DISTRICT HEATING

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NEW DISTRICT HEATING-COOLING PLANT IN NASHVILLE, TENNESSEE

A new solution to the solid waste disposal problem was offered to the nation's cities recently when the mayor of Nashville, Tenn., disclosed details of the first plant designed to convert community refuse into chilled water and steam for year-round space conditioning.

Mayor Beverly Briley said his City will begin operation early in 1974 of a $17 million mid-city cooling and heating plant using solid waste as the fuel (construction of the plant has begun). Chilled water and steam will be sold to defray operating costs.

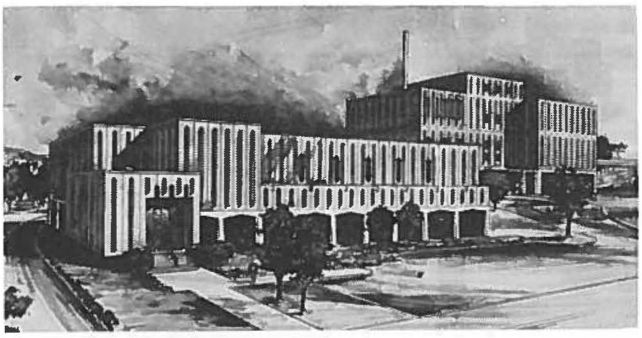

FIG. 1—Artist's rendering of the Nashville Thermal Transfer Corporation plant under construction near downtown Nashville, Tenn. Community solid waste will be incinerated in the building at right to produce steam for heating and for driving the turbines powering two large Carrier water chilling machines located in the building at left.

Just eleven years ago, the Hartford, Conn., Gas Company began operation of the world's first plant designed to sell chilled water for air conditioning central city buildings. This concept, known as district cooling, is now a reality in some 18 cities across the country.

In 1969, the City of Nashville retained the engineering firm of I. C. Thomasson and Associates to determine the feasibility of constructing a centrally located, conventionally fueled facility which would provide heating and cooling for metropolitan government buildings.

The Thomasson study proved that such a plant would be economically sound, and went one giant step further. It suggested that the plant be built to provide chilled water and steam for the entire downtown area, coordinating it with the urban renewal project already underway. The timing was right because streets would be torn up anyway, and the district plant's distribution system would require 15,000 ft of trenching.

The idea of using solid waste as a fuel is not new. One of the first steam-producing refuse incinerators was installed in Manhattan in 1903. Those early incinerators fell far short of their promises because of operating difficulties and air pollution, but modern technology has all but eliminated these problems. The complete absence of odors and the most stringent air pollution control criteria are an essential part of incineration engineering.

Incineration with steam generation has proven to be a satisfactory and economical solution to refuse disposal in Europe, despite that continent's very tough air pollution control. The first such plant began operation in 1954 in Bern, Switzerland, and now most modern European plants combine incineration with steam generation. Perhaps the finest plant of this type was recently opened in Montreal (Winter 1971 issue *District Heating).*

The value of these plants is just beginning to be recognized in this country. The Nashville plant is one of the first in the United States to be designed on a large scale, and will be the first in the world to produce both steam and chilled water as a method of making the plant pay its own way.

Historically, the cheapest way to dispose of solid waste was to dump it. We can no longer afford to misuse potentially valuable land, create possible health hazards, or upset the ecological balance by dumping our wastes in swamps. Each year about 200 million tons of municipal solid waste, or nearly 548,000 tons a day, are discarded in this country. If all this waste was steadily converted to steam it could power approximately 19,500,000 tons of cooling capacity, which is almost 20 per cent of the 100 million tons now installed in the U .S. To produce this much cooling electrically would require nearly 16 million kw, or twice the peak electric demand of New York City.

If all 200 million tons of community refuse were disposed of in sanitary landfills each year—and most of it is today—it would cost about $500 million and consume 60,000 acres of land. The use of solid waste as fuel should completely eliminate sanitary landfill operations.

There is a bright side to this mountain of trash, however. Solid waste is becoming a more dependable source of energy. We are consumers of disposable packages and seem destined to become even more so. The rapidly increasing paper content of today's municipal waste provides a thermal energy value of between 5,000 and 6,000 Btu's per lb, and is expected to increase 10 to 15 per cent in the near future.

On May 14, 1970, the Nashville Thermal Transfer Corporation was chartered under the laws of Tennessee. The original Board of Directors was composed of City Officials, and since that time several members of the State Government have been added.

The Corporation was given the power to issue tax-exempt revenue bonds, and is to turn the plant over to the City when the bonds are paid off. The Internal Revenue Service agreed to the tax-free status on the grounds that this plant is in the best interests of the people.

Approval by the Environmental Protection Agency and other federal agencies also paved the way for purchase from the General Services Administration of a seven-acre tract of land on the river near midtown. The land had been acquired by the Federal Government on a tax lien, and was sold to the City after three questions had been answered. The questions were: Is the plant in the best interests of the City? Will it keep pollution down? And, is this the best use for the land? The answers to all three were "yes."

The project could not have been accomplished without the cooperation of professional engineers, city administrators, lawyers, state officials, members of Congress, the interest and assistance of local businessmen and the invaluable help of financial institutions. Money to purchase the land from GSA was acquired from local banks in Nashville.

The use of conventional fossil fuels to produce the steam and chilled water would have made the local gas utility the logical plant owner and operator, as is the case in Hartford and other cities. But investigation showed that neither the gas utility nor electric utility possessed the requisite authority under the metropolitan charter. A charter referendum would have been necessary, and this would have taken time that was not available.

Several potential customers had already begun construction in the urban renewal area, and a sufficient number of customers were needed to make the project economically feasible. Because of this and other considerations, it was decided that a not-for-profit public corporation should be established to build and operate the plant. The cost of such a plant and distribution system was put at about $17 million.

With the groundwork of land acquisition accomplished, the task of selling the concept to customers was relatively easy. The key customer was the State Government, which had 12 buildings in the city—a 30-year contract was signed. The metropolitan government's four buildings, and 11 private facilities, have also agreed to purchase the service.

The cost of this service is expected to remain fairly constant as opposed to the steadily rising price of fossil fuels. And, as new customers are added and plant efficiency increases, these savings can be either passed along to the customers or used for some other public service.

At the same time that system costs were being worked out, a preliminary environmental impact statement was presented to and approved by the U. S. Environmental Protection Agency. The statement showed that the NTTC plant would not adversely affect city environment, and would in fact substantially improve that environment with respect to air pollution and a solid waste disposal.

Under the terms of the State Government's 30-year contract, solid waste will be delivered to the plant at no cost by the City's refuse collection service. The plant's central location will reduce considerably the hauling time and will result in a savings to the City of about $3 per ton of waste collected, or more than $1.25 million a year. The State, whose 12 Nashville buildings

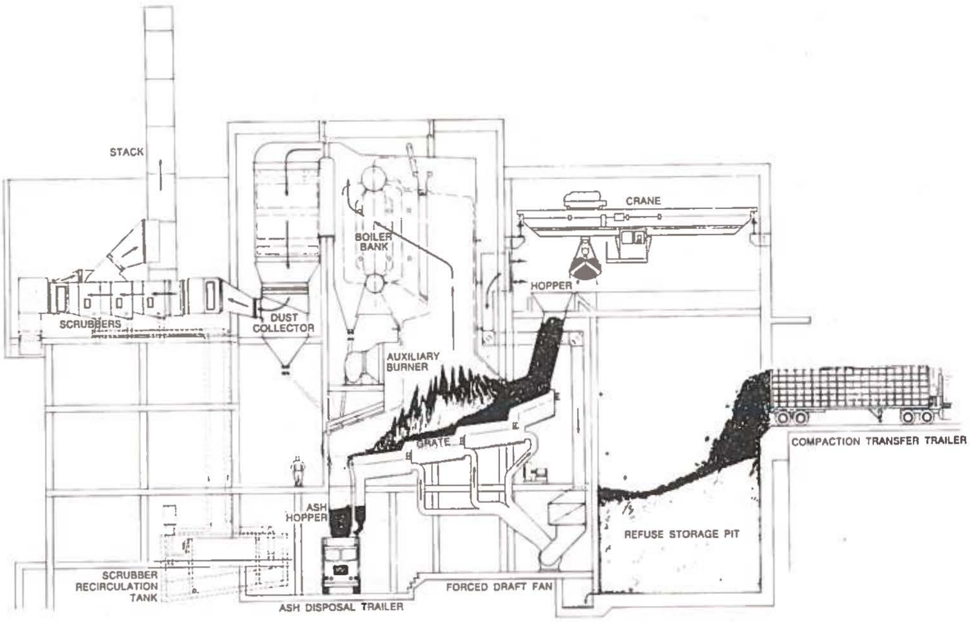

FIG. 2—Schematic diagram of one of the large incinerator-boilers. Solid waste will be delivered by truck (right) and dumped into a large refuse storage pit. An overhead crane will pick up the refuse in one-ton bites and deliver it to the charging hopper. Moving grates will carry the refuse through the combustion chamber, where heat rising from the burning waste will generate steam in the boiler bank. While solid residue falls into a hopper for removal by truck, fly ash will be removed from exhaust air by a dry cyclone collector and the remaining smaller particulates and gaseous pollutants will be treated in the three-phase wet scrubber.

(Continued)

will be served by the system, will save about $164,000 a year in costs of operating heating and cooling plants in its own buildings.

Solid waste will be delivered to the plant in compactor trucks and dumped into refuse pits large enough to permit weekend operation on deliveries made through the week. A crane will pick up this waste in one-ton bites and feed it into the multi-level incinerator-boilers. The crane operator is a key figure in the plant's operation. He must make sure that large noncombustible materials, such as engine blocks and major appliances, are removed from the waste before it is fed to the boilers. However, should such large objects inadvertently be fed to the furnace, they will be discharged with the ash without doing any harm.

Waste will be continuously fed into the incinerator by moving grates. Combustion air will be drawn into the plant through the waste storage rooms so that odors will be burned in the incinerator, thereby eliminating any potential odor problems. In addition, the furnace will be sealed and operated under a slight negative pressure to prevent the escape of dust and odors.

At 1,800 F, glass explodes into tiny fragments much like sand, and metal such as cans will be cleaned of paper and food particles. The sterilized metal can be easily removed from the ash for reclamation.

Emission standards for incinerators are limited to particulate emissions only, but the scrubber system will remove gaseous pollutants such as sulfur oxides, hydrogen chlorides, and other acidic components as well. Therefore, future constraints that may be applied to incinerator emissions are being anticipated.

For the final phase, when refuse will be delivered to the plant from all of Metropolitan Nashville, a new concept in refuse transportation will be required to avoid a traffic jam of garbage trucks.

Local route trucks throughout the county will deliver solid waste to three strategically located transfer stations instead of landfills. At these stations, refuse from many local trucks will be compacted into large trailers which will then deliver the waste directly to the NTTC plant. It is estimated that this will reduce travel by about 90,000 miles each year, keeping local trucks off the main roads and permitting them to return to their routes more quickly.

Sterile incinerator residue will be trucked to two new landfills, which will not require earth covering, or the residue will be sold. The U. S. Bureau of Mines has found that the recovery value of incinerator ash can be from two to three dollars per ton of solid waste burned, after payment of all owning and operating costs. The commercial uses of incinerator ash include roadbeds and building materials, and income can be derived from the sale of materials reclaimed from the incinerated refuse.

Steam will be generated in the boilers at 400 lb and 600 F, and piped to a second building on the property. This building will contain turbine-driven equipment such as the chillers and pumps. Non-condensing turbines on the pumps will reduce steam pressure to approximately 150 lb for use by the condensing turbines on the chillers. This dual usage will provide economical and efficient operation throughout the load range.

The second building will also house the computers which will monitor system operation and prepare customer billing. The use of computers will help eliminate the possibility of human error in plant operation.

Flue gases will be treated by the dry cyclones and scrubbers to remove pollutants. The residue of the incinerated waste will be discharged to an ash dump at approximately 250 F, and the hot ash will be quenched by bleed water from the scrubbers. This water will be lost through evaporation and by removal to landfill areas.

The plant's residue will contain less than five per cent combustibles and less than one per cent putrescibles, and can be considered sterile for all practical purposes. In other words, when the ash is trucked to landfills it will require no earth cover. Initially, the plant will have three 150-ft flue stacks above grade. Ultimately, there will be five stacks.

The plant has been designed so that its interior noise level will not exceed the 90 decibel level established by the Federal Government. Windows will be used sparingly, and sound attenuating materials are part of the interior building design to suppress sound escaping to the outdoors.

Total water demand requirements for the plant's first phase will be 1¾ million gal/day, or about two per cent of the City's 84-million gal capacity. Even so, this is less than the requirements of the plants that are being replaced. About 1¼ million gal of water/day will be needed for two cooling towers. Most of the balance will be for ash quench and scrubbers. Of the total water used by the plant, only 18,000 gal, or less than two per cent, will be fed back into the City's sanitary sewer system. This will be bleed water from the cooling towers, and from boiler blowdown and plant cleanup.

Even though the plant is located on the Cumberland River, no river water will be used, nor will any water be returned directly to the river. Thus, the Nashville plant will not pollute water sources in any way.

The NTTC plant has a contractual arrangement with the City to incinerate 720 tons of solid waste every day. In the event that not all of this refuse is needed as fuel, such as in the spring and fall when less steam is required, the excess steam will be rejected.

Conversely, should normal solid waste delivery be interrupted by such emergencies as incinerator repairs or a strike by refuse collectors, a standby gas and oil boiler has been incorporated in the plant to produce 125,000 lb of steam/hr. In addition, the boilers serving the incinerators also can be fired with gas or oil.

Among the many advantages of incineration over normal landfill disposal is the fact that incineration reduces the volume of solid waste by about 95 per cent; but equally important is the amount of energy that can be recovered. For comparative purposes, one ton of solid waste provides the same amount of energy as one third of a ton of coal, or 65 gal of No. 2 fuel oil, or 8,000 cu ft of natural gas. This much free energy will permit the Nashville plant to produce steam for about 70 per cent less cost than a fossil fuel plant, and chilled water for about 60 per cent less cost, when the ultimate planned capacity is in operation.

The plant will be expanded in two stages so that, within five years after start-up, it will have an ultimate capacity of about 1,300 tons of solid waste/day. This is roughly all the municipal refuse produced in Nashville and Davidson County.

Therefore, by 1978 the plant will be producing 500,000 lb of steam/hr in four incinerator-boilers, and 31,000 tons of cooling capacity in five large water chillers. The use of solid waste to produce this will save 140,000 tons of coal annually, or 2.4 billion cu ft of natural gas, or 20 million gal of No. 2 fuel oil. Because most of the individual systems that will be replaced are powered by electricity, it is estimated that the district plant will actually conserve more than 71 million kwhr each year. This is roughly the consumption of a residental area of 15,000 persons.

While the plant is being expanded to its ultimate size, new buildings will be constructed as part of the City's urban redevelopment effort. The Nashville plant's distribution system will be extended to these potential customers, and this should further reduce costs because of the increased load and improved utilization of steam.

Where possible, the primary and auxiliary equipment in the plant will be steam operated so the need for purchased utilities will be minimal. For example, the plant will supply steam energy for its own fans, pumps and feedwater heating; but it will not generate electricity for any buildings, since the TVA electrical rate for big building users is only 8 to 8½ mils, and this cannot be duplicated by an installation of this type. Electric generation may be attractive in other parts of the country, however.

A major feature of the incinerator operation is what is called "over-air." This simply means that considerably more air can be used than is normally required for combustion in conventionally fueled boilers. Use of a variable volume of combustion air will permit the maintenance of a furnace temperature of about 1,800 F, despite the uneven burning qualities of solid waste. This provides the most efficient burning of refuse, while keeping temperatures below 2,000 F at which nitrogen fixations can begin to occur.

The 27 buildings that will be served by the plant's initial phase now generate about 490,000 lb of particulate matter, and approximately 395,000 lb of sulfur dioxide *during the heating season alone.* By comparison, the NTTC plant's service for these same buildings will generate only 118,000 lb of particulates, and 36,000 lb of sulfur dioxide *annually.*

It is estimated that the annual pollution rate of the existing plants is nearly four times greater for particulates, and ten times greater for sulfur dioxides, than the annual rate for the new district plant.

The Nashville plant's system has been designed with a view to the future as well as to present State, Local and Federal Government criteria. For example, it more than meets the stringent standards for incinerators announced on December 23, 1971, by the Environmental Protection Agency. This limits municipal incinerators to eight hundredths of a grain of particulate matter per cu ft of exhaust gases. The NTTC plant actually will emit less than five hundredths on the average.

This will be accomplished in several ways. Auxiliary burners and "over-air" combustion will completely burn smoke particles so that fly ash will be the only particulate matter leaving the combustion chamber. Dry cyclone collectors will then remove particles above ten microns in size, which make up 30 to 40 per cent of all particulate emissions. Remaining particulates and gaseous pollutants will be treated in three-phase wet scrubbers.

Initially, when consuming 720 tons of solid waste per day in two Babcock & Wilcox incinerator boilers equipped with advanced pollution abatement devices, the steam produced by the recovered heat will be used to drive two Carrier water chillers. Two 6,750-ton centrifugal units are being built by Carrier for the plant.

In the first phase, chilled water at 40 F and steam at 125 lb/sq in. will be supplied through 2.9 miles of underground parallel piping. The condensed steam and hot water will be returned to the district plant in a constant cycle—each will be available throughout the year.

The customer will be billed according to the quantity of water and steam received, and the number of Btu's his building adds to the chilled water or subtracts from the steam. Because the fuel costs nothing and the equipment is centralized, customers will get their chilled water and steam for about 25 per cent less than they now pay for operating their own building systems.

The City is now seeking funds from the Office of Solid Waste Management for a comprehensive study of resource recovery. Because the City has retained title to all solid waste delivered to NTTC, the recovery and sale of ash alone could bring in up to $1 million a year.

In addition, the City will save about $3 per ton of solid waste collected, or more than $1.25 million a year, through reductions in sanitary landfill operation, and will realize another $72,000 savings annually in lower transportation costs.

Revenue bonds, which financed the operation, are guaranteed by contracts signed with the various customers. After bond retirement, the plant becomes City property and will continue to be operated in the same manner. It is expected that operating costs of the plant will become even lower as it expands.

The Nashville Thermal Transfer Corporation is headed by Farris A. Deep, who is also Director of the Metropolitan Planning Commission. The Secretary is Charles E. Griffith III, former Director of Law of the metropolitan government. General contractor for the plant is the Foster & Creighton Company, of Nashville, and the mechanical contractor is the Nashville Machine Company.

Mr. Maurice J. Wilson, Systems Design Consultant with I. C. Thomasson and Associates, said that the Nashville plant will produce steam for about 30 per cent of the cost of steam from fossil fuel plants, and chilled water for about 40 per cent.

Mr. Melvin C. Holm, Chairman of the Board, Carrier Corporation, said the combining of refuse incineration with the district cooling and heating concept is a major step toward true environmental control and energy conservation, and might be called "energy reclamation" because it will reclaim the energy contained in the things we throw away. □