings - more than 60% of the total. On a net present value per 10^6 Btu basis, the present electric users realize the largest unit savings - nearly three times as much as existing steam customers. In all retrofit alternatives there are savings realized by all potential customers during the 25 years except for the present coal customer. (This could be altered if costly cleanup equipment would be required for this firm to continue using coal.)

The Net Present Value of Savings per 10^6 Btu probably comes the closest to being a single number representing the viability of the project from the perspective of the individual customer. In terms of the energy price projection curves of the previous section, it more or less represents (for a designated fuel type and retrofit) a discounted value of the average vertical distance between the price curve for the designated fuel type and the price curve for steam under the proposed retrofit.

The average savings for Retrofit #1 is \$1.73 per million Btu. Such a savings appears even larger when considering that:

- the savings are taken after taxes - this has reduced the savings by a factor equal to the income tax rate of 48%
- the savings are discounted back from 1985 to 1979 - this has reduced the savings by a factor equal to $(1 + \text{user discount rate})^6$ or 57%.

Figure 6. Net Present Value by Present Fuel Type
Retrofit Alternative #1 (A_3f_1)
Base Case

Figure 7. Net Present Value Per 10^6 BTU by Present Fuel Type
Retrofit Alternative #1 (A_3f_1)
Base Case

Figure 8: Net Present Value by Present Fuel Type
Retrofit Alternative #2 (A_3f_2)
Base Case

Figure 9: Net Present Value per 10^6 BTU by Present Fuel Type
Retrofit Alternative #2 (A_3f_2)
Base Case

Figure 10: Net Present Value by Present Fuel Type
Retrofit Alternative #3 (A_{3g1})
Base Case

Figure 11: Net Present Value per 10^6 BTU by Present Fuel Type
Retrofit Alternative #3 (A_{3g1})
Base Case

Figure 12. Net Present Value by Present Fuel Type
Retrofit Alternative #4 (A_{392})
Base Case

Figure 13. Net Present Value per 10^6 BTU by Present Fuel Type
Retrofit Alternative #4 (A_{392})
Base Case

TABLE 3. LIFE CYCLE SAVINGS AND LIFE CYCLE SAVINGS
PER 10^6 Btu BY PRESENT FUEL TYPE (1979 \$'s)

Retrofit Alternative		Natural Gas	Oil	Coal	Electric	Existing Steam	Total
Retrofit Alternative 1	Net Present Value of Savings	\$ 536,347	\$ 63,665	\$ 0	\$3,999,273	\$17,011,505	\$21,610,790
	Energy Consumption Over 25 Years (10^6 Btu)	714,625	116,800	0	864,350	10,825,000	12,520,775
	Net Present Value of Savings Per 10^6 Btu	\$.75	\$.54	\$ -	\$ 4.63	\$ 1.57	\$ 1.73
Retrofit Alternative 2	Net Present Value of Savings	\$ 319,382	\$3,719,743	\$ 0	\$3,976,488	\$16,667,617	\$24,883,234
	Energy Consumption Over 25 Yrs. 10^6 Btu	714,625	3,266,800	0	864,350	10,825,000	15,670,775
	Net Present Value of Savings Per 10^6 Btu	\$.73	\$ 1.14	\$ -	\$ 4.60	\$ 1.54	\$ 1.59
Retrofit Alternative 3	Net Present Value of Savings	\$ 497,926	\$8,225,708	\$(5,495,982)	\$3,947,672	\$16,232,684	\$23,408,007
	Energy Consumption Over 25 Yrs. (10^6 Btu)	714,625	7,948,500	23,000,000	864,350	10,825,000	43,352,475
	Net Present Value of Savings Per 10^6 Btu	\$.70	\$ 1.03	\$ (.24)	\$ 4.57	\$ 1.50	\$.54
Retrofit Alternative 4	Net Present Value of Savings	\$3,270,644	\$8,278,138	\$(5,421,448)	\$3,951,474	\$16,290,060	\$26,368,869
	Energy Consumption Over 25 Yrs. (10^6 Btu)	4,889,625	7,948,500	23,000,000	864,350	10,825,000	47,527,475
	Value of Savings Per 10^6 Btu	\$.67	\$ 1.04	\$ (.24)	\$ 4.57	\$ 1.50	\$.55

Cost Components and Income and
Balance Sheet Data

The cost components for each retrofit alternative are shown in current year dollars on Figures 14 through 17. As expected, the fuel costs dominate because of the escalation rates employed. Capital costs are a significant cost component during the earlier years, but become increasingly smaller as many of the other components escalate over time. As an example, for the fourth retrofit alternative (the alternative with the largest capital investment required), the capital cost component is less than 10% of the total cost by the year 2000.

Income and balance sheet data are presented on Tables 4 through 8 in current year dollars for each retrofit alternative. The second column in the tables is a projection of revenues from each alternative. Theoretically, the capital cost component of the revenue requirement is the sum of the columns designated as depreciation expense, debt interest expense, federal income tax expense, preferred stock dividends, and common stock dividends.

Figure 14: Breakdown of Projected District Heating Costs
Retrofit Alternative #1 (A3f1)
Current Year Dollars

TABLE 4. INCOME AND BALANCE SHEET DATA
RETROFIT ALTERNATIVE #1 (A₃f₁)
(Current Year \$'s x 10³)

Year	Revenues	Depreciation Expense	O/M Expense	Fuel Expense	Debt Interest Expense	Gross Receipts Tax	Taxable Income	Federal Income Tax Expense	Preferred Stock Dividends	Common Stock Dividends	Accumulated Depreciation	Long-Term Liabilities
1985	5,745	671	547	1,351	837	230	2,108	1,012	251	845	671	16,100
1986	5,808	671	585	1,497	802	232	2,021	970	241	810	1,342	15,429
1987	5,890	671	626	1,658	767	236	1,933	928	230	775	2,012	14,758
1988	5,994	671	670	1,836	732	240	1,845	885	220	740	2,683	14,088
1989	6,120	671	717	2,033	698	245	1,756	843	209	704	3,354	13,417
1990	6,272	671	767	2,251	663	251	1,669	801	199	669	4,025	12,746
1991	6,452	671	821	2,493	628	258	1,581	759	188	634	4,696	12,075
1992	6,663	671	878	2,761	593	266	1,494	717	178	599	5,367	11,404
1993	6,909	671	940	3,058	558	276	1,405	675	167	563	6,037	10,733
1994	7,192	671	1,006	3,386	523	288	1,317	632	157	528	6,708	10,063
1995	7,516	671	1,076	3,750	488	301	1,229	590	146	493	7,379	9,392
1996	7,887	671	1,151	4,153	453	315	1,142	548	136	458	8,050	8,721
1997	8,307	671	1,232	4,600	419	332	1,054	506	125	423	8,721	8,050
1998	8,784	671	1,318	5,094	384	351	966	464	115	387	9,392	7,379
1999	9,323	671	1,410	5,641	349	373	879	422	105	352	10,063	6,708
2000	9,929	671	1,509	6,247	314	397	790	379	94	317	10,733	6,037
2001	10,611	671	1,615	6,919	279	424	703	337	84	282	11,404	5,367
2002	11,375	671	1,728	7,662	244	455	614	295	73	246	12,075	4,696
2003	12,231	671	1,849	8,485	209	489	527	253	63	211	12,746	4,025
2004	13,187	671	1,978	9,397	174	527	439	211	52	176	13,417	3,354
2005	14,255	671	2,117	10,407	139	570	352	169	42	141	14,088	2,683
2006	15,447	671	2,265	11,525	105	618	263	126	31	106	14,758	2,012
2007	16,774	671	2,423	12,763	70	671	175	84	21	70	15,429	1,342
2008	18,251	671	2,593	14,135	35	730	87	42	10	35	16,100	671
2009	19,895	671	2,774	15,653	0	796	0	0	0	0	16,771	0

Figure 15 Breakdown of Projected District Heating Costs
Retrofit Alternative #2 (A_{3f2})
Current Year Dollars

TABLE 5. INCOME AND BALANCE SHEET DATA
RETROFIT ALTERNATIVE #2 (A_{3f2})
(Current Year \$'s x 10³)

Year	Revenues	Depreciation Expense	O/M Expense	Fuel Expense	Debt Interest Expense	Gross Receipts Tax	Taxable Income	Federal Income Tax Expense	Preferred Stock Dividends	Common Stock Dividends	Accumulated Depreciation	Long-Term Liabilities
1985	7,092	846	647	1,598	1,056	284	2,660	1,277	317	1,066	846	20,314
1986	7,156	846	693	1,769	1,012	286	2,549	1,223	304	1,022	1,693	19,467
1987	7,244	846	741	1,959	968	290	2,437	1,170	290	977	2,539	18,621
1988	7,355	846	793	2,170	924	294	2,327	1,117	277	933	3,386	17,774
1989	7,495	846	848	2,403	880	300	2,217	1,064	264	889	4,232	16,928
1990	7,665	846	908	2,661	836	306	2,106	1,011	251	844	5,078	16,082
1991	7,867	846	971	2,947	792	315	1,996	958	238	800	5,925	15,235
1992	8,108	846	1,039	3,264	748	324	1,883	904	224	755	6,771	14,389
1993	8,387	846	1,112	3,615	704	335	1,773	851	211	711	7,618	13,542
1994	8,711	846	1,190	4,003	660	348	1,662	798	198	666	8,464	12,696
1995	9,084	846	1,273	4,433	616	363	1,552	745	185	622	9,310	11,850
1996	9,512	846	1,362	4,910	572	380	1,442	692	172	578	10,157	11,003
1997	10,000	846	1,458	5,437	528	400	1,329	638	158	533	11,003	10,157
1998	10,553	846	1,560	6,021	484	422	1,219	585	145	489	11,850	9,310
1999	11,180	846	1,670	6,668	440	447	1,108	532	132	444	12,696	8,464
2000	11,887	846	1,784	7,385	396	475	998	479	119	400	13,542	7,618
2001	12,682	846	1,911	8,178	352	507	887	426	106	355	14,389	6,771
2002	13,575	846	2,045	9,057	308	543	775	372	92	311	15,235	5,925
2003	14,577	846	2,188	10,030	264	583	665	319	79	267	16,082	5,078
2004	15,698	846	2,341	11,108	220	628	514	266	66	222	16,928	4,232
2005	16,951	846	2,505	12,302	176	678	444	213	53	178	17,774	3,386
2006	18,349	846	2,680	13,624	132	734	333	160	40	133	18,621	2,539
2007	19,908	846	2,868	15,088	88	796	221	106	26	89	19,467	1,693
2008	21,644	846	3,068	16,709	44	866	110	53	13	44	20,314	846
2009	23,577	846	3,283	18,504	0	943	0	0	0	0	21,160	0

Figure 16 : Breakdown of Projected District Heating Costs
Retrofit Alternative #3 (A391)
Current Year Dollars

TABLE 6. INCOME AND BALANCE SHEET DATA.
RETROFIT ALTERNATIVE #3 (A₃B₁)
(Current Year \$'s x 10³)

Year	Revenues	Depreciation Expense	O/M Expense	Fuel Expense	Debt Interest Expense	Gross Receipts Tax	Taxable Income	Federal Income Tax Expense	Preferred Stock Dividends	Common Stock Dividends	Accumulated Depreciation	Long-Term Liabilities
1985	16,950	1,963	1,615	4,072	2,450	678	6,171	2,962	735	2,474	1,963	47,119
1986	17,149	1,963	1,728	4,510	2,348	686	5,913	2,838	704	2,371	3,927	45,156
1987	17,405	1,963	1,849	4,994	2,246	696	5,657	2,715	674	2,268	5,890	43,193
1988	17,725	1,963	1,978	5,531	2,144	709	5,399	2,592	643	2,164	7,853	41,230
1989	18,114	1,963	2,117	6,125	2,042	724	5,141	2,468	612	2,061	9,816	39,226
1990	18,580	1,963	2,265	6,783	1,940	743	4,885	2,345	582	1,958	11,780	37,303
1991	19,130	1,963	2,424	7,512	1,838	765	4,627	2,221	551	1,855	13,743	35,340
1992	19,774	1,963	2,593	8,319	1,735	791	4,371	2,098	521	1,752	15,706	33,378
1993	20,520	1,963	2,775	9,213	1,633	821	4,114	1,975	490	1,649	17,670	31,413
1994	21,380	1,963	2,969	10,203	1,531	855	3,856	1,851	459	1,546	19,633	29,450
1995	22,363	1,963	3,177	11,299	1,429	894	3,600	1,728	429	1,443	21,596	27,486
1996	23,486	1,963	3,399	12,513	1,327	939	3,342	1,604	398	1,340	23,560	25,523
1997	24,760	1,963	3,637	13,858	1,225	990	3,085	1,481	367	1,237	25,523	23,560
1998	26,202	1,963	3,892	15,347	1,123	1,048	2,828	1,357	337	1,134	27,486	21,596
1999	27,830	1,963	4,165	16,996	1,021	1,113	2,571	1,234	306	1,031	29,450	19,633
2000	29,661	1,963	4,456	18,822	919	1,186	2,314	1,110	276	928	31,413	17,670
2001	31,719	1,963	4,768	20,845	817	1,269	2,056	987	245	824	33,378	15,706
2002	34,025	1,963	5,102	23,085	715	1,361	1,799	864	214	721	35,340	13,743
2003	36,607	1,963	5,459	25,565	612	1,464	1,542	740	184	618	37,303	11,780
2004	39,493	1,963	5,841	28,312	510	1,580	1,285	617	153	515	39,226	9,816
2005	42,713	1,963	6,250	31,355	408	1,708	1,028	494	122	412	41,230	7,853
2006	46,304	1,963	6,687	34,724	306	1,852	771	370	92	309	43,193	5,890
2007	50,304	1,963	7,155	38,455	204	2,012	514	247	61	206	45,156	3,927
2008	54,756	1,963	7,656	42,587	102	2,190	257	123	31	103	47,119	1,963
2009	59,707	1,963	8,192	47,163	0	2,388	0	0	0	0	49,083	0

Figure 17: Breakdown of Projected District Heating Costs
Retrofit Alternative #4 (A₃₉₂)
Current Year Dollars

TABLE 7. INCOME AND BALANCE SHEET DATA
RETROFIT ALTERNATIVE #4 (A₃₈₂)
(Current Year \$'s x 10³)

Year	Revenues	Depreciation Expense	O/M Expense	Fuel Expense	Debt Interest Expense	Gross Receipts Tax	Taxable Income	Federal Income Tax Expense	Preferred Stock Dividends	Common Stock Dividends	Accumulated Depreciation	Long-Term Liabilities
1985	18,239	2,078	1,786	4,520	2,593	729	6,531	3,135	778	2,618	2,078	49,875
1986	18,480	2,078	1,911	5,006	2,485	739	6,259	3,004	746	2,509	4,156	47,797
1987	18,783	2,078	2,045	5,544	2,377	751	5,987	2,874	713	2,400	6,234	45,719
1988	19,157	2,078	2,188	6,139	2,269	766	5,715	2,743	681	2,291	8,312	43,640
1989	19,608	2,078	2,342	6,799	2,161	784	5,443	2,613	648	2,182	10,391	41,562
1990	20,143	2,078	2,506	7,530	2,053	806	5,171	2,482	616	2,073	12,469	39,484
1991	20,773	2,078	2,681	8,339	1,945	831	4,898	2,351	583	1,964	14,547	37,406
1992	21,505	2,078	2,869	9,235	1,837	860	4,626	2,220	551	1,855	16,625	35,328
1993	22,352	2,078	3,069	10,227	1,729	894	4,355	2,090	519	1,746	18,703	33,250
1994	23,325	2,078	3,284	11,326	1,621	933	4,081	1,959	486	1,636	20,781	31,172
1995	24,436	2,078	3,514	12,543	1,513	977	3,810	1,829	454	1,527	22,860	29,094
1996	25,700	2,078	3,760	13,891	1,405	1,028	3,537	1,698	421	1,418	24,937	27,015
1997	27,133	2,078	4,023	15,383	1,297	1,085	3,266	1,568	389	1,309	27,015	24,937
1998	28,752	2,078	4,305	17,036	1,187	1,150	2,994	1,437	357	1,200	29,094	22,860
1999	30,576	2,078	4,606	18,867	1,081	1,223	2,721	1,306	324	1,091	31,172	20,781
2000	32,628	2,078	4,929	20,894	972	1,305	2,450	1,176	292	982	33,250	18,703
2001	34,930	2,078	5,274	23,139	864	1,397	2,177	1,045	259	873	35,328	16,625
2002	37,508	2,078	5,643	25,625	756	1,500	1,905	914	227	764	37,406	14,547
2003	40,392	2,078	6,038	28,379	648	1,616	1,633	784	194	655	39,484	12,469
2004	43,612	2,078	6,461	31,428	540	1,744	1,360	653	162	545	41,562	10,391
2005	47,205	2,078	6,913	34,805	432	1,888	1,088	522	130	436	43,640	8,312
2006	51,209	2,078	7,397	38,545	324	2,048	816	392	97	327	45,719	6,234
2007	55,666	2,078	7,915	42,686	216	2,227	544	261	65	218	47,797	4,156
2008	60,625	2,078	8,469	47,273	108	2,425	272	131	32	109	49,875	2,078
2009	66,138	2,078	9,061	52,353	0	2,645	0	0	0	0	51,953	0

Impacts on Energy Suppliers

The five present or possible energy suppliers that are affected by the proposed system are displayed in the following table.

Table 8. IMPACTS OF PROPOSED SYSTEM ON ENERGY SUPPLIERS

Firm	Role	Magnitude (10^6 Btu's/Yr)			
		Retrofit #1	Retrofit #2	Retrofit #3	Retrofit #4
Toledo Edison	existing steam system owner	-433,000	-433,000	-433,000	-433,000
	electric	- 34,574	- 34,574	- 34,574	- 34,574
	possible new steam system owner	491,454	580,954	1,369,144	1,496,144
Columbia Gas	Natural gas supplier	- 28,585	- 28,585	- 28,585	-195,585
Oil Supplier (1)	#6 oil supplier	-762,080	-762,080	-949,340	-949,340
Oil Supplier (2)	#2 oil supplier	- 4,672	-130,672	-130,672	-130,672
Coal Supplier*	Coal supplier	0	0	-920,000	-920,000

* The additional coal that would be needed for Acme under the respective retrofits would have a positive impact on coal suppliers.

Toledo Edison is clearly the principal actor in the overall project. The real economic impact on the firm, however, cannot be significant since steam heating sales account for less than 1% of their overall revenues. As reported in Task 5, the project's capital requirements are not large in comparison with the overall capital expenditure program of Toledo Edison.

Operating in a regulatory environment precludes the possibility of earning in excess of a fair return on whatever investment decision they might make. Nevertheless, there are a number of benefits accruing to Toledo Edison from the new steam system that should be pointed out:

- Favorable public relations from having stabilized the recent acceleration of steam prices in the downtown area
- Improved earnings picture resulting from the conversion of the existing steam system and its associated financial losses to a stable, economically viable district heating system
- Deferred tax advantages of accelerated depreciation and 10% investment tax credit - these tax savings accrue to the system owner and are not passed through to the steam customers
- Availability of the Water Street plant for alternative uses to further the redevelopment of downtown Toledo.

The system impact on Columbia Gas is expected to be minimal. Pricing the lost sales in Retrofit #4 at \$2.50 per 10^6 Btu*, results in an annual sales loss on the order of \$500,000. Since natural gas is a scarce fuel, it would seem that these lost sales could be made up elsewhere thereby having minimal impact on Columbia Gas.

The long-term impact on the two oil suppliers is minimized by both firms being large multi-national petroleum concerns. Pricing the lost sales in Retrofit #4 at \$2.43 per 10^6 Btu #6 oil* and \$2.96 per 10^6 Btu #2 oil* results in an annual sales loss on the order of \$2,300,000 and \$400,000 respectively for each oil supplier.

The impact on the coal supplier using \$1.75 per 10^6 Btu* as the price for coal results in a current annual sales loss of \$1,600,000. This impact is roughly equivalent to the loss of a 40,000 ton account. While no firm likes to lose an account, the long-term impact of the proposed system on the large coal producer involved here is expected to be minimal.

* These prices represent January 1979 energy costs.

III. SENSITIVITY ANALYSES ON THE BASE CASE

Introduction

At this early phase of the proposed project significant uncertainties are to be expected in many of the parameters chosen for the base case. To fully assess the potential impact of these uncertainties on the economic viability of the proposed district heating system sensitivity analyses have been prepared for seven different parameters:

- Fuel prices
- Financing assumptions
- System start-up date
- Cost of service
- Changes in consumption
- User discount rates
- Retrofit alternatives.

The impact of each of these parameters is evaluated in the following sections.

Fuel Prices

Of the seven parameters that will be explored in this analysis, none has greater uncertainty associated with it than future fuel prices. Forecasts prepared only a few months ago are already dated by the recent events in the Middle East and prior to that, the Natural Gas Policy Act of 1978 (NGPA). Nevertheless, business decisions must still be made given the best available forecasts.

This study is concerned with four energy sources external to the district heating system: natural gas, oil, coal, and electric. We group natural gas and oil together under scarce fuels because we believe that since the two are close substitutes, gas prices will closely track oil prices in the long term. The range of annual energy price increases in excess of the

general inflation rate that were used in this analysis include:⁽¹⁾

- Scarce Fuel 3% to 10%
- Coal 0% to 7%
- Electricity 4% to 7%.

We refer to these "annual energy price increases in excess of the general inflation rate" as differential escalation rates or simply D.E.R.'s. Since we are already incorporating a general rise in the overall price index of 7%, a D.E.R. of 10% implies an annual price increase in nominal terms of slightly more than 17%.⁽²⁾ A "fuel price scenario" is defined as a combination of three D.E.R.'s - one from each energy source.

Figures 18 through 22 and Table 9 depict the impact of the various fuel price trajectories on the overall economic viability of the proposed district heating and cooling system. It should be recalled that the economic parameter we have selected to reflect this measure of viability is the life cycle savings or net present value of after-tax savings accruing to the user over a twenty-five year period. Traversing a single curve on any one of the Figures reflects the change in life cycle savings with respect to varying scarce fuel D.E.R.'s and constant coal and electric D.E.R.'s. Moving vertically between curves on any one of the Figures reflects the change in life cycle savings with respect to a constant fuel price D.E.R. and varying coal and electric D.E.R.'s.

The most striking aspect of the series of life cycle savings curves is that no fuel price scenario within the above ranges results in a life cycle savings for Retrofits #1 or #2 that falls below the break-even line, i.e., a negative net present value. This is also true for the case of a Retrofit #1 system serving only existing customers. Moreover, the only fuel price scenarios resulting in negative values for Retrofits #3 and #4 are the ones in which the D.E.R. for coal exceeds the D.E.R. for scarce fuels by 3% - e.g., when the coal D.E.R. equals 7% and the scarce fuel D.E.R. equals 4%. This is one of the least probable fuel price scenarios.

The fuel price scenarios, however, do demonstrate the significant impact that fuel price changes can exert on the magnitude of the life-cycle savings. This large impact is due to the fact that (1) fuel costs are a

(1) Range given in DOE contract.

(2) Or more exactly: $(1 + .10) * (1 + .07)$

major cost item of both the existing and the proposed district heating system and (2) changes in fuel costs relate directly to the benefits of the district heating system to potential new customers.

The scarce fuel D.E.R. has the greatest impact since many potential customers currently use natural gas or oil and since the existing steam system is fueled by oil at an overall system efficiency of .568* - i.e., nearly two Btu's of oil input for every Btu of steam for user consumption.

Scarce fuel D.E.R. impacts are greater for the first two retrofits than for the other retrofit alternatives due to the addition of a large coal user in the other retrofits thereby partially offsetting the impact of lower coal costs at Acme relative to scarce fuel savings.

Rising coal prices will have a negative impact on the first two retrofits since the proposed system will be supplied from Acme - a coal-fired generating plant. The impact will be less negative in Retrofits #3 and #4 since rising coal prices also mean increased user savings from the large coal user.

* See Appendix A for documentation.

Figure 18. Life Cycle Savings for All Customers (existing and new)

Retrofit Alternative #1 (A_3f_1)

Figure 19: Life Cycle Savings for all Customers (existing and new)

Retrofit Alternative #2. (A_3f_2)

Figure 20: Life Cycle Savings for all Customers (existing and new)

Retrofit Alternative #3 (A391)

Figure 21:: Life Cycle Savings for all Customers (existing and new)

Retrofit Alternative #4 (A_{392})

Figure 22: Life Cycle Savings for Existing Customers Only
Retrofit Alternative #1 (A_{3f_1})

TABLE 9. LIFE CYCLE SAVINGS FOR VARIOUS FUEL PRICE SCENARIOS
(millions of after-tax 1979 \$'s)

Fuel Price Scenarios			Life Cycle Savings				
Scarce Fuel D.E.R.	Coal D.E.R.	Electric D.E.R.	Retrofit #1	Retrofit #2	Retrofit #3	Retrofit #4	Retrofit #1 (Existing Customers Only)
.065	.035	.055	21.7	24.9	23.4	26.4	16.1
.030	.000	.040	12.0	12.6	6.2	7.3	7.8
.030	.000	.070	14.4	15.0	8.6	9.7	7.8
.030	.070	.040	5.1	3.6	-3.0	-4.0	1.7
.030	.070	.070	7.5	6.0	-0.6	-1.6	1.7
.065	.000	.040	23.0	27.0	25.6	29.3	18.3
.065	.000	.070	25.4	29.4	28.0	31.7	18.3
.065	.070	.040	16.1	18.0	16.4	18.0	12.1
.065	.070	.070	18.4	20.4	18.7	20.4	12.1
.100	.000	.040	43.8	54.3	62.5	71.0	38.1
.100	.000	.070	46.2	56.7	64.8	73.4	38.1
.100	.070	.040	37.0	45.3	53.2	59.7	31.9
.100	.070	.070	39.3	47.7	55.6	62.1	31.9

Note: Base case shown on the first line.

Financing Assumptions

The conclusions of Task 5 related to possible ownership arrangements suggested that the two most viable options were Toledo Edison and City of Toledo ownership. Further analysis showed that the latter was one of last resort, i.e., if no one else could operate the system, then the City of Toledo might be forced to do so in order to ensure an energy source for the downtown district. Based on the assumptions and economic analysis in the base case, it appears that the district heating system is viable under Toledo Edison ownership. Nevertheless, it is useful to explore other financing assumptions so that a more complete understanding of the economics of the proposed system can be gained. It is also useful in the event the assumptions employed in the study should change.

The sensitivity analysis of financing assumptions is not carried out in terms of specific ownership arrangements. Rather it is the consequences of alternative ownership arrangements that are investigated - e.g., differing tax liabilities and costs of capital.

The base case employs a capital mix for Toledo Edison of 50% debt @ 10.4%, 35% common stock @ 15%, and 15% preferred stock @ 10.4%. This results in an average weighted cost of capital equal to 12%. In addition, Federal income taxes would have to be paid on the income earned in order to pay common and preferred stock dividends and a 4% gross receipts tax would also be included in the revenue requirements.

Four sensitivity runs were made modifying these assumptions as shown:

- 100% debt @ 9% with gross receipts taxes
- 100% debt @ 7% with gross receipts taxes
- 100% debt @ 9% with no gross receipts taxes
- 100% debt @ 7% with no gross receipts taxes

There are no federal taxes for any of the four sensitivity runs since the project is financed 100% through debt and thus no income is needed to pay out equity dividends.

It is difficult to link an ownership arrangement with a specific sensitivity case. The City of Toledo has suggested that such a project could not be financed out of general obligation funds since the project benefits only a small portion of the city. Therefore, some kind of revenue bond financing would seem appropriate. Since revenue bonds are project specific, it is difficult to predict what a reasonable interest rate would be because it is unknown how potential investors might evaluate the riskiness of the proposed project. In any case, it is difficult to imagine the rates falling below 7%, since 7% is the level of inflation we are assuming for the entire analysis. The third and fourth sensitivity cases might correspond to public ownership since such an arrangement does not require payment of gross receipts taxes. The first two might correspond to utility subsidiary ownership financed by city-backed revenue bonds and subject to gross receipts taxes. The results are presented below in Table 10.

Various other financing assumptions can be made by combining portions of the base case with the sensitivity cases. The effects of any such combinations can be estimated on the basis of the previously calculated base case and sensitivity cases. For example, the financing combination of 50% city-backed revenue bonds at 7% and 50% base case utility capital structure results in a life cycle savings for Retrofit #1 of somewhere between \$21,700,000 and \$24,300,000 (1979 \$'s).

TABLE 10. LIFE CYCLE SAVINGS OF NEW AND EXISTING CUSTOMERS WITH VARYING FINANCING ASSUMPTIONS (millions of 1979 \$'s)

Financing Assumptions	Retrofit #1	Retrofit #2	Retrofit #3	Retrofit #4
Base case:	21.7	24.9	23.4	26.4
50% debt @ 10.4%				
35% common stock @ 15%				
15% preferred stock @ 10.4%				
FIT and gross receipts taxes				
100% debt @ 9% with gross receipts taxes, but no FIT	23.8	28.0	30.3	33.6
100% debt @ 7% with gross receipts taxes, but no FIT	24.3	28.7	31.9	35.2
100% debt @ 9% with no gross receipts taxes and no FIT	24.3	28.6	31.8	35.1
100% debt @ 7% with no gross receipts taxes and no FIT	24.8	29.3	33.2	36.7

The overall impact of varying the cost of capital is not that significant, especially when three points are considered:

- The additional legal and start-up costs involved in any of the four sensitivity runs have not been estimated and thus not included in the life cycle savings calculation.
- There may be an upper bound on the amount that can be financed by revenue bonds for any single project.
- Since the base case utility ownership arrangement is required to pay income taxes on the income needed to pay out common preferred stock dividends, the effective cost of capital is really 12% plus federal income taxes or $.12 + \left[\frac{.48}{(1-.48)} \right] * \left[(.35 * .15) + (.15 * .104) \right] = 18.3\%$. (As explained in the assumption section of the report, recent legislation has changed the corporate income tax rate to 46%. The economic analysis uses the old rate of 48%.)

The impact of the varying cost of capital is greater for Retrofits #3 and #4 since capital costs represent a relatively larger fraction of overall costs than in Retrofits #1 and #2. The tax savings under public ownership is minimal since the affected taxes account for only 4% of the overall steam price. The city-ownership option should only be considered if Toledo Edison ownership (base case) and a utility subsidiary with low interest rate financing are both determined infeasible.

System Start-Up Date

One of the parameters that may be investigated in Phase II is the optimal construction phasing of the various line extensions - the customers join the system at varying times. A first cut to that analysis is to assume that all customers join the system simultaneously, but to vary the project start date. The results are presented below in Table 11.

TABLE 11. LIFE CYCLE SAVINGS OF NEW AND EXISTING
CUSTOMERS WITH VARYING SYSTEM START-
UP DATES (millions of 1979 \$'s)

Start-Up Date	Retrofit #1	Retrofit #2	Retrofit #3	Retrofit #4
1985 System Start Date (Base Case)	21.7	24.9	23.4	26.4
1990 System Start Date	22.0	26.0	28.0	31.4

The results seem to indicate that the economic viability is not greatly altered by system start date, especially for the first two retrofits. A sensitivity run was also made for Retrofit #1 system start in 1983. Life cycle savings amounted to \$21.3 million, again insensitive to the system start parameter.

It should be pointed out that the two runs are not directly comparable, since the first concerns an investment with a lifetime of 1985-2009; and the second, a lifetime of 1990-2014. To make the proper comparison an adjustment would have to be made to put the two cases in terms of the equivalent investment lifetime 1985-2014. However, such effects are estimated to have an impact of less than 15% and in the direction of making the earlier start date more favorable.

Cost of Service

Two sensitivity runs were considered in the analysis of changes in the overall cost of service: a 25% increase in all anticipated costs for the system and a 25% decrease in all anticipated costs. Twenty-five percent was selected on the basis of conversations with Stone and Webster which suggested that their engineering design estimates had a 95% Confidence Interval of roughly $\pm 20\%$. If it is assumed that the uncertainty of the other cost components is no greater than that associated with the capital cost estimation, then 25% would represent a greater change in the cost of service than could be reasonably expected as a result of estimating uncertainty. The results are presented below in Table 12.

TABLE 12. LIFE CYCLE SAVINGS OF NEW AND EXISTING
CUSTOMERS WITH VARYING COSTS OF SERVICE
(millions of 1979 \$'s)

Cost of Service	Retrofit #1	Retrofit #2	Retrofit #3	Retrofit #4
100% * Cost of Service (Base Case)	21.7	24.9	23.4	26.4
75% * Cost of Service	25.0	29.4	34.0	37.7
125% * Cost of Service	18.3	20.4	12.9	15.1

The results indicate that even with a 25% increase in the delivered cost of thermal energy, the proposed system is still economically viable. The relatively larger impact of the price change on Retrofits #3 and #4 results from the fact that Retrofits #1 and #2 have a benefit/cost ratio (= Life Cycle Savings/Capital Investment) of nearly three times greater than the ratio for Retrofits #3 and #4. Thus a percentage change in the capital investment will have the greatest impact on the ratio, given similar life cycle savings, in which the capital investment is the largest.

Changes in Consumption

A sensitivity analysis was conducted in order to study the effects of changes in the anticipated consumption of the new system while holding the level of capital expenditures constant. Two cases are investigated: 110% and 90% of the current consumption forecast. Such changes could occur in the actual system as a result of facilities expansion and increased user energy efficiency respectively. Table 13 shows the impact.

TABLE 13. LIFE CYCLE SAVINGS OF NEW AND EXISTING CUSTOMERS WITH VARYING CONSUMPTION LEVELS (millions of 1979 \$'s)

Level of Consumption	Retrofit #1	Retrofit #2	Retrofit #3	Retrofit #4
100% of current forecast (Base Case)	21.7	24.9	23.4	26.4
90% of current forecast	18.7	21.4	18.7	21.3
110% of current forecast	24.5	28.4	28.1	31.5

The impact of such changes is directly related to the size of the capital component in the steam cost. If capital costs are a major portion of the overall costs then the effect of spreading those costs over 10% more (or 10% fewer) consumption is much greater than in the case where the capital costs represent a smaller portion. This effect is reflected in the results presented above: the impact of the changes is proportionately larger in the more capital intensive Retrofits #3 and #4. The viability of the system still remains for all retrofits even with the 10% reduction in consumption without any corresponding decreases in the design size of the system.

User Discount Rates

One of the critical parameters in any capital investment study is the discount rate that will be used to equate investment dollars paid out now to dollars earned from the project in future years. The user discount rate used in the base case is 15%. This roughly corresponds to an after-tax rate of return of 15%. If the life cycle savings of the project is positive then it can be said that the investor earned in excess of a 15% after-tax rate of return.

The user discount rate should not be confused with the utility's cost of capital. The utility's cost of capital is needed in order to determine exactly how much interest it will pay in securing capital to fund the project. The system owner will be reimbursed for this expense in the required revenue calculation. The system user is typically not a utility and therefore subject to a different cost of capital or discount rate.

An after-tax return of 15% is a very good investment, especially for one dealing with a basic raw material such as energy. Since the customer (and not the researcher) makes the decision whether or not to change energy sources, it is important to reflect the customer's individual set of investment criteria within the total framework of the economic analysis. In the customer interviews completed in Task 3, many firms stated that they would evaluate the decision to join the system on the basis of a four-year payback period. In most situations the payback period is defined as the period of time required to cover the initial investment, or as the cost of the investment divided by the proceeds per period. For this analysis, the investment decision is more correctly defined as measuring the trade-offs between higher energy costs for the first years of the project and lower energy costs for the later years of the project. There is no investment here in the usual sense because user retrofit costs are insignificant. A measure which is in the same vein as payback period and which could be used in this analysis is the number of years required for the net present value of the early losses to be balanced by the net present value of later savings--i.e., a break-even point. The analysis related to break-even points was discussed in the earlier Base Case Analysis section.

The concept of a project "breaking even" after say four years also can be looked at in terms of user discount rates. It is tentatively estimated that the four-year break-even period stated in terms of discount rates is equivalent to a before-tax discount rate of 24% or an after-tax discount rate of 12%. Therefore, it would seem that the 15% user discount rate employed in the base case analysis is a reasonable value in view of the customer interviews. It should be noted, however, that one large new customer indicated a one-year payback period as being required. Table 14 presents the impact of varying the user discount rate.

TABLE 14. LIFE CYCLE SAVINGS OF NEW AND EXISTING CUSTOMERS WITH VARYING USER DISCOUNT RATES - 1979 \$'s

User Discount Rates	Retrofit #1	Retrofit #2	Retrofit #3	Retrofit #4
15% (Base Case)	21.7	24.9	23.4	26.4
10%	53.1	62.6	66.1	74.4
20%	9.9	11.8	8.6	10.0
25%	5.0	5.5	3.2	3.8

The user discount rate has a rather large effect on the magnitude of user life cycle savings. Nevertheless the proposed system continues to be economically viable even with a 20 or 25% user discount rate.

Retrofit Alternatives

Much has been said about the benefits of each retrofit relative to the energy systems currently in place. However, in addition to deciding that a retrofit should be implemented, a decision must be made as to which retrofit. Reviewing all of the tables that have been presented thus far, it appears that while in most cases the last retrofit has the greatest life cycle savings, the first two retrofits have a much higher return on investment. This is a result of the fact that Retrofits #3 and #4 require an investment of over three times that of Retrofit #1 while returning only a slightly greater life cycle savings. In addition, the point that existing steam customers comprise a much larger share of the consumption in the first two retrofits suggests that the savings estimates for the first two retrofits have a greater degree of certainty associated with them than the savings estimates for the last two retrofits.

The idea of a large system should not, however, be ruled out. The benefits of having the large system include being able to spread capital costs over a larger pool. The principal customer in Retrofits #3 and #4 is the large coal user. The viability of the large retrofits could be significantly altered if costly clean-up equipment would be required for this firm to continue using coal. In addition, the large coal user has an annual consumption of over 50% greater than the existing system, together with a much better load factor than most of the other customers.

The best policy then might be:

- Plan for the small system knowing that it is viable under the current set of assumptions.
- Look at the economics of keeping open the option of doubling or tripling the size of the existing system without committing all of the capital required at the outset. For example, design the transmission across the river - to handle the large retrofit, but wait to construct the long transmission lines until long-term contracts can be signed.

The economics of such options will be investigated in detail during Phase II. Based on the life cycle savings calculations performed in each of the sensitivity studies, it appears that Retrofit #2 is a slightly better investment than Retrofit #1 and that Retrofit #4 is a better investment than Retrofit #3. Such comparisons will be made in a more refined and final manner in Phase II.

IV. CONCLUSIONS

Results from the base case analysis and the accompanying sensitivity analyses indicate that the proposed district heating systems for the Toledo area are economically viable for the set of assumptions employed. The major findings of the economic analysis are listed below.

- The base case life cycle savings for Retrofits #1-#4 in millions of 1979 \$'s are 21.7, 24.9, 23.4, and 26.4 respectively. The life cycle savings for a Retrofit #1 system serving only existing customers is \$16.1 million (1979 \$'s).
- The break-even period (or the point in time when the accumulated life cycle savings become positive) is one year for Retrofits #1 and #2 and eight years for Retrofits #3 and #4.
- A Retrofit #1 system serving only existing steam customers can be justified with present prices on the basis of increased fuel and O&M savings over the Water Street System. As long as the methods used to allocate costs between thermal and electric production seem reasonable to the appropriate regulating agency and as long as existing steam customers have no other feasible energy alternative, the above result presents clear and very strong evidence of the economic viability of the proposed systems. A remaining Phase II question is then which system or system adaptation is the most viable.
- Since typical user retrofit costs amount to less than \$.10 per million Btu's consumed during the lifetime of the system, the critical element in the decision to switch to the new system is the comparison between the price of the customer's present energy source and the price of steam from the proposed Acme System.

- On average the analysis shows that price of the present fuel source exceeds the projected steam price by the year 2000 for coal customers, by 1988 for natural gas and oil customers, and by 1985 for electric and existing steam customers.
- The steam price for the proposed district heating system does not vary significantly between the four retrofit alternatives, thereby indicating no significant economies of scale.
- On a net present value basis, the existing district heating customers accrue the greatest proportion of total system savings. On a net present value per million Btu consumed basis, the present electric users realize the largest unit savings, while the coal user realizes a negative unit savings.
- The proportion of the revenue requirement attributable to capital costs drops from over 50% in the first years of the project to less than 10% in the final years of the project. Fuel price escalation and capital depreciation account for the change.
- The impact of the proposed district heating system on present energy suppliers is expected to be minimal. The suppliers affected are all large corporate concerns.

The most important result of the sensitivity analyses is that for the parameter ranges studied, none had enough of an impact to alter the basic conclusion that the proposed district heating system is an economically viable project. Other results include:

- The fuel price parameter, especially the scarce fuel escalation rate, has a large impact on the magnitude of life cycle savings of the system. Life cycle savings are roughly cut in half if the scarce fuel escalation rate of 6.5% in the base case is changed to 3.0%. On the other hand, the savings roughly double if the rate is changed to 10.0%.
- The assumption of a zero escalation rate for all fuels still results in a positive life cycle savings for Retrofit #1 and #2.

- Financing the project with 100% debt at 9% increases the life cycle savings of Retrofit #1 and #2 by roughly 10%. Lowering the interest rate to 7%, results in an additional 5% savings. Such financing arrangements may be possible with city-backed revenue bonds. However, based on Task 5 conclusions, the magnitude of these increased savings does not seem to warrant further consideration being given to city ownership. On the other hand, methods for obtaining city-backed financing with utility ownership should be investigated since lowering the project cost of capital has a positive impact on savings.
- Financing impacts on Retrofit #3 and #4 are roughly two times greater than those on Retrofits #1 and #2. Thus as capital investment increases there is increased incentive to seeking city-backed financing.
- Implementing the system later than 1985 does not improve the economic viability of Retrofits #1 and #2.
- Increasing the revenue requirement (i.e., price of delivered steam) by 25% decreases the life cycle savings by 15% and 40% for Retrofits #1 and #4 respectively.
- Decreasing the projected level of customer consumption by 10% decreases the life cycle savings by 15% and 25% for Retrofits #1 and #4 respectively.
- The user discount rate represents the rate at which customer savings occurring in many different time periods are equated or collapsed into a single net present value. Lowering the user discount rate from the base case value of 15% to 10% increases the life cycles savings by nearly a factor of three for each of the retrofits. Raising the user discount rate to 25% decreases the life cycle savings by a factor of four and seven for Retrofits #1 and #4 respectively.
- Determining the single best retrofit option is rather difficult at this stage of the study. However, a couple of preliminary conclusions can be drawn. Retrofits #1 and #2 have a higher cost-benefit ratio (life cycle savings divided by

capital cost) than Retrofits #3 and #4 (1.85 vs. .75). In addition, since Retrofits #1 and #2 are affected by the sensitivity analysis to a smaller extent than Retrofits #3 and #4, there is a smaller investment risk associated with Retrofit #1 and #2. Nevertheless, Retrofits #3 and #4 should not be ruled out at this time:

- The principal customer in Retrofits #3 and #4 is the large coal user. The viability of these retrofits could be significantly altered if costly clean-up equipment would be required for this firm to continue using coal.
 - The large coal user has a much better than average load factor.
 - Phasing retrofit options should be considered. One possibility might be to construct the Retrofit #4 transmission line across the river in 1985, but to wait to extend the line out to the coal user until the line is more cost effective.
- Based on very preliminary analysis, Retrofit #2 appears to be superior to Retrofit #1; Retrofit #4, superior to Retrofit #3.

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APPENDIX A. DETAILED DESCRIPTION OF THE ECONOMIC MODEL
DEVELOPED TO EVALUATE THE OVERALL ECONOMIC
VIABILITY OF THE PROPOSED DISTRICT HEATING
SYSTEMS

There are three main steps in arriving at a measure of the overall economic viability of the DHCS.

1. Calculate revenue requirements for the new steam system
2. Determine the regulated price for thermal energy in the new steam system
3. Compute the net present value of the savings accruing to users in switching from their present fuel sources to the new steam system.

Revenue Requirement Calculation

The model developed in this study assumes that the annual revenue requirement is a sum of seven components:

1. Capital charges
2. Depreciation expense
3. Fuel costs
4. Operation and maintenance costs
5. Federal income taxes
6. Property taxes
7. Gross receipts taxes.

Capital Charges and Depreciation Expense

Capital charges are defined to be the product of the rate base and the allowed rate of return. The rate base is set equal to the net book value of the project; the allowed rate of return is set equal to the average weighted embedded cost of capital of the system owner. The net book value of the project is the overall capital cost of the project less accumulated depreciation. For the purpose of determining a regulated price of steam, a

project life of twenty-five years and straight line depreciation are assumed. Naturally, the actual economic life of the project may well exceed twenty-five years and the utility may be permitted to take a form of accelerated depreciation on the investment. These particular factors, however, do not enter into the regulated price calculations of the model and are not expected to be included in rate calculations made by PUCO once the system is in place.

Three sets of cost of capital assumptions are being employed in this study. The first corresponds to the financing of the project at typical utility capital mix and interest rates:

<u>Financing Instrument</u>	<u>Proportion</u>	<u>Rate</u>
Debt	50%	.104
Preferred Stock	15%	.104
Common Stock	35%	.15

The other two sets correspond to city-backed revenue bond financing of unspecified type and quality:

- 100% debt @ 9%
- 100% debt @ 7%.

Capital costs for each of the four retrofits were provided by Stone and Webster.* Their estimates include direct capital costs, indirect costs such as engineering design, distributable costs such as construction management, and an allowance for design uncertainties. The total capital costs in January 1979 \$ are listed below:

<u>Retrofit Alternative</u>	<u>#1</u>	<u>#2</u>	<u>#3</u>	<u>#4</u>
Total Capital Costs (Jan. 1979\$)	\$11,100,000	\$14,000,000	\$32,500,000	\$34,400,000

* Refer to the assumptions section for information on how capital, operating, and maintenance costs are allocated to electrical and thermal energy production. In general, all of the energy savings associated with the cogeneration concept and with the improved thermal efficiencies of the Acme System are credited to the generation of steam. These savings are determined by subtracting the estimated fuel input for the cogeneration system from the total heat input required to generate the steam and electric power under separate systems.

In addition, Stone and Webster developed a construction schedule for the overall project and calculated cash flows for capital expenditures during each year of the three-year construction period. These cash flows were determined on the basis of preliminary PERT charts developed by Stone and Webster for each of the retrofit alternatives.

Retrofit Alternative	#1	#2	#3	#4
First Year (000's-Jan. 1979\$)	\$ 660	\$ 680	\$ 860	\$ 860
Second Year (000's-Jan. 1979\$)	4,140	6,290	12,230	13,120
Third Year (000's-Jan. 1979\$)	<u>6,300</u>	<u>7,030</u>	<u>19,410</u>	<u>20,420</u>
Total Capital Costs (000's-Jan. 1979\$)	\$11,100	\$14,000	\$32,500	\$34,400

These cash flows were then deflated by the inflation rate to put them in terms of nominal dollars for the year in which they would have occurred had the project been completed in January 1979. The inflation rate used throughout this study is 7%. As a sample calculation, the first year costs of \$680,000 (1979\$) for Retrofit #1 would be deflated by a factor of $(1.07)^{2.5}$ to \$557,294 (mid-1976\$).

Retrofit Alternative	#1	#2	#3	#4
First Year (000's-mid 1976\$)	\$ 557	\$ 574	726	726
Second Year (000's-mid 1977\$)	3,740	5,683	11,050	11,953
Third Year (000's-mid 1978\$)	<u>6,090</u>	<u>6,796</u>	<u>18,764</u>	<u>19,741</u>
Total Capital Costs (000's-mixed \$)	\$10,388	\$13,053	\$30,540	\$32,320

The cost of interest during construction (IDC) is calculated by escalating each year's cash flows for capital expenditures by the cost of capital of the DHCS ownership arrangement. In the case of Toledo Edison ownership, company officials have stated that 7 3/4% would be the most appropriate rate to use for short-term construction funds. Therefore, the IDC for Retrofit #1 would be $[557,294 \cdot (1.0775)^{2.5} + 3,740,457 \cdot (1.0775)^{1.5} + 6,090,440 \cdot (1.0775)^{0.5}] - 10,388,191$. This mechanism for calculating IDC is consistent with methods employed by the Public Utilities Commission of Ohio (PUCO) to determine the appropriate capital figures to be entered into the rate base. The resulting IDC calculations for utility ownership are listed below:

	<u>Retrofit #1</u>	<u>Retrofit #2</u>	<u>Retrofit #3</u>	<u>Retrofit #4</u>
Total Capital Costs	\$10,388,191	\$13,053,304	\$30,540,234	\$32,320,746
IDC (for utility owner- ship assumptions - i.e., short-term financing at 7 3/4%)	787,056	1,046,551	2,165,775	2,292,764
Total to be entered into Rate Base (1979\$)	\$11,175,247	\$14,099,855	\$32,706,009	\$34,618,510

The 7 3/4% short-term financing assumption was also applied to the 9% city-backed revenue bond financing. An assumption of 7% short-term financing was made for the 7% city-backed revenue bond financing. The capital costs including IDC are then escalated at the rate of inflation to reflect the change in price levels from 1979 to the construction completion date.

Fuel Costs

The fuel cost component of the retrofit system can be calculated as the product of three terms:

- Projected steam consumption (10^6 Btu)
- Fuel effectiveness ratio or the annual 10^6 Btu heat input at the plant chargeable to steam divided by the annual 10^6 Btu delivered to the customer's gate
- Coal price (\$/ 10^6).

Table 1-A (page A-5) displays the customer energy consumption data generated in Task 3. Summing the appropriate rows of the far right column gives the projected steam sales for any retrofit alternative.

The derivation of the fuel effectiveness ratio is provided on page A-6. The first row of figures is based on Table 1-A. The second row of data was supplied by Stone and Webster. The fuel effectiveness ratio is simply the second divided by the first.

TABLE 1-A EXISTING AND POTENTIAL NEW CUSTOMER PRESENT
ENERGY SOURCE, RETROFIT NUMBER INCLUDED IN,
USER RETROFIT COST AND CUSTOMER ENERGY DATA *

Customer #	Present Energy Source	Retrofit #'s	User Retrofit** Cost	Present Energy Consumption (10 ⁶ Btu's Purchased)	Projected Steam Con- sumption (10 ⁶ Btu's Purchased)
Existing Steam Customers	Steam	1,2,3,4	\$ 0	433,000	433,000
1	Coal	3,4	113,000	920,000	644,000
2	Gas	1,2,3,4	4,000	2,321	1,787
3 }	Gas	1,2,3,4	8,066	5,121	3,943
3 }	Oil	1,2,3,4	8,934	4,672	3,598
5	Gas	1,2,3,4	9,000	1,122	864
6	Gas	4	42,000	167,000	127,000
7	Oil	2,3,4	25,000	126,000	89,500
8	Gas	1,2,3,4	7,500	4,472	3,443
13	Gas	1,2,3,4	9,000	11,688	9,000
15	Oil	3,4	42,000	187,260	144,190
17	Electric	1,2,3,4	72,500	17,065	16,212
18	Electric	1,2,3,4	13,500	10,239	9,727
19	Electric	1,2,3,4	13,000	6,485	6,161
21 }	Gas	1,2,3,4	7,479	3,861	2,973
21 }	Electric	1,2,3,4	1,521	785	746
Totals			\$ 326,500	1,901,099	1,496,144

* User retrofit costs based on Stone and Webster data. All other information is from the Task 3 Final Report.

** For multi-fuel users, user retrofit costs are allocated on a Btu basis.

	<u>Retrofit #1</u>	<u>Retrofit #2</u>	<u>Retrofit #3</u>	<u>Retrofit #4</u>
Projected Steam Consumption	491,454	580,954	1,369,144	1,496,144
Heat Input Chargeable to Steam	488,564	577,538	1,472,196	1,634,361
Fuel Effectiveness Ratio	.994	.994	1.075	1.092

The 1979 price for industrial grade coal (i.e., washed) was reported as \$1.75 per million Btu's by a local supplier. However, since the coal used at Acme is purchased in unit trains and is not required to be a stoker grade coal, the price of the coal currently used there is only \$1.50 per million Btu's. It is assumed that the industrial grade coal and Acme coal will escalate at the same rate - their prices maintaining a ratio of 1.75 to 1.50. The coal prices referred to throughout the study reflect prices for the industrial grade coal.

Operating and Maintenance Costs

The operating and maintenance costs for the new system are composed of three elements:

- Standard O&M costs (including water treatment) chargeable to steam
- Administrative and general costs
- Customer accounting expenses.

Cost data for the first element were supplied by Stone and Webster. Estimates for the other two elements were derived by making the assumption that their costs were proportional on a Btu basis to the administrative and general costs and customer accounting costs under the existing steam system. In 1977 these costs totaled \$79,433. As for all non-fuel cost components, the 1977 figures are escalated to 1979 \$ by the inflation rate of 7%:

Retrofit Standard O&M		Other O&M (1977\$):		Total (1977\$)	Total (1979\$)
#	(1977 \$)	Btu's Retrofit	Btu's Existing Steam *\$79433		
1	\$228,600		\$ 89,759	\$ 318,359	\$ 364,489
2	270,300		106,440	376,740	431,330
3	689,000		251,008	940,008	1,076,215
4	764,900		274,838	1,039,738	1,190,396

Federal Income Taxes

The Federal income tax expense is estimated on the basis of a marginal tax rate of 48%. This assumption implies that the utility is already earning enough income from other sources to place it in the 48% bracket. (As explained in the assumptions section, recent legislation has changed the corporate income tax rate to 46%.) The amount of federal taxes paid is equal to the federal income tax rate times the difference between the revenue requirement and tax deductible expenses. The federal income tax expense is at the same time equal to:

$$\frac{\text{Tax Rate}}{(1 - \text{Tax Rate})} * (\text{Common stock dividends} + \text{preferred stock dividends}).$$

Property Taxes

From the conclusions drawn in Task 5 concerning the new state law exempting all property taxes on those investments in the area of scarce fuel conservation, it is assumed that the new system will pay no property taxes.

Gross Receipts Taxes

As reported in Task 5, the new system will probably be subject to a gross receipts tax. It is assumed that this tax is equal to 4% of the revenue requirement.

Steam Price Calculation

The revenue requirement is then equal to the sum of all seven of the above cost components. The regulated price for thermal energy in the new steam system equals the above revenue requirement divided by the projected

steam consumption.

User Life Cycle Savings Calculation

The life cycle savings of the proposed project accruing to any single user is essentially equal to the energy costs that the user would have incurred had he retained his present fuel system less the energy costs associated with the new system less the user retrofit costs associated with the switch over to the new system. The detailed calculation of these savings is a combination of seven elements:

- Present value factor
- Tax rate
- Previous fuel consumption
- Price of previous fuel
- Annualized user retrofit cost
- Projected new steam consumption
- Price of the new steam.

These elements are related in a functional way by the following formula:

Present value of system savings for any one year =

$$\begin{aligned} &\text{Present Value Factor} \times \sum_{\text{for all customers}} (1 - \text{Customer Tax rate}) \times \left[\left(\text{Previous fuel consumption} \times \text{Price of previous fuel} \right) - \right. \\ &\quad \left. \left(\text{Projected new steam consumption} \times \text{Price of new steam} \right) - \text{Annualized user retrofit cost} \right] \end{aligned}$$

Present Value Factor

The present value factor is a mechanism that is used to relate cash flows that occur during different periods of time. Unless otherwise noted, all dollar amounts used in this study are in terms of 1979 \$'s, i.e., the savings associated with each year in the lifetime of the project are all "brought back" or discounted to the common base year of 1979. The formula

for the present value factor employed in this study is:

$$\text{Present value factor} = \left(\frac{1}{(1 + \text{user discount rate})} \right)^{(\text{Year of Savings} - 1979)}$$

The user discount rate is an input parameter linked to the set of assumptions or conditions being investigated at the time.

Tax Rate

Most users must share with the federal government any savings (or any losses) that result from a switch to the new steam system. The federal income tax expense is estimated on the basis of a marginal tax rate of 48%. This assumption implies that the user is already earning enough income from other sources to place it in the 48% bracket.

Not all customers are subject to federal income taxes. Non-profit organizations (users #2, #5, #7, and #15) are all assumed to be exempt. In the existing steam system, it is assumed that the proportion (on a Btu basis) of exempt users in 1977 will remain constant over the lifetime of the investment. This proportion is roughly 15%. Exempt users would not be permitted the 10% energy tax credit on the retrofit that is allowed to the non-exempt users.

Previous Fuel Consumption

Information concerning previous fuel consumption is provided in Table 1-A. It is based on the customer analysis completed in Task 3.

Price of Previous Fuel

Oil, natural gas, coal, and electric prices are started at a 1979 base and then escalated at the rates prescribed by the fuel price scenario being investigated at the time. Except for natural gas, energy prices were obtained from local supplies or utilities.

Fuel Prices: \$/10⁶ Btu at Gate

<u>Fuel</u>	<u>1979 Base Rates</u>
Natural Gas	\$ 3.26
Oil (#2)	2.96
Coal (industrial)	1.75
Electric	\$14.80

The \$3.26 figure for natural gas is based on the assumption that by the time the project starts the price of natural gas will be 10% over whatever price is being charged for oil at that time. Linkage of natural gas prices to petroleum prices is clearly the intent of the recently passed NGPA (Natural Gas Policy Act) toward industrial and commercial consumption of natural gas.

The fifth energy source that could be potentially replaced by the new Acme steam system is the existing Water Street steam system. The forecasted price for steam that would be produced over the next thirty years at Water Street for existing customers is the sum of three components:

- fuel costs
- general O&M costs
- gross receipts taxes.

The fuel cost component is calculated in much the same fashion as it was earlier for the new Acme steam system. Total fuel costs are a product of three terms: 1) the total customer consumption or Btu's purchased; 2) the fuel effectiveness ratio or the ratio of Btu's purchased by the plant to the Btu's purchased by the steam customer; and 3) the price of fuel. Customer consumption figures are based on Table 1-A. Toledo Edison records indicate that in 1977, 762,000 million Btu's were purchased by the plant, while 433,000 million Btu's were sold to customers. The resulting fuel effectiveness ratio of 1.76 was assumed to remain constant over the twenty-five year period of the analysis. The fuel used at Water Street is #6 oil. Since the oil prices referred to in this study reflect #2 oil prices, the assumption is made that the present ratio of #6 oil price to #2 oil price would remain constant over the lifetime of the investment decision. Based on information provided by local oil suppliers, that ratio is currently 2.47/2.96.

General O&M costs for the existing system are based on 1977 operating figures for the Water Street station. They were provided by Toledo Edison and are presented below.

<u>Account</u>	<u>1977\$'s/10⁶ Btu*</u>
Power	\$.76
Distribution	.33
Customer Accounting	.02
Administration and General	.18
Property Tax	.28
Depreciation	.40
Total	\$1.97

These costs are assumed to escalate at the rate of inflation. The depreciation charge of \$.40 represents an adjustment in the 1977 figure of \$.70. The modification was made in order to reflect the changes that were expected to be made in both the depreciation methods and base during the 1980's.

Annualized User Retrofit Cost

The annualized user retrofit cost is equal to the annual equivalent payment that would be required to finance the user's retrofit expenses over the entire twenty-five year lifetime of the project. The estimates of the user retrofit expenses were provided by Stone and Webster and are listed in Table 1-A. As discussed in Task 5, profit-making customers would probably be entitled to take a 10% energy tax credit on their retrofit expenses.

Projected New Steam Consumption

Information concerning previous fuel consumption is provided in Table 1-A. It is based on the customer analysis completed in Task 3 and on the following fuel efficiencies: .77 for natural gas and oil, .70 for coal, and .95 for electricity.

* Toledo Edison records maintain the Water Street statistics on the basis of dollars per thousand pounds of steam. The company provided a conversion factor of 1.14 million Btu = 1000 lbs of steam to adjust the statistics. This conversion factor is based on engineering performance data and is system specific.

Price of New Steam

The regulated price of steam produced by the new system was calculated in an earlier section.

B-1

TABLE 1-B

DOE/TED DISTRICT HEATING/COOLING STUDY

CASH FLOW FOR CAPITAL EXPENDITURES

1979 \$ X 1000

Alternate No.	A3(f1)	A3(f2)	A3(g1)	A3(g2)
First Year	660	680	860	860
Second Year	4,140	6,290	12,230	13,120
Third Year	6,300	7,030	19,410	20,420
TOTAL	<u>11,100</u>	<u>14,000</u>	<u>32,500</u>	<u>34,400</u>

B-2

TABLE 2-B

DOE/TED DISTRICT HEATING/COOLING STUDY
LOSS OF ELECTRICAL GENERATION AT ACME STATION

Alternate No.	Loss in MW
A3(f1)	19.2
A3(f2)	23.8
A3(g1)	55.5
A3(g2)	60.4

NOTE: These losses are based on the maximum hourly output of steam for each of the four alternates.

TABLE 3-B

DOE/TED DISTRICT HEATING/COOLING STUDY

(TABLE 7-4)

ENERGY SAVED BY THE PROPOSED
DISTRICT HEATING SYSTEM
(10⁶ Btu/Yr)

<u>Alternate</u>	<u>Present Energy Input</u>		<u>Energy Used By Proposed DHS</u>	<u>Energy Saved</u>
	<u>For Steam</u>	<u>For Elec. Power</u> ¹		
A3(f1) •	900,196	419,372	907,936	411,632
A3(f2)	1,026,196	495,746	1,073,284	448,658
A3(g1)	2,133,456	999,197	2,471,393	661,260
A3(g2)	2,300,456	1,052,428	2,686,789	666,095

¹Based on estimated electric power generated by cogeneration at the average 1977 Acme heat rate of 13,600 Btu/kwh

TABLE 4-B

DOE/TED DISTRICT HEATING/COOLING STUDY

(TABLE 7-5)

FUEL CHARGEABLE TO STEAM
(10^6 Btu/Yr)

<u>Alternate</u>	<u>Energy Sendout</u>	<u>Energy Input For A Steam Only Plant</u> ¹	<u>Energy Saved</u> ²	<u>Fuel Chargeable To Steam (FCS)</u>	<u>Ratio of FCS To Steam Only Plant</u>
A3(f1)	605,963	750,697	262,133	488,564	0.65
A3(f2)	716,317	887,410	309,872	577,538	0.65
A3(g1)	1,688,155	2,111,274	639,078	1,472,196	0.70
A3(g2)	1,844,746	2,311,463	677,102	1,634,361	0.71

¹Based on efficiency of 80.72 percent for steam generated by No. 16 Boiler and 77.76 percent for requirements in excess of No. 16 Boiler capacity

²Energy saved by cogeneration

TABLE 5-B

DOE/TED DISTRICT HEATING/COOLING STUDY

ANNUAL HEAT LOADS

DATA FROM BATTELLE STUDY AND TEDCO

	Customer Requirements (10) ⁶ Btu/Yr	Line Losses @ 23.3 %	Heat Output From Acme (10) ⁶ Btu/Yr
Existing Downtown System	433,000	100,889	533,889
Nine New Customers			
2. 2321 x .77	1,787		
3. 9793 x .77	7,541		
5. 1122 x .77	864		
8. 4472 x .77	3,443		
13. Allowance	9,000		
17. 17065 x .95	16,212		
18. 10239 x .95	9,727		
19. 6485 x .95	6,161		
21. 3861 x .77	2,973		
785 x .95	746		
	<u>58,454</u>	13,620	72,074
Total For A3(f1)	491,454	114,509	605,963
Customer No. 7			
126,000 x Ave .77 & .64	<u>89,500</u>	<u>20,854</u>	<u>110,354</u>
TOTAL For A3(f2)	580,954	135,363	716,317
2-Customer			
15. 187,260 x .77	144,190		
1. 920,000 x .7	<u>644,000</u>		
	788,190	<u>183,648</u>	<u>971,838</u>
TOTAL For A3(g1)	1,369,144	319,011	1,688,155
Customer No. 6			
167,000 x (.77 & .64)	127,000	29,591	156,591
TOTAL For A3(g2)	1,496,144	348,602	1,844,746
	373		

TABLE 6-B

DOE/TED DISTRICT HEATING/COOLING STUDY

FUEL AND O&M COSTS

ALL COSTS ARE IN 1977 DOLLARS

Alt.	Energy Chargeable To Steam (FCS) (10 ⁶ Btu/Yr)	Fuel Cost @ \$1.17/(10) ⁶ Btu \$ x 1,000	O&M At Acme 40% x Fuel Cost	Water Treatment		Total Oper. Cost (Fuel & O&M) \$/Yr	O&M For Transmission & Distribution \$/Yr
				Flow Per Year	Cost @ 60¢/1000 Gal.		
A3(f1)	488,564	571.6	228.6	482,709,000 Lbs/Yr 58,000 x (10) ³ Gal/Yr	34.8	\$ 835,000	\$134,400
A3(f2)	577,536	675.7	270.3	570,617,336 Lbs/Yr 68,501 x (10) ³ Gal/Yr	41.1	\$ 987,100	\$147,600
A3(g1)	1,472,196	1722.5	689.0	1,345,010,000 Lbs/Yr 161,586,000 Gal/Yr	97.0	\$2,508,500	\$238,360
A3(g2)	1,634,361	1912.2	764.9	1,473,865,600 Lbs/Yr 176,574,500 Gal/Yr	105.9	\$2,783,000	\$250,800