SURVEY OF EXISTING DISTRICT HEATING SYSTEMS

REACTORS

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The basic aim of the survey is to determine the state of development and planning of these types of district systems. In the western world, there is a wide variance of capacity, but it can be stated generally that those countries that developed systems early have a substantial lead in technology. Development in the eastern bloc is largely parallel to that of the west in that most work has been undertaken during the post-war period.

World events have played their part, notably the oil crisis of 1973, which has led to more rational energy policies and usage, in addition to the consideration of alternative primary fuel sources. While this quest for other energy reserves continues, most countries are turning to indigenous fuels. This, of course, leads, wherever possible, to partial fuel independence, a state that is more pronounced in the eastern bloc.

At present, the Federal Republic of Germany has the largest connected public system in the west, although in terms of megawatts per thousand inhabitants, Scandinavia comes out ahead. Obviously, information from eastern Europe is difficult to obtain, although it is known that substantial district heating systems are in existence in the bloc. As far as heat production is concerned, there are two systems:

1. *dual-purpose, where a power station (nuclear or conventional) produces heat as by-product in the generation of electrical energy*
2. *heat-only, where the production of heat energy is the primary purpose.*

In terms of economic feasibility, a local nuclear power station could be more efficient than a conventional station, when dual-purpose stations are considered.

Quite obviously, present and future usage and development depend on several important factors, including geographical location, influencing climate, local supply, and political considerations. At the present time, western development is limited mainly to preliminary studies and the consideration of one of the most important basic questions, that covering the role of nuclear energy in district heating systems.

INTRODUCTION

This paper presents a survey of the previous development, current state-of-the-art, and possible future development of existing district heating systems. Only heat production has been considered, since other papers discuss the problems of heat transport and distribution. The data that have been used are those appertaining to 1975.

After initially discussing the fundamental reasons for the development of different types of district heating systems in the various countries and also the various pros and cons that may have influenced this choice, there follows a comparison of the development of the main economical data relevant to these countries. From the development phase, we next move to the current installations. Because of the varying sources, the information used had to be quantified to a common reference basis.

The third and last section of this paper looks at the possible future development of district heating supplies and discusses, with regard to the other

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papers on this topic, some of the ecopolitical aspects and possible ideas for the future application of nuclear energy to district heating systems.

DEVELOPMENT OF DISTRICT HEATING SUPPLIES

If we disregard the fact that some 2000 years ago the Romans used a type of district heating system, then, for this industrial age, the following picture emerges (Fig. 1). The first installation is said to have been put into service in the U.S. in 1882, and the first installation in Europe was started in 1893 in Hamburg. Later we will see that, with the exception of Sweden, all the countries that have had an early start in district heating now have the largest connected thermal capacity.

The next item to be examined is the development of district heating in the countries that are considered. In Fig. 2, we can see that the connected thermal capacity of some west European countries varies significantly. Of these, the development in the Scandinavian countries has been remarkable, especially that of Sweden, where the strongly accelerated growth of district heating supplies has been exceptional. The stimulus for this expansion appears to be due to a number of factors, including the political atmosphere, forward-looking planning authorities, and energy economics.

In total, the public district heating supplies of the countries of western Europe all show different development growth rates. It is Great Britain and France that distinctly differ from the development pattern that has been established by the other countries during the past 15 yr. This may in some way be due to the restrictive governmental policies that have been imposed on the State-owned utilities.

The district heating supply for North America is <1% of the total energy consumption. It is estimated that this represents only some 10% of its potential. The statistical data that have been used are based on the use of steam; no differentiation has been made between the hot water and the steam cycles. In North America, the major factors influencing the choice of individual rather than a central heat source for houses and buildings were cheapness, convenience, and the

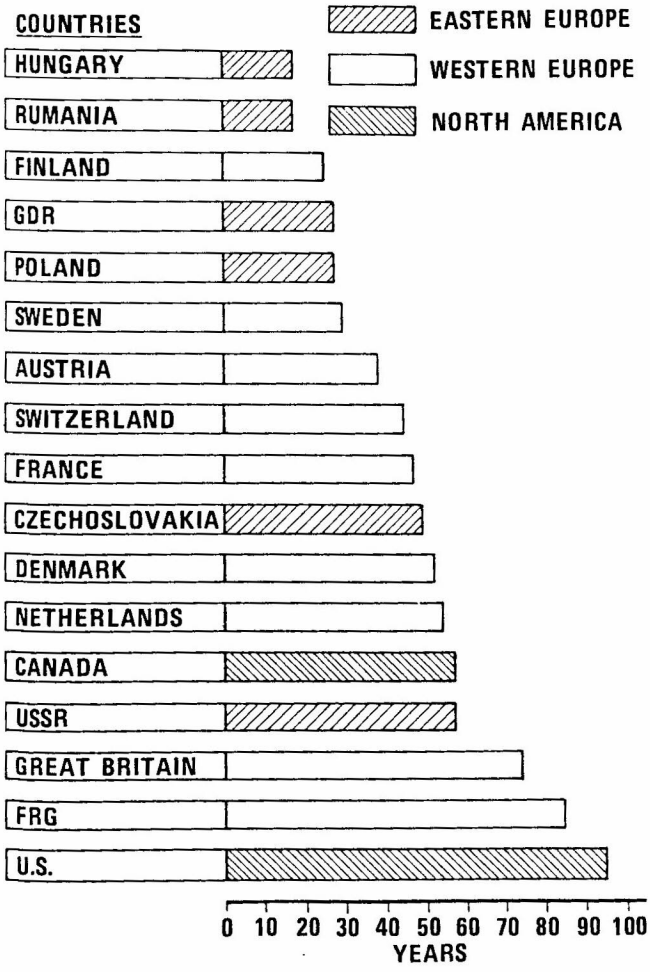

Fig. 1. Length of time of district heating (as of August 1977).

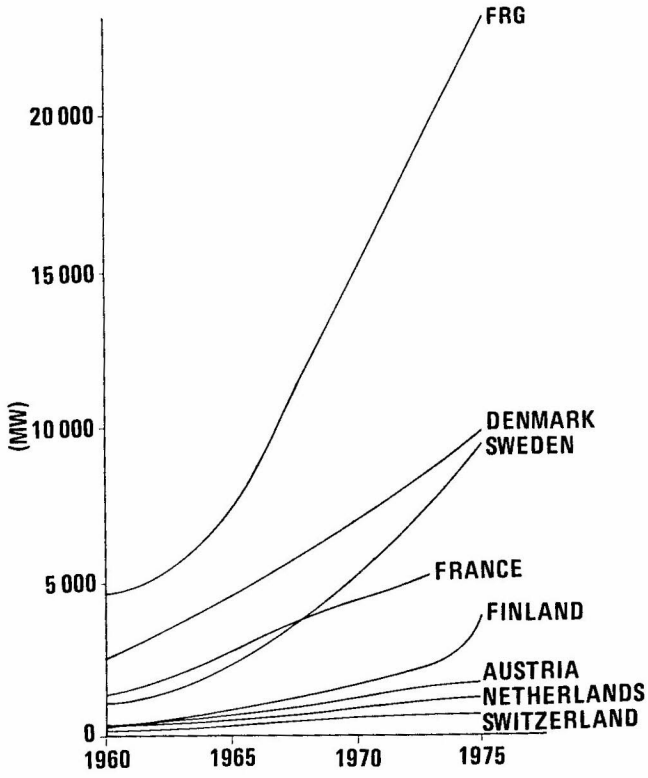

Fig. 2. Development of connected thermal capacity (western Europe).

then-presumed inexhaustible supplies of oil and natural gas.

In Fig. 3, data from some east European countries are shown. If some rather unique aspects are disregarded, it can be seen that, as in the west European countries, the real development of district heating systems only started after the Second World War. However, the impression gained of the overall development picture is one of remarkable uniformity. This may be due to the very comprehensive economic planning programs and the vigorous promotion of extensions to the district heating systems.

In summarizing this development, it may be said that up to the oil crisis of 1973, the economic and environmental motives took precedence, but from 1973 onward, the energy saving and the energy independence stimuli have been additionally considered. Since this time, there is no doubt that a remarkable increase in the growth of district heating systems has taken place. To emphasize this statement, the consideration of the primary energy situation should also be cited.

PRIMARY ENERGY CONSUMPTION

A comparison of the primary energy situation in the individual countries gives an explanation about necessary energy imports and makes it possible to estimate what the future developments could be. In the following, the primary energy consumption has been divided into four groups:

1. coal
2. oil
3. gas
4. others.

From Fig. 4, it can be seen that Denmark has the highest proportion of oil usage, with nearly 88%, followed by Sweden and Switzerland, with 70%. The primary energy situation of both the Federal Republic of Germany (FRG) and Austria also shows a relatively high proportion of oil. Sweden, Switzerland, and Finland use a greater proportion of indigenous primary energy, including ~25% hydro power, and The Netherlands uses almost 50% gas.

The high proportion of oil dependence has awakened efforts in almost all countries to reduce it, basically by rational energy usage, for instance,

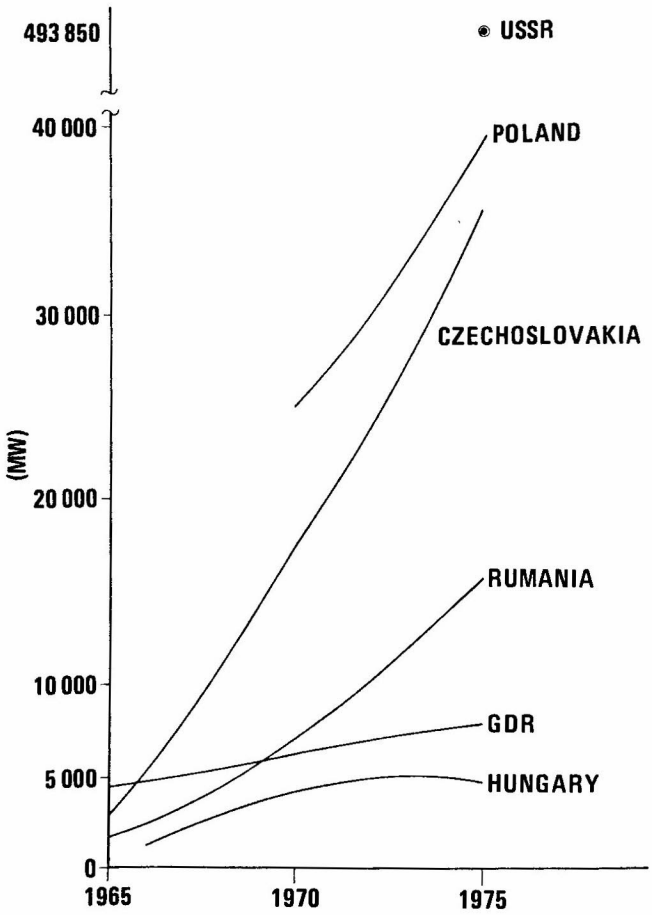

Fig. 3. Development of connected thermal capacity (eastern Europe).

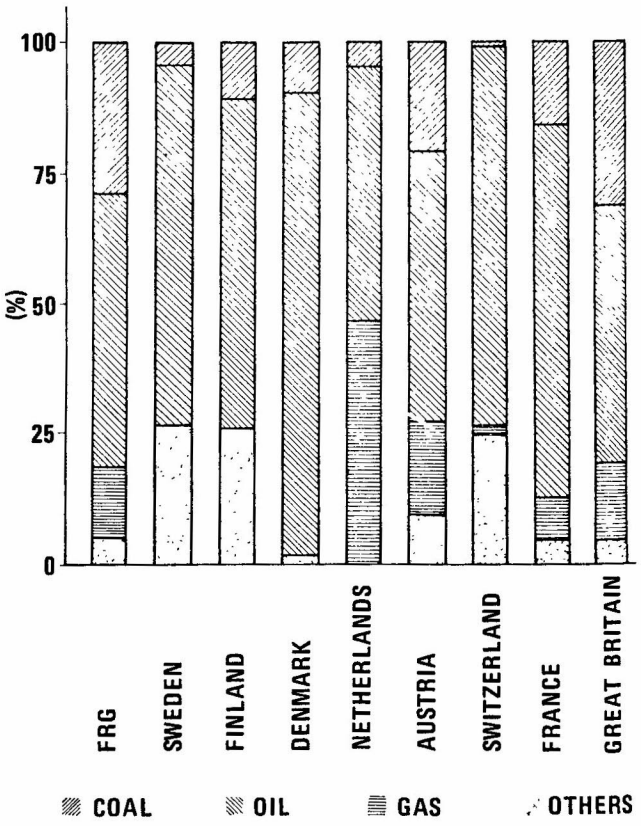

Fig. 4. Primary energy situation (western Europe).

by greatly extending district heating systems. As is shown later, especially in Sweden, a remarkable lead in the acceleration of the extensions to district heating systems has been attained. The east European countries (Fig. 5) show that, in comparison to the west European countries, the percentage of coal used is much greater. In general, it is over 50%, but in Poland, Czechoslovakia, and the German Democratic Republic (GDR), it is more than 80%. Rumania is an exception, since it has indigenous oil and gas reserves.

The gas and oil consumption in this group of countries is at the moment principally supplied by the USSR. However, it may be presumed that for the future, these countries' primary energy requirements will not be able to be supplied completely by the USSR. Information in press releases from the east European countries indicates that they are actively attempting to obtain supplies of oil from other sources.

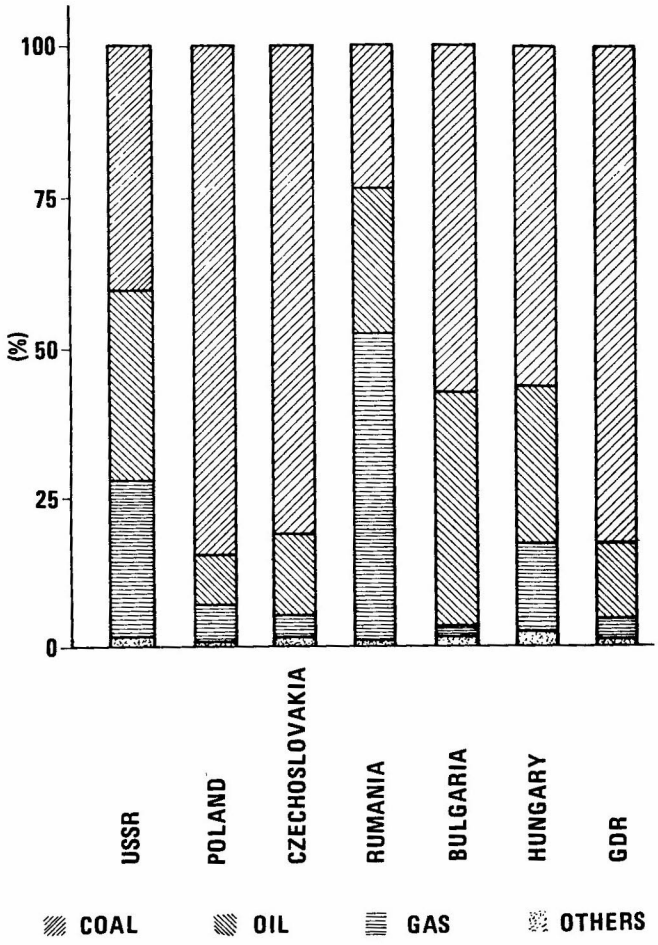

Fig. 5. Primary energy situation (eastern Europe).

CURRENT SITUATION OF DISTRICT HEATING SUPPLY

Figures 6 and 7 show the situation of the public district heating supply in various European countries. Regarding first the total connected thermal capacity, it can be seen that the FRG, in comparison to the other west European countries, has established by far the largest public district heating supply system. However, if we take as a comparison a specific connected capacity, in MW per 1000 inhabitants, a completely different and more realistic picture is presented. Contrary to the comparison with absolute data, it can be seen that Sweden, Denmark, and Finland have intensively developed their district heating systems, while that of the FRG is remarkably postponed. In addition to the total connected thermal capacity and the specific connected capacity, Fig. 6 also shows the maximum heat output. From the ratio between maximum heat output and the total connected thermal capacity, information about the supply policy in the relevant countries can be deduced. Regarding the presented data, it may be stated that of the west European countries, Sweden, Denmark, Finland, and the FRG have all made substantial progress in the installation of district heating.

Before we carry out a similar comparison of the east European countries, it is necessary to refer to the fact that normally, for these countries, only summarized data for both the public and industrial production of electricity and heat are available. In addition, it must be stated that it is, in principle, very difficult to obtain complete data from the east European countries. The available data show that the total connected thermal capacity of the USSR is far greater than that of the other countries. But if we again compare specific connected capacities, the high value will be reduced to a more comparable dimension. As can be seen, the USSR, Czechoslovakia, Poland, and Bulgaria have all considerably developed their district heating supplies.

DISTRICT HEATING PRODUCTION TECHNOLOGIES

Accurate statistics about the more usual types of stations for district heating are, unfortunately, not yet available. In the literature,[1-4] one can read that countries with developed district heating systems strongly perfer the dual-purpose cycle rather than the single heat type. For the dual-purpose plants, these countries prefer the back-pressure turbines and extraction-condensation machines. Bled steam techniques are also used in the FRG, the Netherlands, USSR, and Czechoslovakia. But the last-mentioned countries, according to the published data about the bleed-off capacities, are clearly less than those of the FRG.

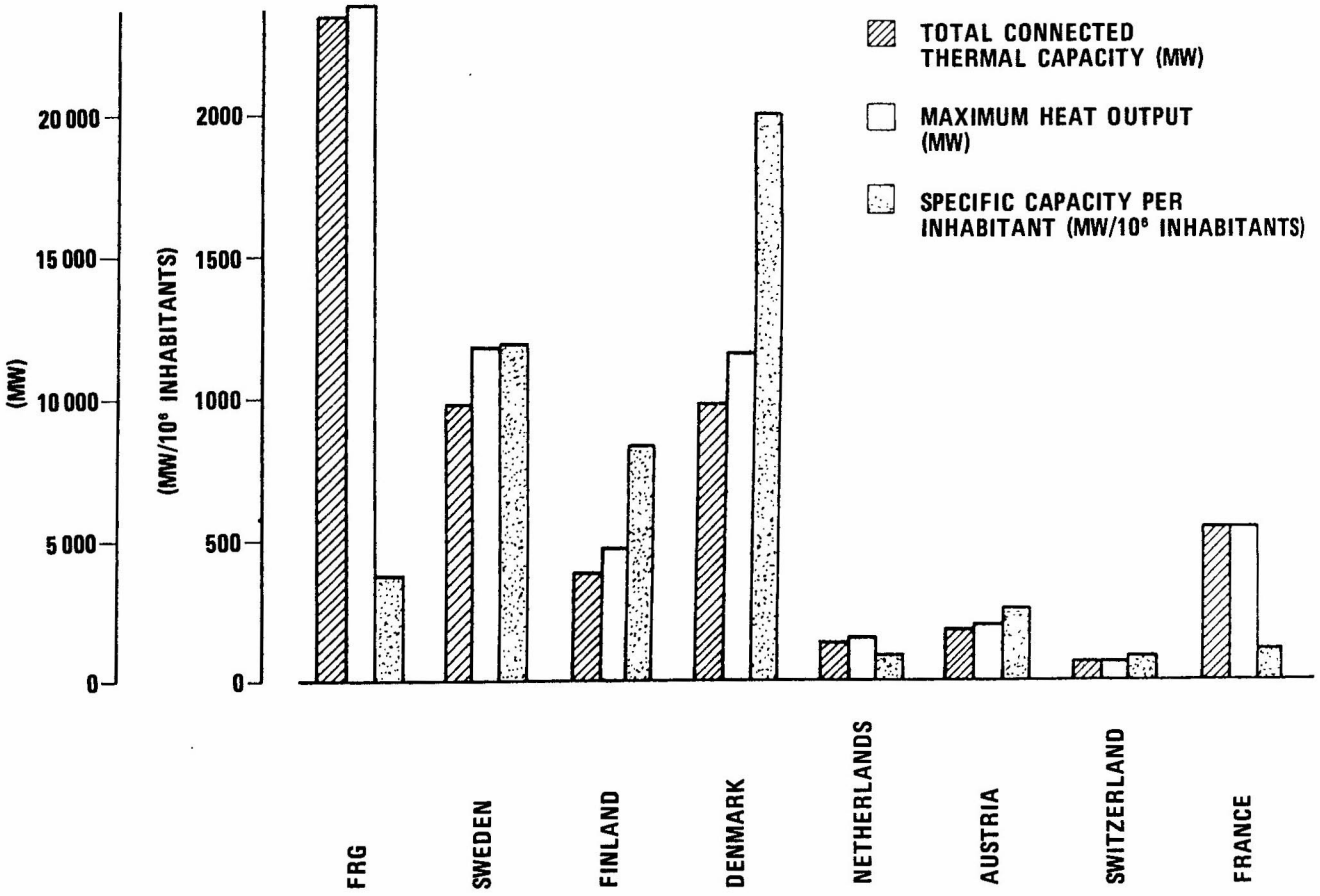

Fig. 6. Comparison between connected and specific capacities (western Europe).

A large part of the heat demand is supplied in all countries by stations producing heat only. Decisive for the application of stations for the combined production of electricity and heat, or stations producing heat only, are obviously the regional influences, which are shown in comprehensible detail.

One can also see that uniformity and standardization in the east European countries are much more advanced than in the other countries. In western Europe, it is only in Sweden and Finland that there are the first indications of the start of the planning of purpose-designed hot-water and turbine units. Except for the nuclear power plant at Agesta, which is located near Stockholm and is now shut down, nuclear power plants have not yet been used for district heating purposes. Development work that has been carried out in several countries shows that dual-purpose nuclear power stations with a thermal rating of some 1500 MW(thermal) are more economic than similar conventional combined stations. Therefore, whether nuclear energy will be used in the future for district heating supplies will essentially depend on the development of a sufficiently high heating demand.

In some countries, gas turbines provided with waste heat boilers have been installed to help meet the peak-load heat requirements of the district heating networks, but it is again only in the east European countries that a uniform application can be recognized.

FUEL PROPORTION

Figure 8 shows the fuel proportion in western Europe for both heating and combined stations. The countries with hydropower—Sweden, Finland, Switzerland, and Austria—all have very similar fuel proportions. Sweden and Switzerland use almost 100% oil for district heating, while Finland and Austria use almost the same percentage of coal, but Finland uses some 10% more oil than Austria, where gas supplies are available. The Netherlands has indigenous gas reserves and, because of this, almost exclusively uses gas for the requirements of district heating.

In the east European countries (see Fig. 9), the use of solid fuel predominates over all other fuels and, with the exception of the USSR and Rumania, is

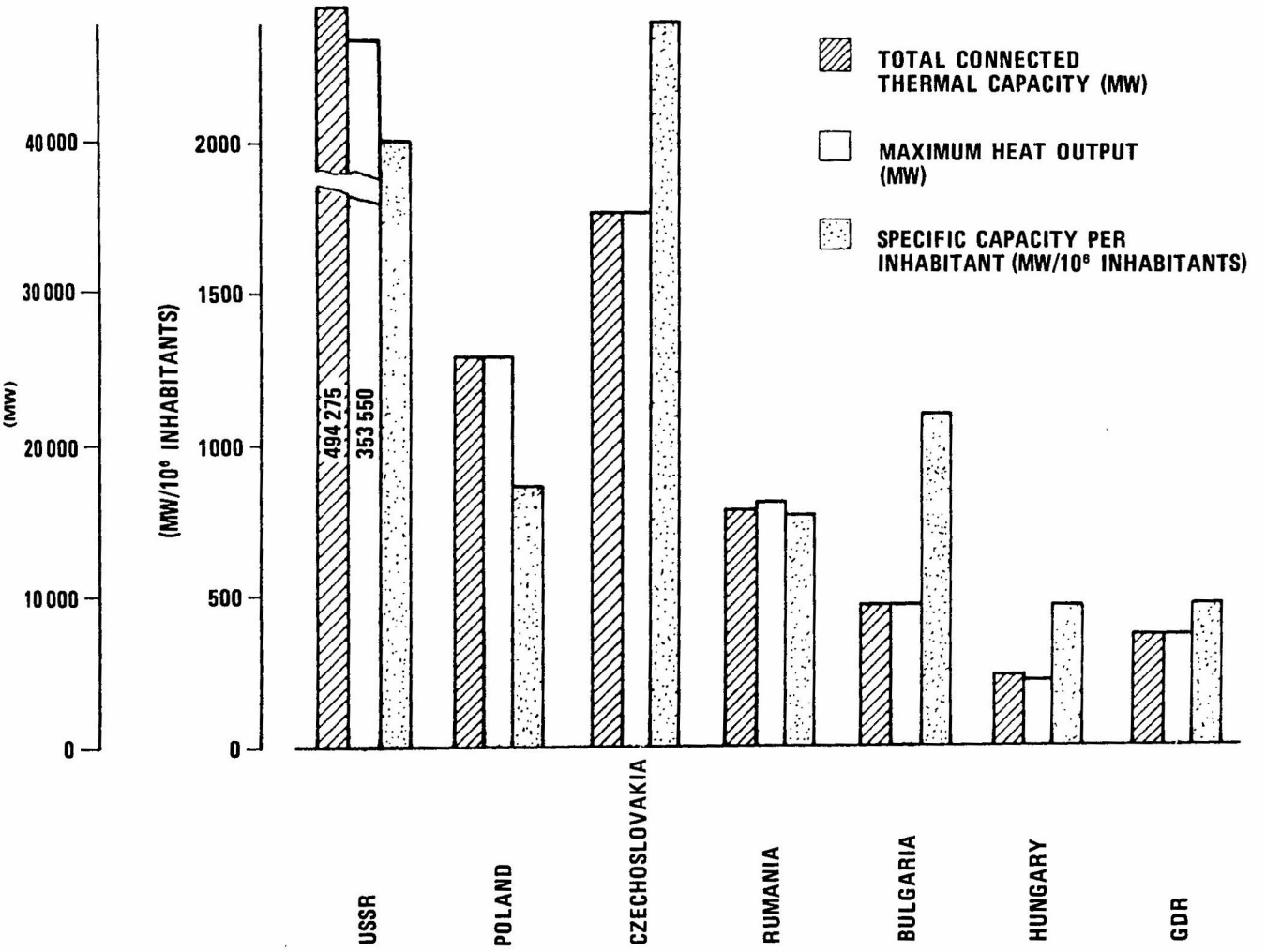

Fig. 7. Comparison between connected and specific capacities (eastern Europe).

in excess of 80%. Rumania, which has oil and gas reserves, uses some 64% gas for district heating, compared with only 36% for the USSR. These data distinctly show the predominant use of indigenous energy sources by this group of countries and indicate a firm policy for fuel independence.

DURATION OF USE

The annual duration of use of the installed district heating production capacity is dependent on various factors, including the geographical position, resultant climate, and the different regional, supply, and political factors that overlap the climatic dependency in many cases.

In Fig. 10, the annual utilization, expressed in equivalent full-load hours and calculated from available data, is shown for the countries considered. The influence of climatic differences is not shown clearly because the available data (heating peak loads, yearly heat supply) are only relevant to single years and have not been normalized. The climatic influence on the utilization of district heating production plants will become clearer if we compare the load duration curves. This is shown in Fig. 11 for the cities of Helsinki and Hamburg, which have both rather large district heating systems and different climatic conditions.

FUTURE DEVELOPMENT OF DISTRICT HEATING SYSTEMS

Earlier, it was stated that the oil crisis of 1973 was a milestone in the development of district heating (when both energy saving and energy independence became a requirement). Since that time, especially in the western countries, clear tendencies have appeared toward an acceleration of the formulation of district heating supply policies. These are

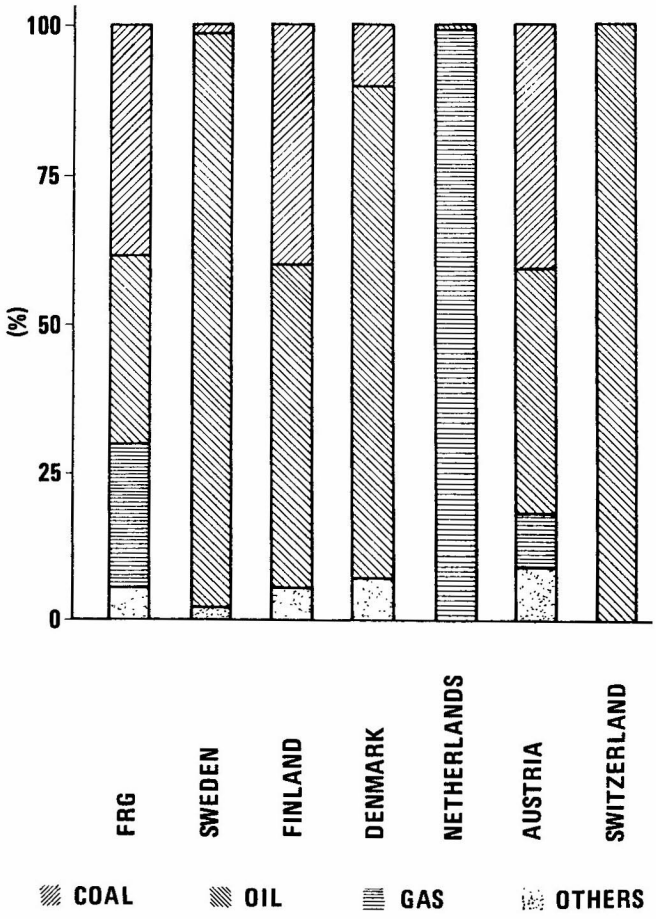

Fig. 8. Fuel proportion for district heating (western Europe).

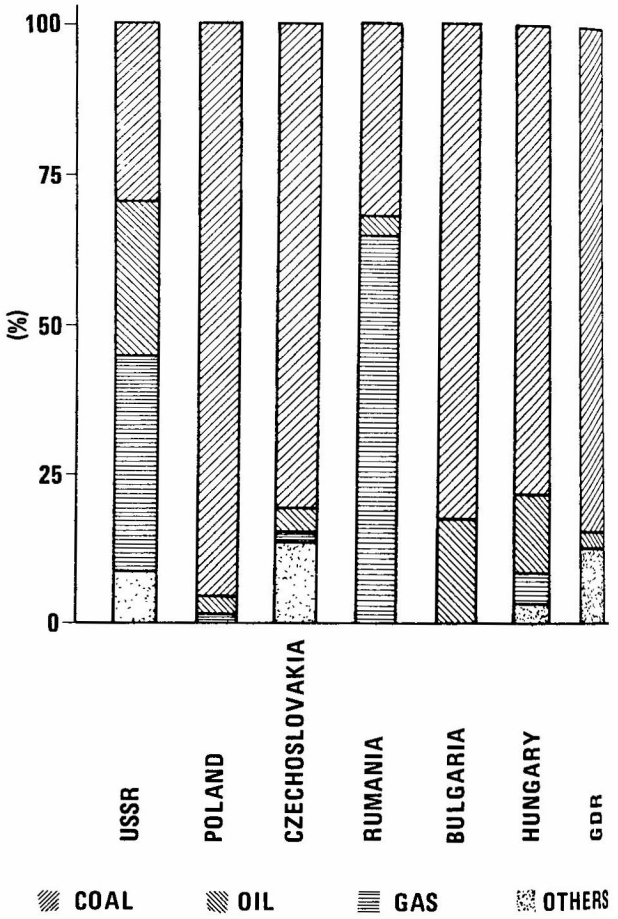

Fig. 9. Fuel proportion for district heating (eastern Europe).

usually based on combined heat and power production. In the east European countries, there are very strong government policies for the acceleration of extending the district heating systems. These policies exist mainly in essential investment substitutions for energy supply equipment and also for house building. However, while in the east European countries clear aims had been formulated and promoted, the west European countries in general have only carried out preliminary studies and made some program proposals; in addition, in some of the countries a stronger official policy has emerged.

A quite notable development has occurred in Scandinavia. In 1976, the countries there formed District Heating North, with very clear-cut aims, the realization of which, because of the various interests involved, will only be possible by political decisions. In the FRG, the Federal Ministry of Research and Technology has, for the past $2\frac{1}{2}$ yr, been carrying out a survey of the market potential of an accelerated program to extend in the near future the district heating systems. The results of this survey show that 25% of the low-temperature heat required by the FRG can be supplied by means of district heating using dual-purpose plants. Information from the Netherlands, France, and Switzerland indicates that they have separately arrived at similar solutions.

The major question that is now being considered in all countries is what part can nuclear energy play in this development! According to the economic planning of the east European countries, until 1980 the major source of energy for their district heating will continue to be coal, but after that year, nuclear power plants will play an ever increasing role in the production of heat. The USSR and especially Poland, Czechoslovakia, and Bulgaria have very advanced plans for building nuclear power plants for district heating.

All the Scandinavian countries have included the building of nuclear power plants in their economic programs, and in Sweden a survey has been carried out into the feasibility of having three large city regions, with very large heating networks. In this case, 2000 MW(thermal) could be provided by nuclear power plants and would result in a reduction

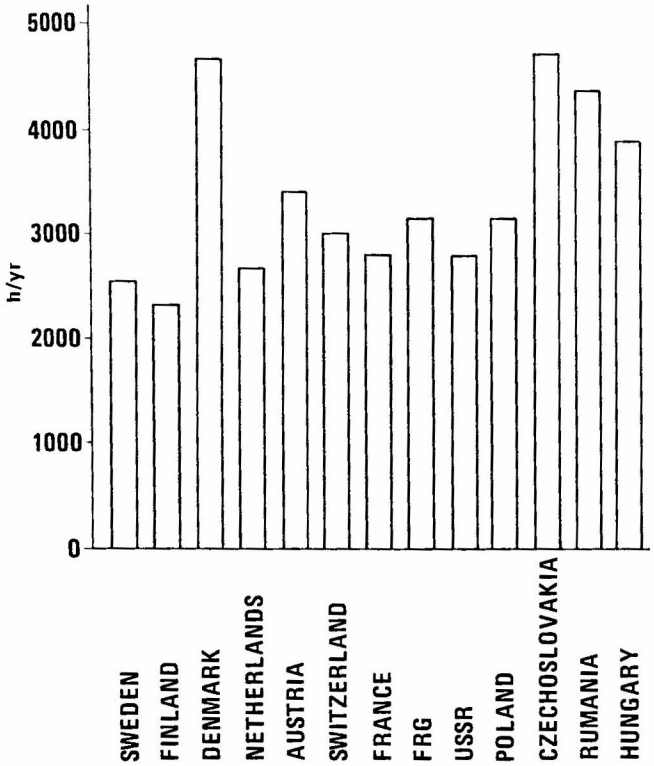

Fig. 10. Annual utilization of heat production capacity.

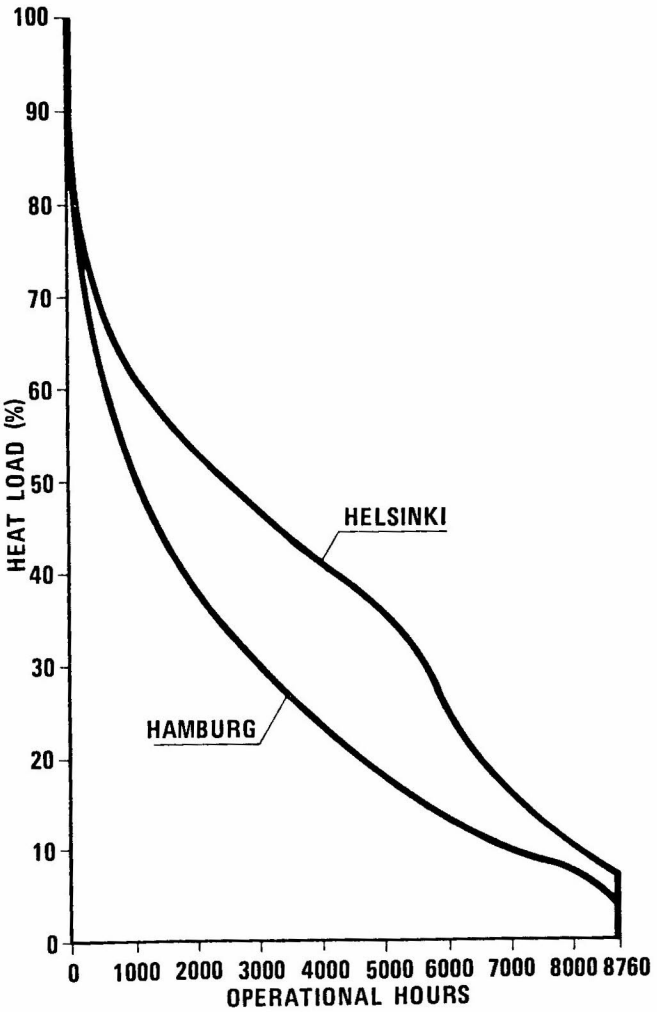

Fig. 11. Load duration for district heating systems.

of energy import (equivalent to 5 million SKE) and of environmental pollution.

In Denmark, where the combined heat and power plants have been sponsored by the government, it has been found that to ensure the future continuity of energy supplies, a nuclear power plant provides the optimum solution. Finland, which also considers the combined heat and power unit as the most favorable solution, has very firm plans to build a nuclear power plant for district heating. This plan will serve the greater Helsinki area and, to implement this project, in 1976 a consortium was formed by the largest utility and several local communal companies.

Switzerland in the long term and the FRG have very firm policies. The Federal Ministry of Research and Technology in the FRG has prepared a study and has already selected a number of high-density population areas for the building of large heat supply systems in the immediate future.

Feasibility studies have also been completed of large nuclear power stations, with a combined heat and power output, but all of them indicate that the introduction of such large units is not without some economic risk. The tendency of the generally privately owned utilities is to be conservative, and they much prefer the smaller units, with which they have had considerably more experience.

The future use of nuclear power plants for district heating would appear to be both technically and economically viable within certain constraints. The realization depends not in the least on government policies and support programs that will enable the utilities to start the extension of plants of this complexity. (See Refs. 1 through 6 for more information.)

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