DISTRICT HEATING

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- Utilities and Industries in Japan's Urban Areas
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Waste Heat By Utilities and Industries In Urban Areas In Japan

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and
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Actual Condition of Energy Consumption in Japan

The recent development of scientific technique has accelerated industrial expansion, and the people's desire to make their living environment more pleasant has become stronger, centering around heating and cooling, both of which constitute a factor in the rapid increase in energy demand.

On the contrary, the sudden increase in demand for energy, and the exhaustion of fossil fuel as a source for supplying it, have now become a grave concern all over the world; and the progress of technique of the new source of energy, with atomic energy as its center, is strongly expected. However, we can only rely upon the existing fossil fuel for the next 30 to 40 years, or until the secure and stabilized supply of nuclear energy will be realized. In Japan, especially, which depends upon shipments from abroad for more than 80 per cent of its necessary energy, the security of high quality energy and the effective use of energy are very important questions.

The demand for energy in Japan has increased in proportion to the rapid growth of the Gross National Product of the country. Mining and industry groups require an overwhelmingly large amount of energy—50 per cent of the total demand. Against this, the demand ratio for household and commercial use, with ordinary families as its center, is 18 per cent, which is far less than that of the U.S.A. and West Germany; this fact is a big feature of Japan, and clearly reflects the policy that the priority has been given to the nation's industry. This low ratio will remain almost unchanged for some time in the future, according to a survey made of future prospects concerning energy demand. However, increase of energy for household and commercial use is expected, as the increase of social overhead capital improves the standard of living. The demand for energy for household and commercial use, especially for heating and cooling, is expected to increase rapidly; in parallel with the recent realization and planning for district heating and cooling.

Fig. 1 shows the changes up to now, and future prospects of the energy supply in Japan. The itemization of supply of energy, and presumed amount of discharge of SO_2, CO_2 and heat caused by energy conversion are shown in Fig. 2.

This article attempts to state the actual condition of waste heat discharged from facilities and industries in urban districts, taking the focus of heat discharged by consumption of energy.

Waste Heat in the Kanto Districts

The final form of energy is heat. When energy is consumed, all the energy is converted to heat in the end,

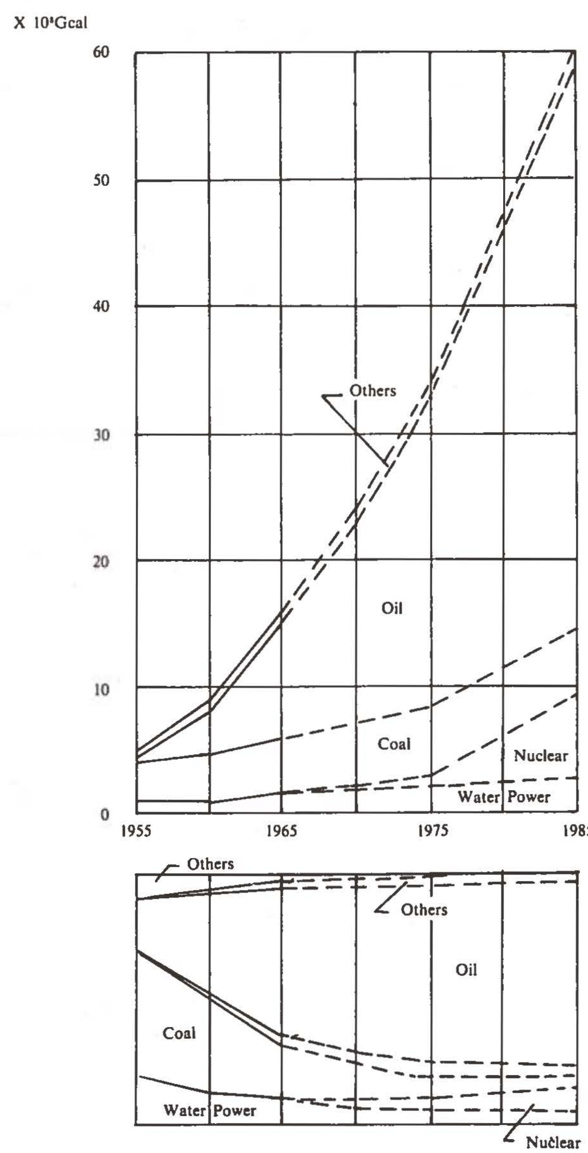

Fig. 1—Primary energy supply in Japan.

regardless of the difference in place and time of energy consumed. When the primary energy (coal, oil, natural gas, etc.) is converted to the useful energy or the secondary energy, waste heat is produced at the time of energy conversion. The same thing takes place when the secondary energy (electricity, city gas, etc.) is converted to useful energy; useful energy is finally also converted to heat.

As already stated, a rapid increase in the amount of energy consumption is expected in Japan in the future. It is, therefore, necessary for us to give full consideration to the impact of heat on the human environment, in parallel with the question of securing the source of energy. As it is considered that the demand for electric power, especially, is expected to increase in the future, among various other kinds of energy, the thermal effects caused by steam and atomic power plants will cause very serious problems. At the same time, waste heat produced by various activities in urban districts has already been bringing about changes in the weather conditions of cities: pollution, other contaminating materials, etc. are problems.

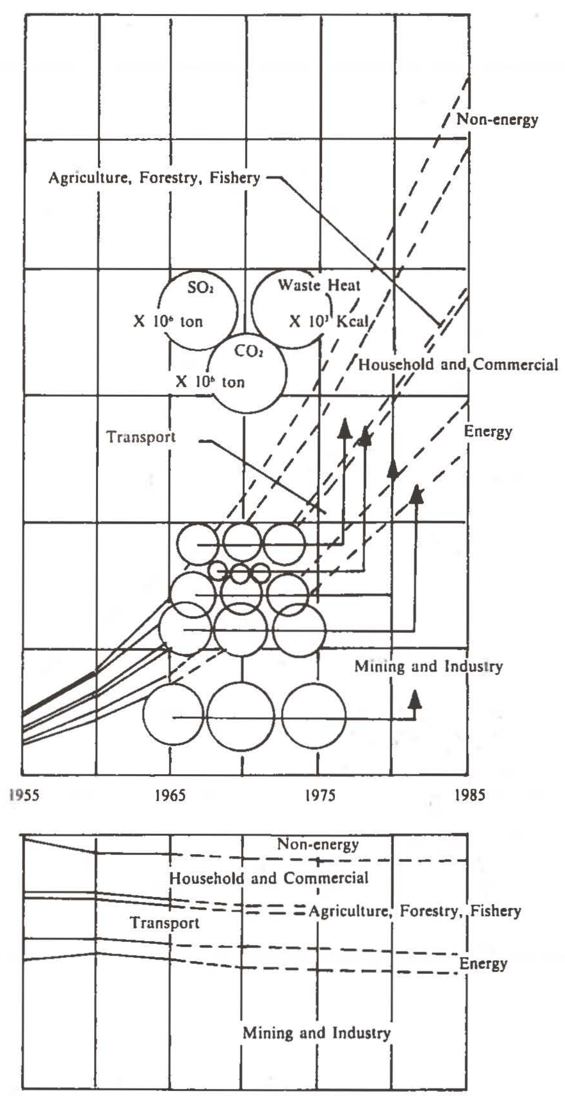

Fig. 2—Estimate for energy and pollution.

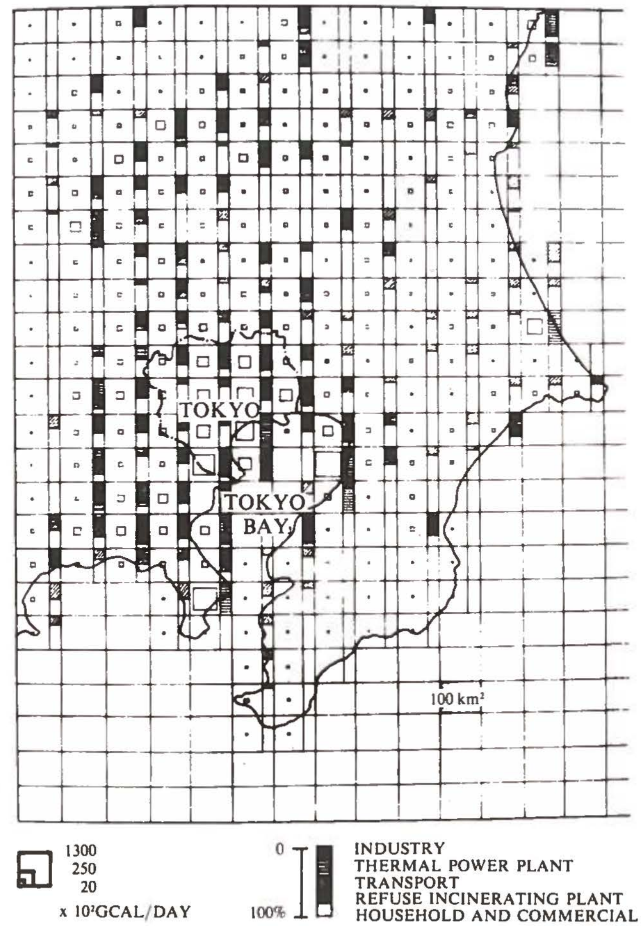

Fig. 3—Waste heat map in "Kanto" area.

The distribution chart of waste heat in the Kanto Districts centering around Tokyo (Fig. 3), is for the purpose of determining the actual condition of waste heat. On this chart, the amount of waste heat discharged by power plants, refuse incinerating plants, manufacturing plants, general buildings (heating) and automobiles is estimated by combining it with investigative and statistical data, using the mesh map of 10 Km² by latitudes and longitudes. In Fig. 3, the blackened squares in the meshes show the size of the waste heat capacity, and the graphs at the right side show the breakdown of the source of waste heat. The direct impact of waste heat appears as the temperature rises and influences the climate of the city. The result of the calculation in Fig. 3 is shown in Fig. 4. When factories, power stations and other utilities are added, the degree of rise in temperature becomes greater. In Fig. 5, SO_2 distribution in Tokyo is shown.

Investigation of Waste Heat by Utilities and Industries at the City of "Y"

The amount of consumption of thermal energy in urban districts continuously increases, and causes a problem to human environment. The amount of thermal energy consumed by thermal power plants and factories is especially great in Japan. Accordingly, the amount of waste heat is also very large, and of the total energy consumption, it is estimated that 7.4 per cent is from ther-

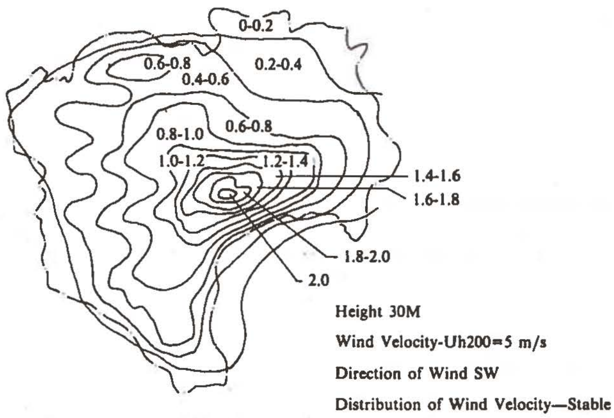

Fig. 4—Temperature distribution in Tokyo (C).

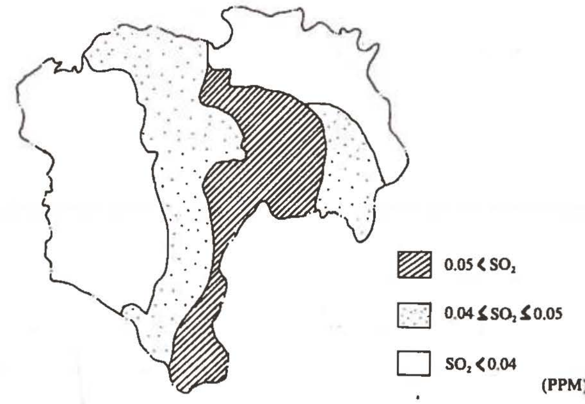

Fig. 5—SO_2 distribution in Tokyo (1965-69).

mal power plants and 10.6 per cent from factories (Fig. 6). In Japan, cooling water consumption in factories is 56.5 per cent fresh water and 92.7 per cent sea water.

As there exist little data, in general, about the actual condition of waste heat, in spite of the fact that a great amount of it is discharged by many utilities and industries, we have investigated thermal energy of such large scale plants as power stations, gas plants and industry in the City of Y, one of Japan's Coastal industrial cities. The results of the investigation are given in Fig. 7.

First, the use of heat at the highest temperature range is that for heat equipment such as furnaces. The heat capacity by the temperature of process used is given in Fig. 8. Each circle indicates one process at a factory. A wide range of temperature from 200 to 600 C was used, but the process with the largest heat capacity belongs mostly to that of 700 C. Heat capacity is big also at gas plants, oil refineries and potteries. Steam is used for the process temperature in the next stage of the use of heat. Heat capacity of steam used, classified by pressures, is given in Fig. 9. The scope of the temperature of the steam used is 150 to 350 C. On the other hand, when we see the output of heat, there are two cases where the heat is abandoned directly to the air and to the sea, river and air, by using water. The capacity of the waste heat from cooling water is itemized by water temperatures at the outlets in Fig. 10. These temperatures are mostly 10 to 40 C in January, but there are some processes where they are 50 to 75 C. Comparison of the amount of waste heat by cooling water with the amount of the total thermal energy consumption is shown in Fig. 11. Its ratio, in the case of thermal power generation, oil refinery and chemical industry, is over 50 per cent. The ratio in the case of the electric machine industry, transport machine industry, metal and pottery industries is lower, and most of the heat at these places is discharged into the air.

As noted above, a substantial amount of high-temperature heat at factories is discharged after it has been cooled down by a large amount of water or air, which makes it difficult to utilize the waste heat effectively. Fig. 12 was made by synthesizing Figs. 8 and 9. On this chart, temperatures are arranged on the ordinate, and the accumulation of heat capacity is put on the abscissa. By the gradual utilization from the left upper part to the right lower part on this chart—or utilization of heat in order from high to low temperature—it becomes possible to save much energy. The waste heat thus collected may be utilized as energy for living (district heating cooling) at the neighboring districts.

Actual Condition of Various Kinds of Waste Heat

1. Power stations. There are not many instances where waste heat from power stations is advantageously used in Japan. There are only a few power stations where it is utilized experimentally for agriculture and fish farming. Combined heat and electric plants, where waste heat will be utilized for district heating and cooling, are still in the research and planning stage, and have not yet materialized. On the contrary, power plants in Japan raise the efficiency of the electric power generation up to about 40 per cent by way of lowering the steam pressure coming into the condenser to about 0.05^{ata}. As a result, the temperature of waste heat is as low as 30 to 40 C.

The temperature of cooling water at the outlets in power plants around Tokyo is, according to the investigation, 33 to 34 C in summer, and about 17 to 19 C in winter. The waste heat capacity is about one Gcal per one kwhr, and in the case of a power plant with the output of 1,000,000 kw, about 1000 Gcal/H of waste heat by cooling water is discharged. Around Tokyo at present, 10,000 Gcal/H of waste heat at the peak is thrown into the sea. As the heat capacity of waste heat from a power plant is large compared to the fact that its temperature is not so high, its effects on the fishing industry recently have become disturbing. It is, therefore, considered necessary to carry out positive research about the effects on the environment, together with the study of utilization of waste heat in the future.

2. Gas plants. A large quantity of energy is consumed in the production of gas at gas plants. To cite an example in Tokyo, there are five gas plants which can supply 19,230,000 M^3/day of gas; and the total waste heat capacity is estimated at 15,200 cal/day. The quantity of waste heat at gas plants is fairly small, or about five per cent of the total heat capacity consumed. As such high-

temperature equipment as a furnace, with the capacity of 700 to 1100 C, is used in the production of gas, the quantity of waste heat to be discharged directly to the air is rather large.

3. Refuse incinerating plants. The refuse discharged from every family has increased in quantity and has become complex in quality, in parallel with the rise and diversification of the standard of living of late. The calorific value of refuse becomes higher and higher, accelerated by ever increasing consumption of plastics.

The ways of refuse disposal differ to a great extent from city to city, also in Japan, and the incinerating method is considered best at present. The 24-hr incineration of refuse is carried out by facilites at the refuse incinerating plants around big cities. The capacity of these plants is fairly large—300 to 900 tons per day. When the calorific value has increased and the scale of refuse incinerating plants has also been enlarged, the amount of waste heat from those places becomes enormous.

To take Tokyo as an example, there were ten refuse incinerating plants, as of 1971, and their disposal capacity totaled 4655 tons per day. However, this capacity can dispose of only about 30 per cent of the total amount of refuse discharged by Tokyo, and construction of additional refuse incinerating plants is now being planned at four places. When these plants are completed, it is estimated that the waste heat capacity from Tokyo's refuse incinerating plants will reach 11,800 Gcal/day. Almost all the plants have waste heat boilers in order to cool down the furnaces, and although steam is consumed inside the plants to some extent, most of it is released to the air through condensers at present.

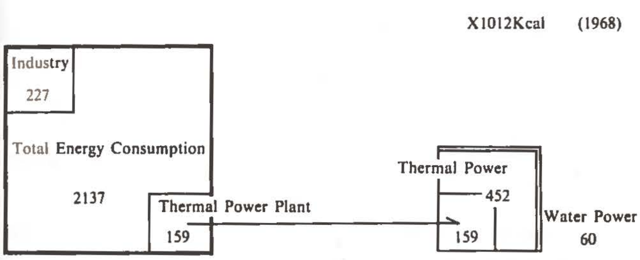

Fig. 6—Rate of waste heat by condensing water.

Although the waste heat capacity of a refuse incinerating plant is less as compared with that of a power plant, the possibility of utilizing the waste heat for district heating and cooling is large, because the recovery temperature is high and many plants are situated in urban districts.

Utilization of Waste Heat

The possibility of utilizing waste heat depends upon (1) quantity of waste heat (2) recovery temperature and (3) stability of waste heat supply. In consideration of these three factors, the sources utilizing the waste heat most effectively for the urban energy demand, are the thermal power plant and the refuse incinerating plant. Since the thermal power plants in Japan are generally designed exclusively for generating electric power, they cannot be utilized directly for heat demands such as room heating and cooling, hot water supply and industrial processes, on the ground of quality of waste heat (temperature). However, if the BTG system is slightly modified, the utilization of waste heat would be facilitated.

Type of Industry	Numbers of Factories
Thermal Power Plant	3
Gas Plant	2
Iron	1
Oil Refinery	2
Chemical	5
Non-ferrous	1
Metal	1
Pottery	4
Food	10
Electric Machine	4
Transport Machine	11
Others	1
Total	43

Fig. 7—Factories investigated.

As for the waste heat from the refuse incinerating plant, while its quantity is not so high as that of the thermal power plant, the recovery temperature is high enough to adequately satisfy the heat demand mentioned above.

With regard to the stability of waste heat supply, it is a matter of administration rather than technology, where these two sources of waste heat are concerned.

Taking the case of Tokyo as an example, a very extensive area can be supplied with heat, if the waste heat from the thermal power plant and the refuse incinerating plant is utilized effectively.

Countermeasures for Thermal Pollution: Tokyo Bay Energy Project

The principal countermeasures for thermal pollution (Fig. 13) are (1) Utilization of ecosystem (use of clean

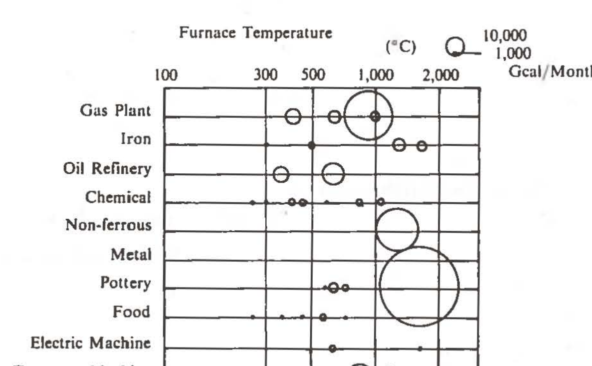

Fig. 8—Process temperature by furnace—quantity of heat.

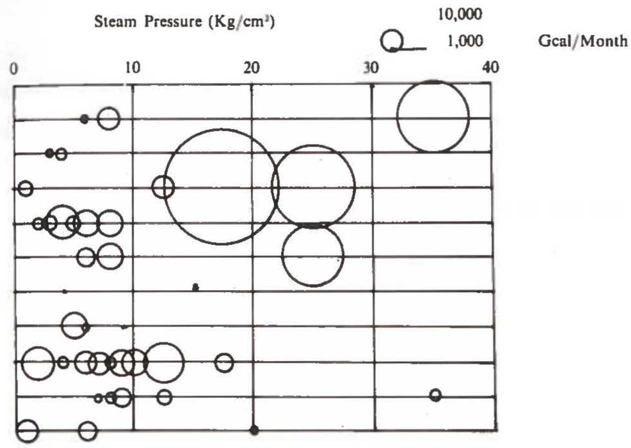

Fig. 9—Steam pressure—steam consumption.

energy) (2) Diffusion of energy (3) Minimization of energy (4) Review on land use plan.

In promotion of these countermeasures, it is essential to combine some of them from the total viewpoint. We are engaged in the technological studies of the use of clean energy, development of a large refrigerating column, utilization of waste heat and energy, etc. Now we will talk about the use of waste heat, which has a high technical feasibility.

Useable waste heat sources are mainly thermal power plants, waste incineration plants and big factories. Little

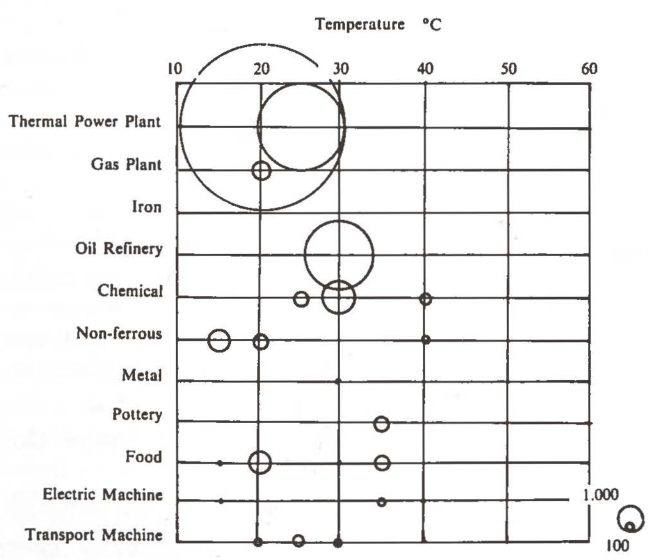

Fig. 10—Output temperature of cooling water—quantity of waste heat.

waste heat is used on a large scale in our country, and most of it is discharged into the air or water. On the other hand, Japanese cities are provided with energy mostly in the forms of electricity, gas and oil.

For thermal energy especially, we are dependent largely on oil or gas. Recently, a system of air conditioning to reduce environmental pollution and consumption of energy resources, and to improve living conditions, has attracted much attention, and its expansion is now underway. Introduction of such a system or other effective means will allow, in a wide area, the use of heat which has been discarded as waste, in combination with air conditioning. Wide and multi-purpose use of waste heat contributes not only to minimization of energy, reduction of heat generation, prevention of local heat generation in cities, but sometimes also to decrease of household energy used.

The Tokyo Bay Energy Project is designed for the Tokyo Megalopolis which has a large energy consumption and density, with a view to establish a wide and multi-purpose heat network (as an area minimum energy system), in an organic combination with a system

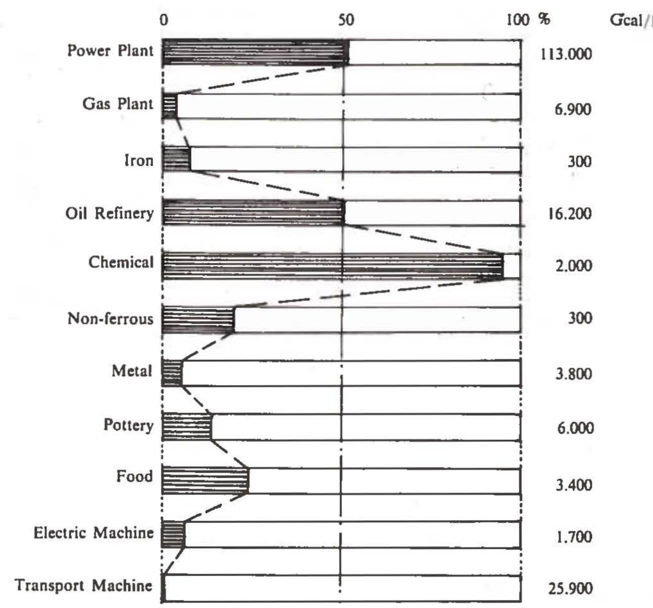

Fig. 11—Ratio of waste heat by condensing water to energy consumption.

of furnishing electricity and gas. This project has the following four purposes:

1. Control of environmental pollution, especially as a countermeasure for heat pollution.
2. Saving of energy resources.
3. Conservation of living conditions—introduction of a heat providing system as urban infrastructure.
4. Prevention of natural damages in cities.

This system, almost free from technical problems, is considered as a short or medium-term project among

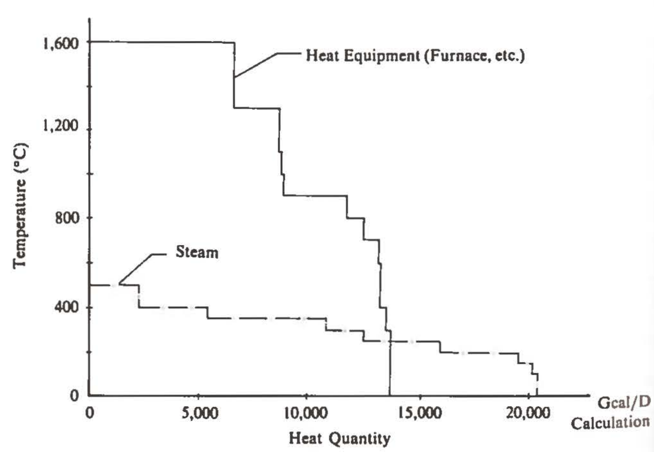

Fig. 12—Thermal energy consumption temperature—quantity of heat.

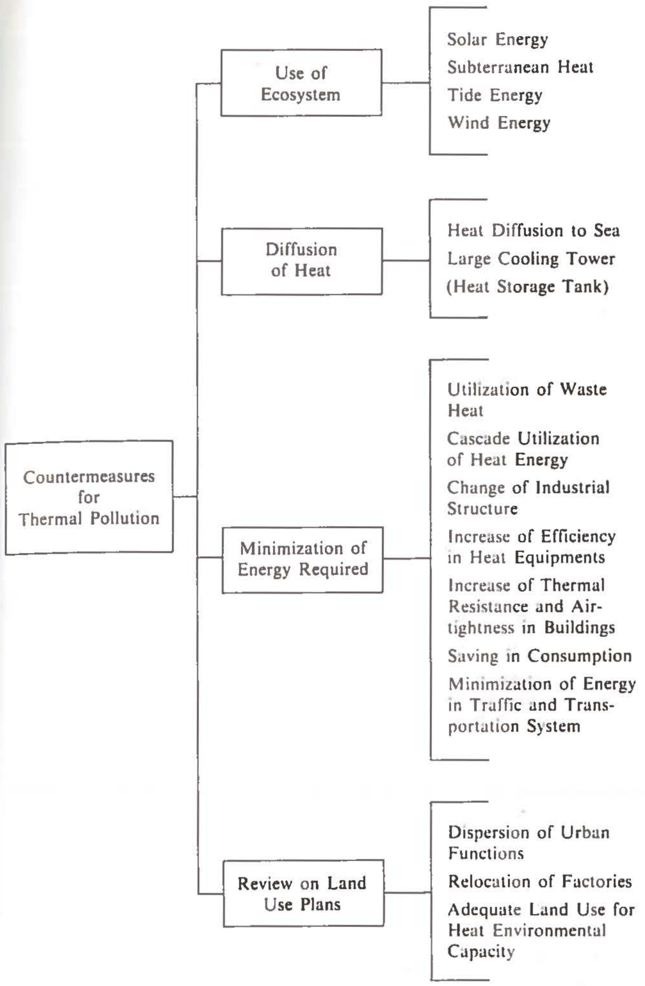

Fig. 13

future energy projects. In joint use with the countermeasures (technical and political) mentioned above, this system works as an effective means for prevention of thermal pollution, and conservation of energy. The details of this project are not described here. Feasibility studies of similar systems are promoted mainly by the Government and local authorities. ✹

(This article was based on a paper presented by the authors at the Second International District Heating Conference in Budapest, Hungary in May 1973, and is reproduced with the authors' permission.)

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Member Company News

RIC-WIL, Brecksville, Ohio, has transferred its electric pipeline tracing systems business to newly formed subsidiaries—Pipe Heating Systems Inc. in the United States, and Pipe Heating Systems Ltd, in Canada, effective immediately. Ric-wil introduced SECT™ electrical tracing systems for pipelines to the U.S. and Canadian markets in mid-1973.

Executive Vice-President G. D. Zeile reported, "Our reception in the marketplace has been phenomenal, making it necessary to add a larger staff and a separate organization much faster than we anticipated. Due to the excellent acceptance of our electric tracing systems, we have established not only a separate organization, but a separate corporation with its own General Manager, Paul J. Hollis. At the same time, we have created a western sales and engineering office in Southern California to service the western market. That office will be manned by N. Bruce Carson, who continues to serve as our Chief Engineer, and will act as Western Regional Sales Manager."

The Company's electrical tracing system utilizes the skin, or proximity effect, of 60 Hertz alternating current to provide extremely economical, safe, rugged and dependable heat along the entire length of a pipeline. Mr. Zeile explained, "Never before have we been able to design and supply a tracing system for long pipelines that is as efficient and dependable as the SECT system. For 65 years, Ric-wil has offered tracing with steam, electrical resistance, and other heating devices, but all these methods have had practical limitations as the piping system became longer. We find our SECT system is, in fact, a major breakthrough, overcoming all of the limitations the old heating methods have involved.

"Compared to the old methods of heating or tracing, the 'skin effect' has several distinct advantages. With this system, for example, we can reheat a cold line rather than purging. In addition, the SECT method promises low installation cost, safety, extreme reliability, excellent utilization of input energy, and simplicity.

"We already have several fuel oil lines and crude oil lines in operation. One paraxylene line has been operating for a year. We have designed two sulfur lines, one of which is ready to operate, and our backlog is continuing to grow. The most exciting part of this development is that, while the SECT system has been applied efficiently to a line as short as 900 ft, the biggest savings come as the lines get longer. We frequently find we can supply economical electrical heating to pipelines up to 18-20 miles from a single transformer station."

Ric-wil has been a leader for 65 years in preinsulated, prefabricated piping systems, primarily for the distribution of hot and cold water, steam and condensate, oil and other viscous fluids.