DISTRICT HEATING AND COOLING

Vol. 72-No. 4
2nd Quarter 1987

Development of District Heating in Buffalo

Also in This Issue:

- Free World's Largest System—NYC's Con Edison
- Military Village Links with German Neighbor
- Trends and Aspects in DHC—A View From Denmark
- Marketing Workshop
- Nashville DHC System

78th Annual Conference Technical Program

See p. 26A

$36 Million Expansion

Municipal Waste Fuel District Heating & Cooling System Nashville, Tennessee

John Wimberly, P.E.
I.C. Thomasson Associates, Inc.
Consulting Engineers
Nashville, Tennessee

Glenn A. Swinehart; P.E.
Catalyst Thermal Energy Corporation

Abstract

In 1974 Nashville Thermal Transfer Corporation initiated the first district heating and cooling system to provide uninterrupted service using municipal solid waste as the dedicated fuel. Thirteen (13) years of successful operation combined with the dynamic growth of the Nashville Metropolitan area led to the recent system expansion.

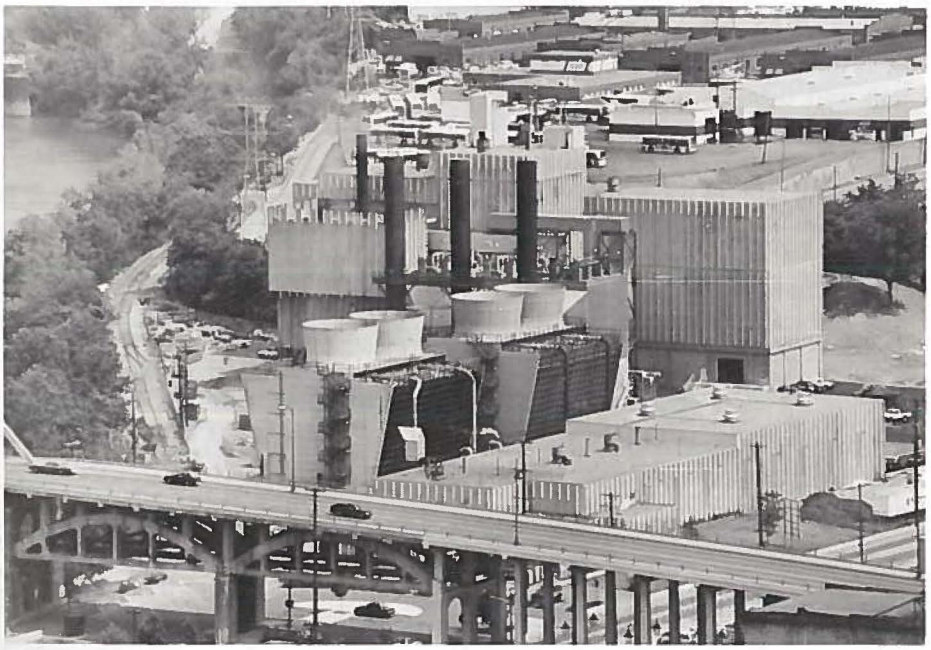
The expansion was completed in 1986 to provide steam and chilled water service to eight (8) new customers which include banks, office buildings, a new state office building, convention center and hotel. The number of buildings served was expanded from 29 to 37.

The waste burning capacity was increased from 720 tons/day to 1120 tons/day. Steam generating capacity was increased from 160,000 lbs/hr to 250,000 lbs/hr and chilled water production capacity was increased from 13,500 tons to 27,000 tons.

The distribution system was expanded by more than 7150 lineal feet to a system total of approximately 4.2 miles. The new distribution piping is installed in a 8.5 ft. diameter tunnel which was bored approximately 40 ft. below grade.

Cogeneration of electricity was also included in the expansion to fully utilize the facility's 1120 tons/day waste burning capacity. A 7.3 MW steam turbine generator produces power which is sold to the Tennessee Valley Authority.

Nashville Thermal Energy Corporation Hosts Marketing Committee Tour



Representatives of the Nashville Thermal Energy Corporation, hosted a tour and discussion session for IDHCA Marketing Committee Workshop attendees. This system produces steam and chilled water using municipal refuse for more than thirty buildings in downtown Nashville. It's an excellent example of DHC and waste-to-energy technologies working together for the good of the community.

Introduction/Background

Unlike many resource recovery projects which are prompted by landfill problems, Nashville's refuse-fired district heating project was developed primarily to provide energy for the City's central business district. The city first identified an energy demand, and then developed a plan for using municipal waste as the fuel to meet the demand. At the time of the project's inception in 1969, a number of city and state office buildings were confronting the need to replace their boilers. The idea for a new central heating and cooling system for these buildings was then extended to a plan to service the entire downtown area. Initiated as part of a downtown urban renewal program, the Nashville project was originally envisioned as a district heating and cooling facility that would generate steam using oil and gas-fired boilers with electrically driven centrifugal steam using oil and gas-fired boilers with electrically driven centrifugal water chillers. Preliminary designs had already been started when it was decided that the plant was to be a refuse-fired facility, based on

European resource recovery technology. The city of Nashville commissioned a study to assess the feasibility of a dual-purpose project that would incorporate both district heating and cooling for the central business district and the provision of solid waste disposal services based on resource recovery for Nashville and Davidson County.

As the commissioned study was being conducted on the proposed project, the advantages of resource recovery over landfilling of solid waste became obvious. After a thorough analysis of the feasibility of developing a refuse-fired district heating-cooling system, resource recovery equipment and designs were chosen and the Nashville project became the first operation in the country to combine the technologies of waste incineration with steam and chilled water production.

Since that beginning, the not-for-profit private corporation governed by a Board composed of representatives from the city, state, and private sector has demonstrated its ability to handle the complex issues connected with converting waste into energy and delivering that energy on a reliable basis to customers.

Finally and very importantly, the facility, which has burned more than 1,800,000 tons of Nashville's solid waste to date, is economically viable. Therefore in 1984, the city counsel voted unanimously to expand the plant.

Purpose of Expansion

The downtown Nashville area is experiencing growth sparked by the revitalization of the business district and the need for new office space. A new downtown convention center opened in early 1987 and an adjoining hotel will open later this year. A new financial center has already been completed in addition to several major new office buildings. These new buildings, as well as several existing buildings, will benefit from heating and cooling services from the new facility based on cost comparison studies prepared for individual buildings.

Studies of new buildings and existing buildings not connected to the plant indicated that there was sufficient additional load in the downtown area to justify major expansion in the output capacities of the facility's solid-waste-fueled heating and cooling. These studies showed significant benefits to the buildings from service from the central plant. New buildings added to the loop will soon be utilizing 100% of the capacity added by the expansion.

Converting more of Nashville's waste into energy at the facility will reduce the very critical need for landfill. Energy revenues generated from the sale of steam, chilled water, and electricity will keep the cost of waste disposal at a reasonable level.

Waste Processing Capacity

Prior to the expansion, the plant processed 482 tons/day of the total 1400 tons per day of burnable waste generated in the Nashville area. This represents 34% of the burnable waste generated in Metro (Davidson County). The other 66% was being trucked to a landfill.

In 1987, the first full year of operation for the expanded facility, Metro is projected to generate 1425 tons per day of burnable waste. The plant will process 98% more waste than in previous years.

The impact of the expansion will be felt in the shift of the major disposal center from the landfill to the plant which is more centrally located. In 1987, the plant will handle 952 tons per day, seven days per week, or 67% of the burnable waste.

Energy Marketing

In 1985, the plant served 29 public and private buildings in downtown Nashville with steam for heating and chilled water for cooling. Several of these buildings, including a major hotel and a State office building and performing arts center, have no other sources of heating and cooling. A provision for interruptible rates was necessary to sign buildings whose existing systems were operating satisfactorily. The plant is delivering steam and chilled water to existing customers on a reliable basis at rates competitive with other energy sources. The first rate increase in five years, an increase of 3%, was instituted by the plant's Board of Directors in 1986.

The completed expansion, serves a total of 7.5 million square feet of air conditioned space. The new customers signed to date have a combined steam demand of 93,920 lb/hr and a demand for chilled water of 7765 refrigeration tons. Approximately 48% of the new steam demand and 53% of the new chilled water demand is interruptible.

In addition to steam and chilled water production, the expanded plant cogenerates electricity with a 7.3 MW steam turbine-driven generator. Based on projected steam production in 1987, 30,844,000 kwh of electricity will be produced for sale to the regional utility. Sales in 1987 should amount ot $1,098,000 according to the utility's current rate schedule for purchasing cogenerated electricity. Revenues from the sale of steam and chilled water to new customers plus electricity sales are estimated to increase total plant energy revenue of 47,110,854 in 1987. Table 1 shows existing and projected plant performance.

System Expansion

In order to meet the anticipated demand, the following major equipment was added:

1. One 400 tons/day waterwall-type, mass burning incinerator-boiler capable of generating 90,000 pounds per hour of 400 psig, 600 F steam.
2. Two 6750-ton steam turbine-driven centrifugal chillers for production of chilled water.
3. One 7.3 MW steam turbine-driven generator for cogeneration of electricity.

These additions bring total solid waste burning capacity from the three units to 1120 tons/day with a steam-generating capacity of 250,000 lb/hr. Total chilling plant capacity from the four units is now 27,000 tons.

The truck bridge, waste storage pit, and incinerator building were expanded to accommodate the new

TABLE 1

Existing and Projected Operating Results

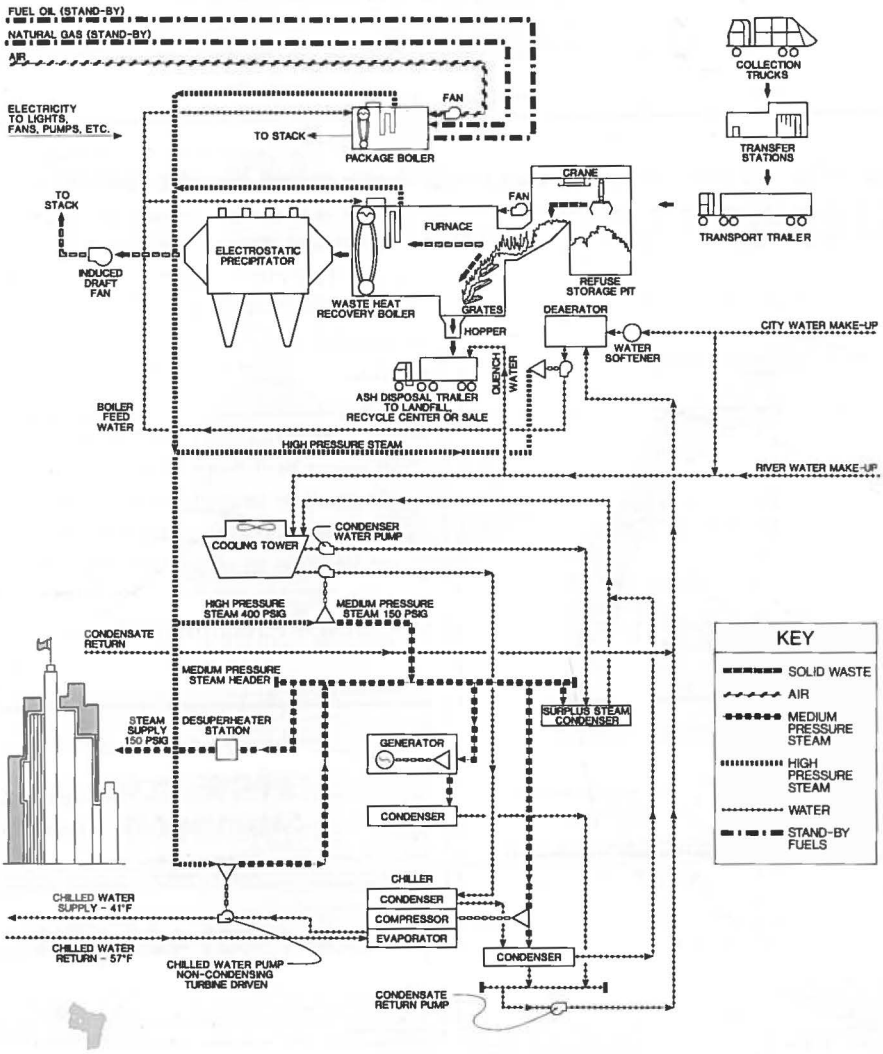
Revenues ($ Millions)	1985	1986*	1987*	1988*
Steam	1.8	1.8	2.5	3.1
Cooling	2.6	2.7	3.6	4.9
Electricity			1.1	1.3
Annual Payment from City**	2.5	2.5	2.5	2.5
Interest Income on Reserve Fund	0.5	0.8	0.8	0.8
TOTAL REVENUES	7.4	7.8	10.5	12.6
Expenses ($ Millions)				
Operating	3.6	4.3	5.0	5.3
Debt Service	1.5	2.0	2.4	6.5
TOTAL EXPENSES	5.1	6.3	7.4	11.8
Net Income	*2.3*	*1.5*	*3.1*	*0.8*

*Projected

**For disposal of waste. Average disposal cost over last five years—$11.39/ton.

FIGURE 2

Flow diagram of district heating, cooling, and cogeneration plant fueled by municipal solid waste



incinerator-boiler and its auxiliary equipment. A new electrostatic precipitator was added to control emissions from the new unit. A major objective of the design of the expansion is to assure continued environmental acceptability of the facility.

Approximately 2.5 acres of land adjacent ot the existing incinerator building was acquired for the expansion bringing the total area of the site to ten acres. The chilling plant building was expanded to house the new chillers and turbine generator and their auxiliary equipment including a computerized control system. A new two-cell cooling tower was constructed to accommodate the new chillers and turbine generator. A flow diagram of the overall process is shown in Figure 2.

The distribution system was expanded to provide service to the new customers, and two loops were formed to permit backfeeding if necessary during repairs. The expansion includes 7150 linear feet of new distribution piping, bringing the total distribution system to approximately 4.2 miles as shown in Figure 3. Steam and chilled water piping were routed through an 8.5-ft diameter tunnel drilled specifically for the district heating and cooling system as shown in Figure 4. This expedited installation of the piping and caused no disruption of traffic. The piping and valves are also more accessible in the tunnel than if the streets had been excavated and the lines had been direct buried.

Fast track design and construction of the expansion was completed within a period of twenty-four (24) months while keeping the plant in operation twenty-four (24) hours per day. Service requirements of the new buildings mandated close adherence to the construction schedule.

Economics

The total construction cost of the expansion is expected to be $36,300,000 compared to a budget of $36,735,000. In fact, the second new chiller and the second distribution loop up Seventh Avenue were added when it became apparent that construction was proceeding sufficiently well within the

TABLE 1

Existing and Projected Operating Results

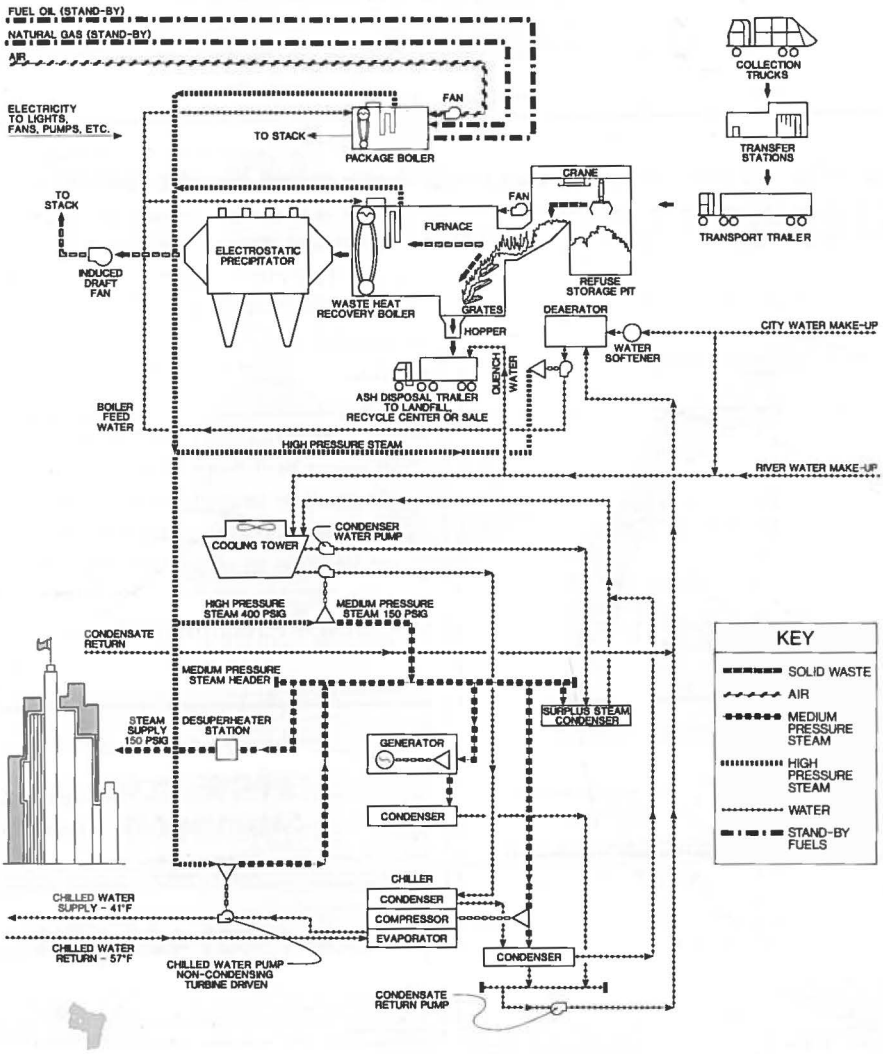
Revenues ($ Millions)	1985	1986*	1987*	1988*
Steam	1.8	1.8	2.5	3.1
Cooling	2.6	2.7	3.6	4.9
Electricity			1.1	1.3
Annual Payment from City**	2.5	2.5	2.5	2.5
Interest Income on Reserve Fund	0.5	0.8	0.8	0.8
TOTAL REVENUES	7.4	7.8	10.5	12.6
Expenses ($ Millions)				
Operating	3.6	4.3	5.0	5.3
Debt Service	1.5	2.0	2.4	6.5
TOTAL EXPENSES	5.1	6.3	7.4	11.8
Net Income	*2.3*	*1.5*	*3.1*	*0.8*

*Projected

**For disposal of waste. Average disposal cost over last five years—$11.39/ton.

FIGURE 2

Flow diagram of district heating, cooling, and cogeneration plant fueled by municipal solid waste



incinerator-boiler and its auxiliary equipment. A new electrostatic precipitator was added to control emissions from the new unit. A major objective of the design of the expansion is to assure continued environmental acceptability of the facility.

Approximately 2.5 acres of land adjacent ot the existing incinerator building was acquired for the expansion bringing the total area of the site to ten acres. The chilling plant building was expanded to house the new chillers and turbine generator and their auxiliary equipment including a computerized control system. A new two-cell cooling tower was constructed to accommodate the new chillers and turbine generator. A flow diagram of the overall process is shown in Figure 2.

The distribution system was expanded to provide service to the new customers, and two loops were formed to permit backfeeding if necessary during repairs. The expansion includes 7150 linear feet of new distribution piping, bringing the total distribution system to approximately 4.2 miles as shown in Figure 3. Steam and chilled water piping were routed through an 8.5-ft diameter tunnel drilled specifically for the district heating and cooling system as shown in Figure 4. This expedited installation of the piping and caused no disruption of traffic. The piping and valves are also more accessible in the tunnel than if the streets had been excavated and the lines had been direct buried.

Fast track design and construction of the expansion was completed within a period of twenty-four (24) months while keeping the plant in operation twenty-four (24) hours per day. Service requirements of the new buildings mandated close adherence to the construction schedule.

Economics

The total construction cost of the expansion is expected to be $36,300,000 compared to a budget of $36,735,000. In fact, the second new chiller and the second distribution loop up Seventh Avenue were added when it became apparent that construction was proceeding sufficiently well within the

FIGURE 3

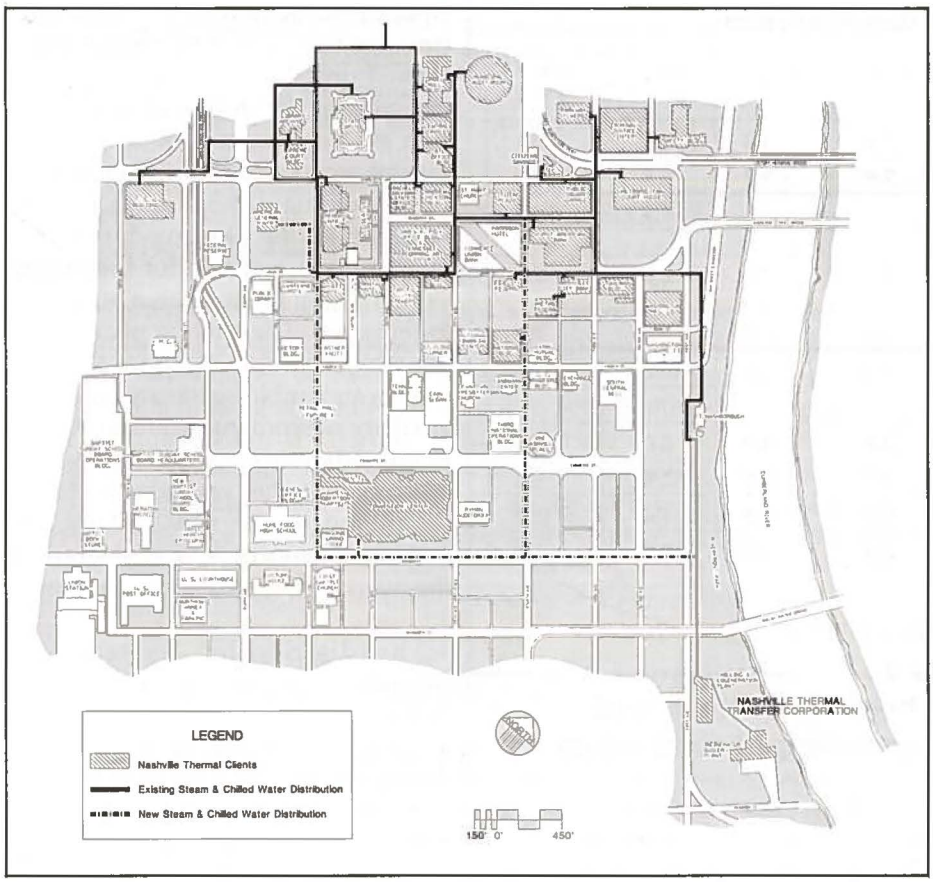
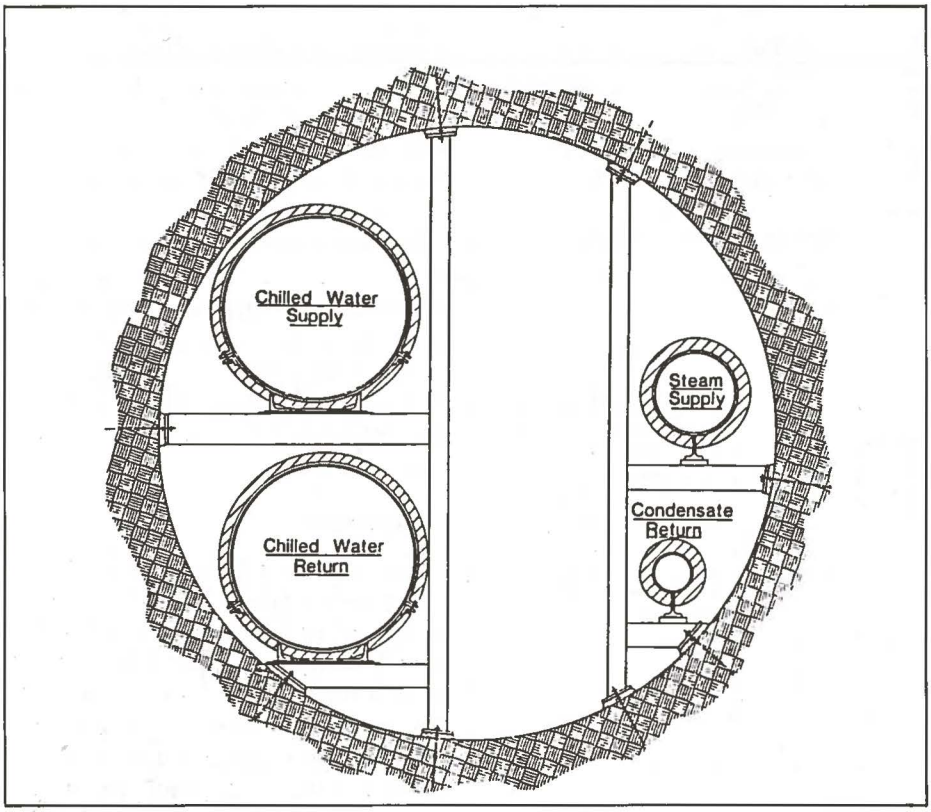


FIGURE 4

Cross section of Nashville's distribution tunnel



original budget to permit the expenditure of another $6,000,000 for these additions.

Financing for the project was arranged through the city, utilizing revenue bonds payable over thirty (30) years. Security for the revenue bond financing is from steam and chilled water revenues from the additional buildings connected the expanded system, from electricity sales for the cogeneration plant, and from city payments for disposal of additional quantities of waste. A summary of projected operating results is included in Table 1.

Conclusions

Expansion of the Nashville refuse-fired district heating and cooling plant is economically sound. The capital cost of the expansion and the additional operating and maintenance costs are covered by revenues generated by the expanded plant.

Economies of scale permit the expanded plant to process waste more cost effectively, benefiting both the city and the plant's energy customers. Rates for purchased steam and chilled water are projected to increase more slowly than the customer's cost of generating these commodities in-house. The city's need for new landfills is diminished due to disposal of increased quantities of waste at the facility.

Completion of the expansion provides additional low-cost heating and cooling to buildings downtown plus cogeneration of electricity. Revenues derived from these sources permit the plant to burn more of the city's waste at a reasonable cost per ton, reducing landfill space requirements.