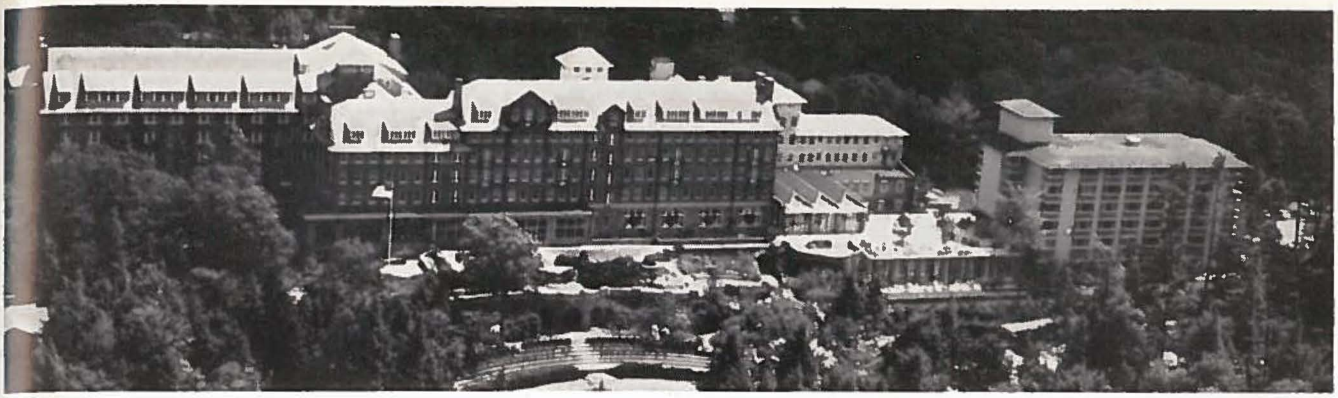

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DISTRICT HEATING

INTERNATIONAL DISTRICT HEATING ASSOCIATION

IDHA

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WASTE

HEATS VIENNA

The city's economy will benefit considerably from the incineration of garbage to produce steam sufficient to meet overall district heating needs and to provide electricity for the national grid.

by **DIPL. ING. FRANZ SWATY**
Commissioner
Vienna City environmental protection

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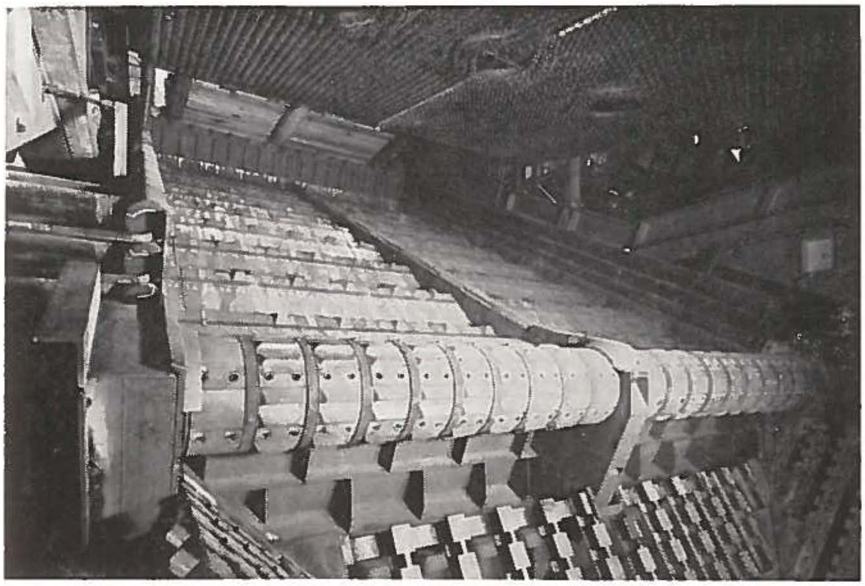
Vienna, the capital and at the same time a state of the Federal Republic of Austria, contains one quarter of the total population of the Republic of Austria. The development of the state and city administration has, amongst other things, led to statistical evaluation of the population flow thus permitting a regulation of economical factors which can be directly influenced by the city administration. For example, the administration provides electricity consumption expressed in round figures at 3.2 TWh/yr, gas consumption at 800 million cu metres/hr and the daily delivery of tap water both from the several hundred kilometres long service pipes as well as from the local ground water at 370 million litres/day.

Apart from delivery of energy for the population, the city has to administer hospitals with 22,000 beds and deliver their energy together with that for schools with 180,000 pupils, kindergartens with 20,000 children, and some 200,000 premises belonging to the city of Vienna. Problems of energy as well as those pertaining to the cost of heating, ventilating and air-conditioning are of course very important in such an enterprise since, excluding electric energy, the delivery of heat for the administrative sector requires 60,000 to 80,000 metric tons of liquid fuel plus some 25,000 to 30,000 metric tons of coal each year.

The general situation in the heating sector which until the Second World War comprised individual heating systems in private homes as well as in commercial buildings, has rapidly changed in structure after the War. Modernization of the hospitals, new school and kindergarten construction, as well as a wide range of social housing projects meant that a central heat distributing system became necessary; this led firstly to the creation of medium-sized heat distributing systems and during the last 10 years towards the large-scale district heating system now developed. At present, with a housing production in Vienna ranging between 10,000 and 12,000 units a year, all are being equipped with a central heating system.



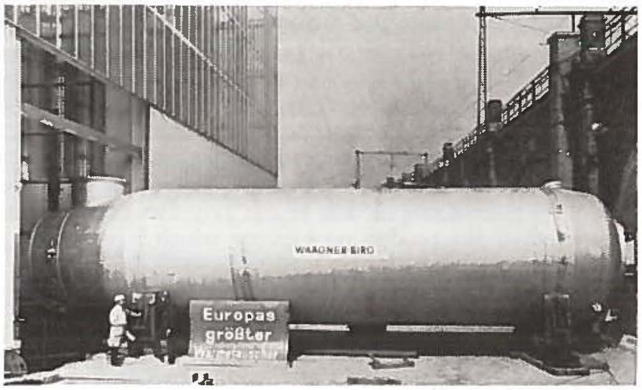
Special grates are used to ensure progressive and steady burning of the low calorific value fuel.

The development of this situation led to consideration of the idea of a district heating system covering all the requirements of the city of Vienna. The construction of the new general hospital as well as the new clinic of the Vienna Medical Faculty stressed the need for such a system. This new clinic has 2,500 beds and with full employment conditions, creates a human tide of 10,000 to 20,000 persons for professional as well as scholastic reasons; as it lies in a very densely built-up area of the city, it has to receive long distance energy delivery on a large scale. For the air-conditioning alone of this clinic, some 7 million cu metres/hr of air are used.

The thermal consumption at lowest ambient temperatures necessitates a maximum of approximately 100 Gcal per hour (116 MW), while for cooling in summer a delivery of some 40 Gcal per hour (46 MW per hour) will be necessary. The competent political bodies which authorized this construction decided accordingly that the heat production had to be undertaken outside the city area and a suitable site was found 2.5 km away from the clinic. After a detailed analysis of all the important factors, the conception of the 'Spittelau' large scale district heating plant was born, with a maximum attainable heat production of 250 Gcal per hour (290 MW). A heat production plant of this size should be capable also of meeting other needs of the city administration as far as possible. The last few years have shown that the incineration of waste is becoming more and more a task of the city administration. Vienna now annually produces quantities of waste amounting from 360,000 to 400,000 metric tons a year, with a heating factor of some 1,600 to 1,800 kcal/kg. If these quantities of waste could be burnt without any residue, they would produce enough heat to supply 50,000 premises. However, since this quantity of waste is spread over a whole year, during winter periods of low outside temperatures production must be based upon other primary energy sources while in summer the heat produced by burning waste must be used for other purposes, i.e. for technical heating in hospitals, for refrigeration in absorption units, for the production of hot water and for other industrial purposes. The production of such large heat volumes also presupposes that the necessary channels exist for feeding the plant and also for distributing the heat. An appropriate sub-division of the heat capacity permits a very economical distribution of heat and electric energy production.

Electricity Consumption

In the Federal capital more or less one-third of the electricity consumption has to be taken from the electricity network of the Republic of Austria, which is fed mainly by hydro-electric generators, while only two-thirds of the supply comes from city-owned power plants and from condensing plants. Such production takes place essentially in winter, so that the common production of heat and electricity in one plant should prove particularly economic.



Measuring 16 metres long with a diameter of 4 metres and a weight of 120,000 kg, the largest heat exchanger supplied for a European plant will cool the largest gas turbine installation yet supplied by Brown Boveri-Sulzer Turbomaschinen AG.

The Spittelau plant is thus based upon three principals:

1. Making use of the necessity of burning waste linked to the use of the heat produced during winter and supplying the necessary heat, and refrigeration by absorption units to hospitals in summer and using the remaining heat for industry would present the ideal solution.

2. Parallel production of heat and electricity for winter usage.

3. The highest heat consumption in winter when ambient temperatures are very low can be covered by simple hot water tanks which are easily serviced, have good heat emission and last but not least are very cheap.

The basis of planning therefore lay in establishing a good balance as far as the size and capacity of the plant is

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Conveyor system in Spittelau carries garbage from storage to feed the dual boilers. The two belts are interconnected to permit changeover in the event of breakdown.

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concerned, so that an economic solution could be found within the framework of the different sectors of the plant. To calculate the distribution of the maximum loads for the different units provisional heat consumption in a year had to be established. For the major consumer of heat, the general hospital, precise figures were available; for all other buildings within the delivery sector of the district heating plant assumptions had to be made. A detailed analysis of the structure of these consumers and the peculiarities of their consumption was established taking into account fluctuations between winter and summer, between working days and Sundays, as well as the peak points of consumption during the day. It was found that the characteristics of heat consumption of the different consumer groups resulted in a maximum heat production rate of 250 Gcal. The establishment of such a balance between all components is one of the main characteristics of all district heating plants and permits a more economic use of the long distance pipelines as well as of the production capacity which is involved.

More precise analysis of the consumer groups and of their expected characteristics enabled calculation to be made of the curve of heat consumption for the whole year, giving a provisional forecast of a total heat consumption of 650,000 to 700,000 Gcal yearly.

To meet this heat supply initially dependence was made only on the waste incineration plant of the size previously indicated. Since Vienna already had a waste incineration plant of some 120,000 to 140,000 metric tons/yr, it became absolutely necessary to build a second plant with a capacity of some 180,000 to 200,000 metric tons. The size of the waste incineration plant could be defined by taking into account the fluctuations between winter and summer as modified by the necessary servicing time during summer and its capacity could thus be calculated.

Daily Incinerating Capacity

The daily maximum incinerating capacity amounts to 720 metric tons equivalent to a maximum heat delivery value of 30 to 32 Gcal per hour, based upon the normal incinerating process. Two units would deliver this production capacity, so that even in summer with one unit being serviced or under repair a basic production of 15 Gcal per hour would remain available. Waste incineration thus provided a basis for heat production, and on the estimated consumption figures of the different enterprises, total heat production per annum based upon waste incineration was evaluated at 200,000 Gcal. This could cover from 25% to a maximum of 30% of the total heat necessary under full load. This upper limit cannot be raised, as it is based upon the heat load on the grate in an incinerating plant working under the highest load conditions. In more powerful waste incineration plants such as other cities have, the quantity of waste to be incinerated had to be somewhat reduced. The maximum heat production rate in waste incinerating plants must thus be considered as a constant.

To be able to guarantee a constant heat delivery if the waste quality is bad or if the furnace load burns too quickly, each waste incinerating unit also needs to be equipped with a combustion chamber for heavy fuel oil; these heavy oil combustion chambers permit a unit rise from 15 to 30 Gcal/hr and thus can give a combined heat capacity from waste incineration plus heavy oil of 60 Gcal per hr. The heat capacity due to waste incineration thus remains constant at about 30 Gcal per hour. With supplementary oil heating it is possible to maintain a constant steam pressure at constant temperature in the system so as to safeguard under all conditions the production of 2 MW in the steam-electric plant coupled to the waste incinerator. With the first waste incinerator, difficulties in running the plant came up when a constant steam delivery for a large laundry was necessary, as it was found very difficult to maintain a constant pressure in the steam system owing to the pipe connections causing changes.

Burning Used Coal

Also foreseen in this plant is the incineration of heavy waste after it has been reduced to small size as well as direct combustion of hospital waste. The problem of burning used oils can also be solved; the used oil is mixed with heavy fuel oil and burnt in the combustion chamber by means of a suitable oil burner care being taken not to exceed the maximum admissible thermal load in the combustion chamber during regulation of the steam system.

This waste incineration system therefore offered a solution for several problems in the city while the heat obtained could be used all the year round for the administrative buildings and for private consumption. More than 7,000 maximum load hours per year exist for each steam system, taking into account 6 to 8 weeks a year for servicing and repairs.

Many studies and analyses were necessary before deciding upon such a high cost system for combined heat and electric energy production. Projecting the heat delivery per annum and deducting the basic load of the waste heat, enables a heat curve to be derived for the process of heat delivery and after optimization a total capacity of 100 Gcal per hour is obtained for the combined production of heat and electric energy; some 4,000 to 4,200 high load hours present good economics. This heat production capacity of 100 Gcal per hour can, with normal thermal power processes, produce some 60 MW of electric energy; however, maximum heat production periods never coincide with peak electric energy production. If maximum electric energy of 60 MW is produced the low temperature return steam will give a maximum of 40 to 48 Gcal per hour in the heating system, while with approximately 100 Gcal per hour of maximum heat production the maximum electric energy figures vary between 40 and 45 MW. A highly flexible system has to be adopted permitting good adaption to heat and electricity in their required proportions of production and guaranteeing under all loads most efficient use of the heat resulting from the combustion material. As far as the hot water system is concerned, it was desirable to obtain a primary circulation temperature of 150°C; it was found that the conventional steam condensing systems could not be used. For this reason the Ackeret-Keller principle of the closed gas turbine was chosen and the delivered work equally split to represent 30 MW and 50 Gcal per hour for each purpose and aggregating the maximum heat capacity. It was found that with a number of high loads of about 4,000 to 4,200 hours and assuming 5,700 running hours, the plant could be self-sufficient as far as electric energy is concerned and with both units could produce some 180,000 MWh, delivered to the public electricity network. Heat delivery had to be about 400,000 Gcal per hour, so that the power output would consume in round figures 55 to 60% of the total plant production. This optimization denotes suitable working hours as well as the appropriate amounts of electricity and heat.

Ackeret-Keller System

The advantages of the Ackeret-Keller system are well known. Above all they consist in a high energy extraction from the fuel, as well as large scale of maximum working efficiency in a wide range of different loads. This is because turbines and compressors always work with maximum efficiency even under partial load conditions and therefore always have constant and most favourable pressure conditions, prevailing changes in the load only being obtained by altering the specific weight of the heat carrier, i.e. by a change of pressure. Running of these units is very simple and it has been proved that they can work as a heat carrier for a very long time without servicing and overhaul. No corrosion is caused by air. For the Spittelau plant, two large closed turbine units were planned; compared to the 15 and 18 MW units previously considered as large, the capacity of the actual production units was raised to 25 to 30 MW.

With this waste incineration combined with power production between 80 and 90% of the total yearly requirements can be met.

Oil-fired Furnaces

A third component of heat production is the oil-fired furnaces, which cover short periods of peak loads during winter when outside temperatures are at their lowest. For this purpose two hot water boilers would be needed, each having a maximum capacity of 45 Gcal per hour, making it possible to heat directly the water returning from the steam system to the pre-circulation temperature of 150°C or even 170°C. These hot water boilers have been chosen because they make it possible, within the shortest possible starting period and with very easy control to provide full production capacity, with very little energy loss to meet peak needs; regulation of the two boilers can be handled at the same time by the operators for the two units. This is the first time that hot water boilers of this size have been manufactured, and experience has shown that boilers with an in-flow and an out-flow combined with the mixed return flow guarantee safe functioning and at the same time use very little electric energy.

The Spittelau plant is thus subdivided into three large units:

1. Waste incineration with a production of 30 Gcal/hr combined with a post-heating oil burner system of some extra 30 Gcal/hr, to be used essentially during peak-load periods.

2. Parallel production of heat and electricity, of 100 Gcal/hr and 60 MW, respectively maximum values.

3. Peak load period heat production with heavy oil furnaces having a total capacity of 90 Gcal/hr.

The general outline of these three units has been planned in such a way that it became possible to design the whole plant with a minimum loss of space. Three chimneys serve the waste combustion, power plant and oil combustion; the separate chimneys are joined at a higher level in one shaft but remain separated by brick walls and reach a height of 120 metres.

A high exhaust gas speed was chosen to ensure that combustion gas would be completely mixed with the environmental air at a height of from 200 to 300 metres so that any pollution of the environment was avoided. For a waste incinerating plant situated close to a city, it is self-evident that each unit should be equipped with a dust-filtering system. The maximum contents of dust of the combustion gases will be maintained below 80 mg/cu Nm.

Hot Water Boilers

To have maximum production from the three units 10 hot water boilers, each with a capacity of 160 cu metres, were used as a heat reserve which make it possible to balance the variations of heat consumption and to maintain maximum average values in the distributing system. The reserve heat contents of these boilers as well as the changes in these reserves are the main criteria for the regulation of the whole plant and define the future working load. These heat reserve boilers ensure a constant efficiency, and cover the consumption peaks in the distributing system; they make it possible to obtain a maximum average production from the waste incinerating units, the oil furnaces and the power plant as well as peak heat production from the oil burners, so as to cover maximum heat requirements in an economic way. For maximum average production, the quantities of waste available per year, must be taken into account as well as the quantities of used oil which have to be stocked and the requirements for electric energy, considered as unvariable factors. This production also depends upon the outside temperature, so that peak production can be attained according to the characteristics of the total consumption. To fill in the requirements successfully, it is necessary to control and regulate the complete installation from one central point; it must also be possible to register all production values as well as the delivery values at this same central point. This

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General view of the Spittelau garbage incinerating and steam producing plant which provides district heating for the city of Vienna on an economical basis as well as feeding electricity into the Austrian grid.

(Continued from page 15)
central control of the total installation has been most economically arranged in the Spittelau plant. Few personnel are required and the safe functioning of the whole installation is heightened by this central control system. Independent central control of the whole process facilitates attainment of maximum average capacity; furthermore, constant checking of the total heat and electric energy output undertaken parallel to the central control system of the production process makes it possible to have a detailed year-long picture of the economic situation of the plant.

Cooling system

For effective functioning of the plant, a return cooling system backed by river water cooling is necessary. These cooling systems would be applied in such a way as to guarantee maximum production with maximum safety. Eight large return cooling units installed under the same roof as the power turbines make it possible to control the return cooling process in such a way as to have them correspond to maximum production. As far as electric energy production in wintertime is concerned, cooling becomes necessary at peak production by low temperature return cooling for the gas turbine; mechanically cleaned river water is used. The plant also produces hot water, which covers the needs of the general hospital. This part of the plant is fully automatic; it decalcifies water and produces 110 cu metres of soft water per hour of first quality for the laundries and for other cleaning purposes in the hospital. For the boiler systems and heating systems, partially salt-free and absolutely salt-free water are used respectively. Considering the fact that the long distance pipes contain between 500,000 and 2 million litres of water, the production of soft water cannot be adapted immediately to consumption when difficulties in one pipe arise. The reserves previously mentioned have thus another task, namely to make it possible rapidly to fill a part of the pipes which have undergone repair; a smaller decalcification unit makes it possible to top up the reserves at a later date.

The whole conception of the district heating plant at Spittelau therefore differs from previously installed heat production plants, by the fact that in a relatively large plant, (the plant will be one of the largest in Western Europe), as far as capacity is concerned, all requirements are taken care of as good civic economy requires. The Spittelau plant does not consider heat production as a by-product of electric energy production, but has been conceived so that heat production is the main aim and covers the city requirements. Production of electric energy has been included in the plant to make it compatible with an economic heat production. Thus the plant was conceived, according to rather new guide-lines; as a result of the precise planning which has gone into all details for a maximum capacity of the total installation, a very good economy and safe functioning to the highest degree can be confidently expected. □

AIR POLLUTION CONTROL ASSOCIATION MEETING

APCA conducts a major technical forum as part of its annual meeting each June in which more than 120 papers are presented covering a broad range of air pollution research and control activity. This year's meeting will be held June 27 to July 1 in Atlantic City, N. J.

The Air Pollution Control Association has named Dr. Lewis H. Rogers to the newly-created post of Executive Vice-President. He will direct the staff activities of the 6,000 member organization from it headquarters in Pittsburgh, Pa.

The APCA, which includes sectional chapters in both the United States and Canada, is comprised of air pollution experts from all levels of government, industries, education, equipment manufacturing, and research and consultant organizations.