INTERNATIONAL DISTRICT HEATING ASSOCIATION
IDHA

DISTRICT HEATING

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STATEMENT OF POLICY

The International District Heating Association represents those companies and individuals engaged in the concept of supplying thermal energy in the form of steam, hot water, and chilled water for heating, cooling and process use in organized communities. It represents the industry throughout the United States and Canada, and has affiliates throughout the world.

The membership is involved in and greatly concerned with the most efficient use of energy, the planning and development of central cities and other high density areas, the conservation and encouragement of investment in the industry, and the protection of the environment in an intelligent and rational manner.

The IDHA, by the very nature of the industry, supports clean air and protection of the urban sector because these efforts are best achieved by central energy distribution methods. It is opposed to an emotional atmosphere in environmental matters resulting in unnecessarily costly, constrictive or ambiguous governmental controls. It supports safety programs that are proven concepts with economically justified benefits.

The Association's objectives are to collect, coordinate and disseminate ideas and information on efficient methods of producing, distributing, marketing and utilizing central energy systems, and on the accounting and administrative methods employed in the industry; to advance knowledge and learning, and to stimulate invention and research; and to cooperate with other organizations and agencies by interchange of ideas and information.

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Germany Looks Toward Nuclear District Heating

To reduce their dependence on oil, the Federal Republic of Germany is studying ways of establishing combined heat and power production from nuclear sources. This article, based on a paper to the German Nuclear Forum by Dr. Hans-Peter Winkens, Chairman of the country's District Heating Association, examines some of the underlying issues.

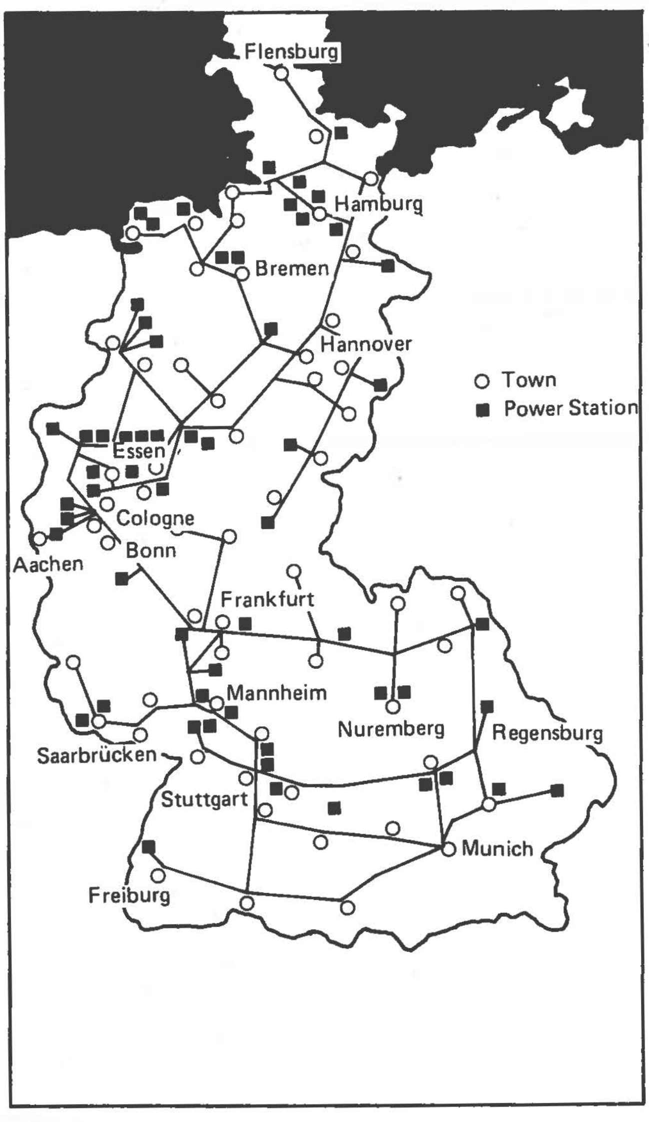

Fig. 1—Map shows one possible scheme for linking the major cities and towns of the Federal Republic to a hot water grid supplied by nuclear power stations.

If, contrary to many views expressed these days, one is of the opinion that an adequate energy supply would not endanger our world in the short term, one nevertheless has to admit that the costs of using known resources will be higher in the future than is the case now. Furthermore, the bitter perception of such an unjustifiable dependence on efforts forces us toward a more economical use of energy. To this end district heating supply by means of heat generating stations can cover the demand for space heating with 15-20% of that of the fuel expenditure of individual heating systems, since the heat lost in the process of electricity generation can be recovered.

In 1971, in the Federal Republic of Germany, 76% of the total energy consumption was covered by the demand for heat: 40% was used for space heating and 36% for process heating. Over 63% of the supplied energy was lost. Our main objective for the future has to be the use of these wastes. For instance, in the generation of electricity by a condensing steam turbine power plant, more than 60% of the input of fuel heat is lost as waste heat and boiler loss; with the same electrical output of 100 MW the waste heat could be used to heat 25 000 homes.

Various European countries are investigating to what extent nuclear electricity generation can in the future be combined with district heating supply to homes, business and industry and also with the supply of high temperature process heat. The development of district heating will also be boosted by other reasons. Recent research has clearly shown that emissions from the much smaller individual heating systems of homes, business and industry at low altitude have a much stronger impact on our environment than was believed. The shift of emission to higher altitudes is a real improvement. Besides the fact that during combined generation of current and heat, total emission decreases, the expulsion of flue gases to higher altitudes possible at a large central plant offers a distinct improvement. With nuclear combined stations the environmental side effects are, of course, much less.

Also, because of the strong shift of people looking for employment in commerce and the service sector, population in and around towns increases. This, together with a large increase in energy consumption, leads to the installation of power plants in the neighbourhood of the consumer centres. In the future not only towns will have a concentrated heat consumption, although this is necessary for an economical district heating supply system; the trend is toward wide-area district heating networks which could also be fed by nuclear power stations.

District heating in Eastern Europe has been supplied for many years now by combined heat and power stations. According to a Soviet report at the 1974 World Energy Conference, more than 50% of domestic heat demand in the Soviet Union is already supplied by heat power stations. In Denmark, more than 30% of the homes are now on district heating and by 1980 service will have reached over 50%; in Sweden around 70% of space heating needs will be supplied by district heating in 1980. Also between 20 and 60% of the inhabitants of Finnish towns will be supplied by district heating.

Thirty-five towns in Sweden have district heating. Västeras is heated almost entirely by district heating. For densely populated areas, nuclear heat and power stations are being discussed. Plans for Stockholm envisage a nuclear power station with a light water reactor situated southeast of the city which would supply about half the needed maximum annual heat output of about 1700 Gcal/h per year in a distribution network extending for more than 60 km.

In Finland, half the demand for heat in the Helsinki area is already met by district heating with an output of 1100 Gcal/h. Demand in 1985 is estimated at 3500 Gcal/h which will be supplied via two nuclear plants of which one, east of the city, will be in service in 1982-84 and the other, to the west, in 1990.

Because Switzerland could hitherto cover her electricity needs with water power, district heating supply by means of heat and power stations has played a minor role there. However, for some years now, plans have been introduced in every town which lay the foundations for an extensive district heating application with combined power stations during the next 20 to 30 years. It is suggested that individual heating systems in Switzerland could as a result be reduced by 95%. Densely populated areas would receive hot water directly from their district heating systems and the rest of the country would be supplied with electricity.

In the Federal Republic of Germany about 7 to 8% of the total demand for space heating and the preparation of hot water is met by district heating. In 1972 district heating supply was between 38 000 and 40 000 Tcal, two-thirds of it coming from combined heat and power stations was around 5000 MW. A study, *Energy and Waste Heat*, undertaken in 1973 by order of an interparliamentary organisation, calculated that the heat demand in 1970—for space heating and preparation of hot water had been 541 000 Tcal. Basing itself on estimates and supposing the existence of a far reaching

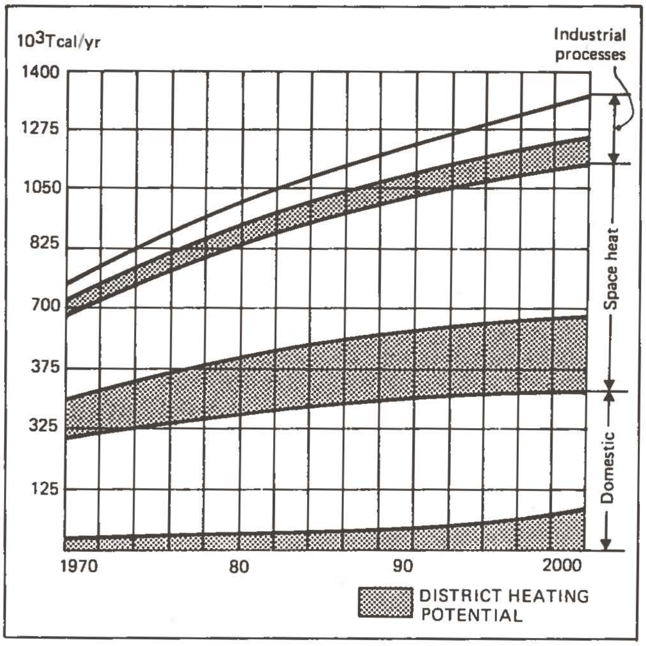

Fig. 2—Heat load forecasts for industrial and space heating to the end of the century.

heat demand as an economical necessity for the application of district heating, the study draws the conclusion that 42% of this heat consumption, around 228 000 Tcal, could have been covered by heat power stations, representing an equivalent saving of 26 million t of coal. On the other hand, 20 000 to 30 000 MW of combined power station output should have been available, which would have corresponded to more than 50% of the public power station output.

It must be accepted that further developments and heat demand forecasts are not yet known. The figures underline, however, the significance of an intensive heat power economy and also show their strong influence on the structure of electricity generation. A quick estimate shows that, already in more than 30 cases of increasing heat demand in the coming 10 to 15 years to be supplied by means of a district heating system, coverage by nuclear heat and power stations would be economically profitable.

In the wake of the oil crisis, the Federal Ministry of Research and Technology initiated two study programmes into secondary energy systems. KFA Jülich, in association with a number of engineering firms, undertook the study of secondary energy resources, and Dornier Systems, in cooperation with Lurgi and STEAG, the study of non-nuclear energy sources. Last November the first results were presented.

The first study considers that district heating is not feasible in communities of fewer than 20 000 people, as in these cases about 61% of the homes still heat by means of furnaces and about 74% of the homes are single family dwellings. Forty-eight per cent of the homes in West Germany fall within this category. The study concludes that in the light of known development plans the potential for district heating for homes and

Gcal = Billion calories Tcal = Trillion calories small scale use might increase from 147 500 Tcal/year in 1970 to 348 200 Tcal/year in the year 2000, which amounts to about 32% of the total heat demand of this group. On the other hand, industrial district heating potential is estimated to be only about 90 000 Tcal/year (28%).

Development of district heating potential up to 2000 envisages a heat output of around 100 000 Gcal/h in 1985 rising to 140 000 Gcal/h in 2000 with an associated electrical output of 30 to 50 GW.

The second study reaches similar conclusions for the year 2000, whereas 20 years later district heating will share 50% of the supply to small consumers and households, and 20% of the coverage of the energy demand by industry.

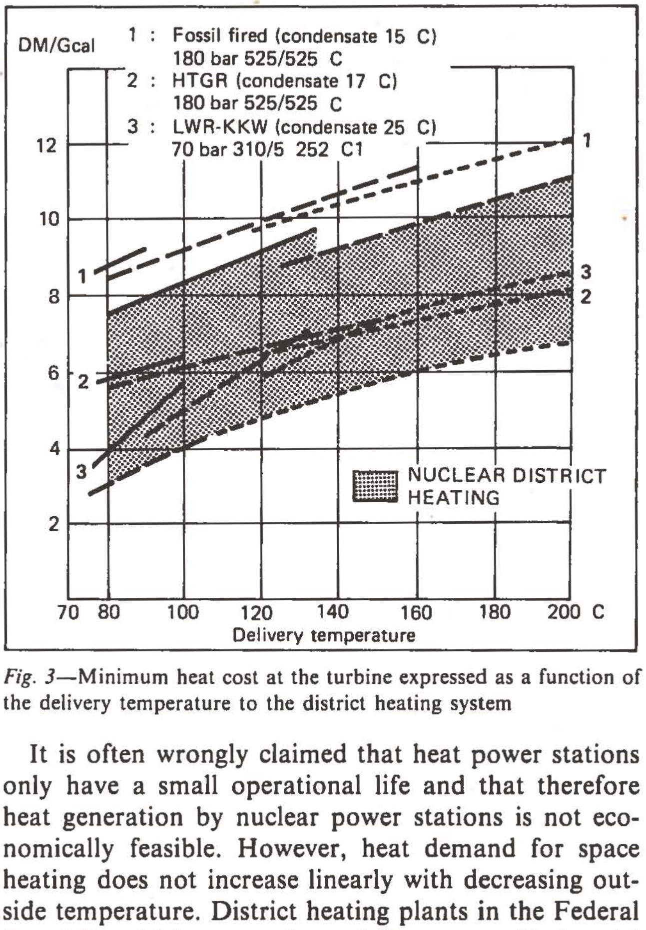

Fig. 3—Minimum heat cost at the turbine expressed as a function of the delivery temperature to the district heating system

It is often wrongly claimed that heat power stations only have a small operational life and that therefore heat generation by nuclear power stations is not economically feasible. However, heat demand for space heating does not increase linearly with decreasing outside temperature. District heating plants in the Federal Republic, which cover substantially space and industrial energy needs, achieve utilisation about 3000 h drawn from the energy peak load. Furthermore, at times of peak energy demand, only 11% of the annual energy supply is lost. This part of the annual heat demand is generally not associated to power generation but supplied from peak-load boilers. Therefore, combined heat and power stations can achieve a utilisation of between five and 6000 h/year at least. If use of peak-load boilers at heat power stations with back pressure turbines is not foreseen, the heat dumped at times is reduced so as to get a higher electrical output and balance by means of heat storage capacity of the network of special accumulators to achieve a balance.

This is significant when you consider the determined costs for heat generation dependent on the delivery temperature of different heat power stations. The costs of heat generation are calculated on the basis of operating value processes, i.e. by evaluating the loss of electrical output due to heat production against the average costs of generated current from condensing power stations: DM 0.04/kWh is achieved only at a nuclear power station for a utilisation of about 6000 h; similarly the cost for a coal fired power station would be DM 0.06/Gcal, assuming an equivalent fuel cost of DM 20/Gcal. It should, however, be noted that these costs assume a return water temperature of 70 C. In most cases, return temperatures are now even lower at peaking times. With temperatures of 40 C the costs are as much as DMI to 2/Gcal, especially with multi-stage heat-up.

An expert in conventional power-heat-coupling will first of all be astonished by the fact that, in reaching 100 C, light water reactor (LWR) nuclear power stations show lower heat generating costs than heat power stations with high temperature reactors (HTGR), and also that at high delivery temperatures costs are not significantly different. This depends first of all on the assumption that, with regard to the condenser energy production for both types of power stations, costs for energy production of DM 0.04/kWh are the same.

With both reactor types the loss in electricity production connected with heat supply is about the same if one assumes the same condensing operations. Since LWR plants have a lower overall thermal efficiency, the thermal rating of the reactor must be increased to compensate reactor output. As a result, the ratio of electricity to heat production for an HTGR is about double that of a light water reactor.

The lower production costs of the LWR's, together with lower delivery temperatures, are essentially based on the fact that the condenser generally has to work on a somewhat lower entrophy level than at an HTGR. In order to keep the final moisture content low, the steam expansion through the turbine must be arrested at comparatively high temperatures and pressures. Thus the loss in energy generation, relative to the heat supplied, is less than with an HTGR plant.

Also, the steam supply situation with the LWR seems to be somewhat more favourable as it is possible to decouple it under light load conditions. For 20 ata/250 C costs are estimated at DM 12.5/Gcal and for 32 ata/250 C, DM 13.4/Gcal.

A particularly favourable heat to electricity production ratio can be expected from the direct cycle HTR, as here the heat, within a temperature range of 140 C, could be decoupled without appreciable loss.

The choice of delivery temperature from the power station will largely be determined by an optimization of the costs of generation and distribution, considering the relation with heat supply. As a nuclear plant will generally be supplying heat over a larger area and, therefore, the cost of the distribution system will be greater, an economical delivery temperature will be in the range of 140 to 180 C.

In considering the costs for additional peak heat generation and all the other network and power plant costs, the heat cost to the consumer, depending on the distance of the supply system, are as shown. The costs of heat supply charged to the client are, depending on quantity and service period, between DM 55 and 70/Gcal. The study concludes therefore that, up to a range of about 40 km, district heating from nuclear combined plants is competitive and that by the end of the century a substantial part of the district heating load will be covered by nuclear power stations. Most of the plants which in fact are now either in the planning stage or under construction could be used for a regional district heating system.

While the programme study *Secondary Energy Resources* limits itself to regional extension of district heating, the programme study *Non-Nuclear Energy Resources* considers that in the year 2020, after regional extension of the district heating supply system for the whole of Germany, a national grid will have been installed into which all large power stations will feed heat and on which all towns of over 40 000 population will be connected. About half the energy demand of those towns should be supplied from the grid. The hot water should have a maximum delivery temperature of 180 C and the storage capacity of the grid would be so large that during electrical peaking periods full electricity supply would be possible and consequently the grid would essentially be fed during the night. Such a scheme would require an investment of DM194 billion of which DM100 billion would be for the regional connection grid. This way the average energy cost would be DM 52.55/Gcal. On the other hand, the costs of regional supply by means of pure power stations would be about DM 58.37/Gcal.

It is interesting to consider such an extreme model, and it seems to be economically realistic. But what would be the advantages of the inter-connected system over the regional supply system when it is possible to produce simultaneously electricity and heat almost ready for consumption. This calculated alternative—close to reality—will not be executed without also considering district heating supply from heat stations. Therefore it is questionable that the inter-connected heating system is the only way to go, in the long run, for district heating supply. Also, the study sets expectations for the output capacity of a profitable district heating supply system too high and it must be feared that, because of wrong interpretation of this study, ideas about furtherance of district heating in the Federal Republic have been damaged and a development will be started in which economical suitability and necessities are being by-passed.

Meanwhile new studies have been commissioned and they will show more evidently which road has to be taken. In September 1974, the Federal Ministry of

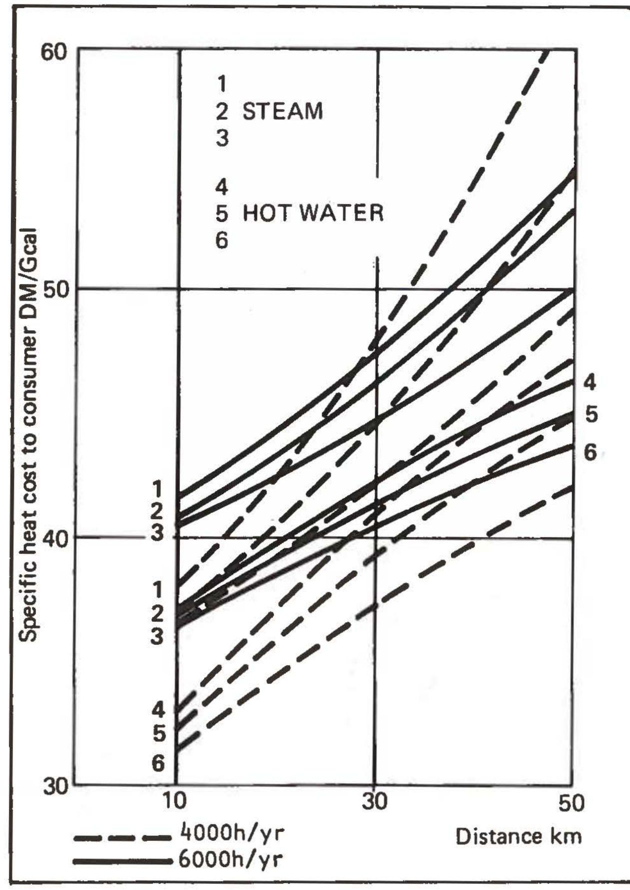

Fig. 4—Specific heat costs to the user as a function of distance from the heat source, using water and steam as the transport fluid

Research and Technology commissioned a DM10M investigation into the possibilities for the application of district heating by means of heat power stations in Germany including four project studies for nuclear heat power stations.

These studies aim first to show the technical and economical preconditions for a wide area district heating service and, in particular, the current and future relations to heat generation, heat distribution and heat supply. These will then be compared with the other possibilities of covering the energy demand for space heating, hot water, and process heat. Secondly, an evaluation is being made on the current and future energy demand for the whole of the Federal Republic as far as it can be covered by district heating from combined power stations. For this purpose, the characteristics of a "heat atlas" for Germany will be worked out. Furthermore, on the basis of actual investigations from models and project studies, it will be shown how this energy demand can be covered through fossil-fired and nuclear plants, taking into account the gradual extension of generating and delivering plants. In two further sections the ecological and economical effects will then be treated.

The four locations for the project studies have been chosen to serve as models for the joint study. These are: West Berlin, where already a nuclear, wide area, heat supply system would be possible if a suitable generating site were available; the western Ruhr district around Oberhausen; the Rhine-Neckar territory (Mannheim, Ludwigshafen, Heidelberg), where in the mid-eighties the necessary conditions for a regional district heating system will exist; and Bonn-Bad Godesberg. The last region is a case; the use of nuclear district heating would require a long-distance grid system coming from planned nuclear power station Mülheim-Karlich. In these four studies the technical and economical developments for the period 1975-1990, and eventually 2000, will be shown on the basis of concrete planning.

The economical characteristics of nuclear powered coal gasification will also be investigated. In future, synthesized gases will increasingly substitute for natural gas, which will be used for space and production heating. The average costs of this process are naturally less than those of electricity generation at condensing nuclear plants, but higher than the known costs of a combined nuclear heat and power station. Unlike gas synthesis, the losses of nuclear power heat coupling are only small. Also, the initial capital costs for the same energy output are only half those of the nuclear gas generator.

It might also be possible to cover a large part of the space and process heat demand by means of electrical energy, especially as, in the foregoing considerations on the basis of its small heat density, it would not be possible to replace it by district heating, or by gas. Models have already been developed for a totally integrated heat demand coverage with district heating and electricity from combined heat and power stations. The required high load factor for electric heating could be reached by either night storage heating, or a combination of electrical direct and storage heating, or by using small electrically heated district heating plants or individual heating installations which, in peaking hours, would be partially or completely boosted with fossil fuels. In this latter case, heat pumps could, in favourable conditions, lead to significant energy-savings.

With already known and proven techniques, the largest part of the heat demand in the Federal Republic could be highly efficiently covered. However, it has to be stressed that, to this end, the electricity industry must embrace the idea of integrated heat demand coverage and adjust their plans for new generating installations in good time. Indeed, this development should be started immediately, particularly in regard to the construction of new nuclear power stations, so that the depletion of fossil fuel resources in the coverage of energy demand could be effectively reduced with consequent ecological advantages. ✸

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(Comments from our readers are invited. Editor.)