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District Heating with Combined Heat and Power Generation

Survey of Present Day Practice

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District heating using combined heat and power generation is now absolutely standard all over Europe. With the likely exhaustion of fossil fuel reserves, we shall become more dependent upon nuclear power, probably using fast breeder reactors, whatever the various pressure groups may have to say. Under such circumstances CHP (combined heat and power) is the only feasible method of making adequate use of the energy produced. Let us now examine the progress which has been made in this field in various European countries.

Austria

In 1971 Austria, which has a population of only seven million, already possessed ten ITOC stations with a total installed heating capacity of about 570 MW. In addition, numerous group heating schemes, refuse incinerators with waste heat extraction and direct-fired stand-by plant are in existence. The distribution of heat take-off between the various consumers is as follows:

Industry: 10.2%
Public authority housing: 56.2%
Offices and private dwellings: 33.6%

The largest schemes are to be found in the capital, Vienna; and in Graz, where there is an ITOC plant operated by the Steirische Elektrizitatsgesellschaft. The Vienna district heating system employs ITOC turbines, as well as large refuse incineration plants able to deal with 50% of the refuse produced by this city of over two million people.

These plants yield steam at 300 C, used for the production of electricity in back-pressure turbines and for servicing the district heating network during the summer months, when the ITOC stations are shut down. The Vienna system, unlike most Continental district heating systems, still uses a number of steam lines for distribution.

During 1976 the total amount of heat supplied to consumers was 9600 Terajoules.

Belgium

There are four companies in Belgium that are members of SA Intercom, and these supply heat in the form of steam to the towns of Verviers, Alost and Zwevegem. At Bressoux, hot water is used as a district heating distribution medium and the heat is obtained from the ITOC station Bressoux. In the other schemes, combined heat and power generation is also practiced together with refuse incineration.

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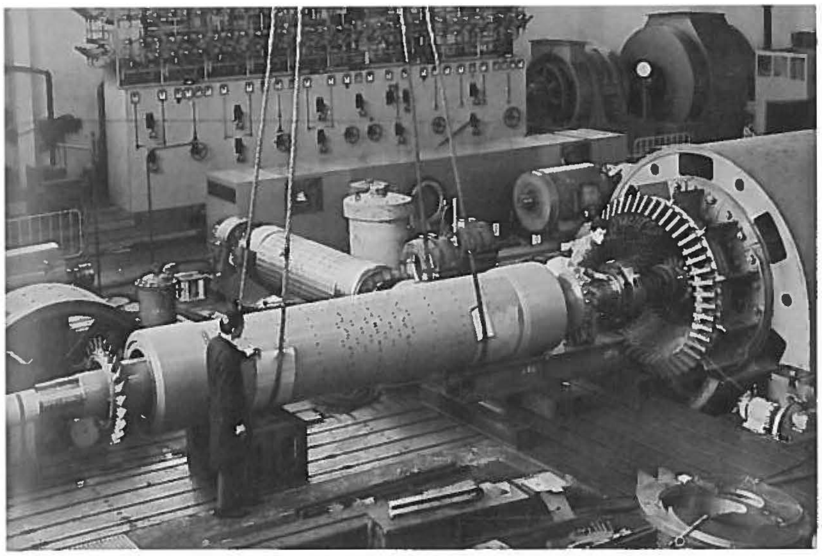
Denmark

The population of Denmark is only 4.9 million, yet its district heating capacity in 1975 was 9885 MW, the highest per capita development of any country in the Free World, and only surpassed elsewhere by Czechoslovakia and the Soviet Union.

Denmark is also a very important originator of district heating equipment of all kinds, and an enormous and lucrative export trade has been built up based upon this field. Ninety per cent of all towns with populations exceeding 2000 have some sort of centralized heat supply.

There are 20 very large ITOC stations with a combined capacity of 5000 megawatts, with a number under construction. Virtually all the distribution systems use hot water with a flow temperature of 90-110 C, and a return of 60-65 C. As the country is flat, there are few difficulties associated with regard to level differences, as for example in West Germany, and for this reason most supply is direct without the use of heat exchangers.

Volud refuse incineration plant used in conjunction with an ITOC turbine to supply a Danish heating network.



An ITOC station during construction.

Exceptions to this rule are provided by the upper floors of very tall blocks and for the supply of heat to older areas of the cities, where it is felt that the ancient radiator systems cannot withstand the high system pressures of the district heating network.

Most Danish district heating systems employ meshed networks where there are always several sources of supply at any given point. This insures against breakdowns. Denmark was one of the first countries to make it obligatory to fit pressure regulators at the consumer's premises. This is essential in leveling out supply pressures in the face of variations due to ground contours and differences in building heights.

Unlike most other countries, the industrial load of Danish district heating systems is very low, amounting to only one per cent of the whole. On the other hand, district heating is very popular with ordinary householders, as it is a good deal cheaper than competing methods of heating. District heating is organized in Denmark by a mixture of private enterprise companies and municipal power companies. Both are characterized by excellent commercial organization, superb public relations and the very minimum of bureaucracy.

Finland

District heating started in Finland as recently as 1955. Yet by the end of 1976, Finland possessed 17 ITOC turbines with a combined power production of 850 MW and able to deliver 1471 MW of heat to the various district heating systems.

By the end of 1975 there were 32 large district heat undertakings with 9570 major consumers, serving a total building volume of 140 million cubic metres; 750,000 people in the country of 4.6 million were being supplied by a distribution network of 1080 kilometres.

The annual heat delivered to the consumers amounted to 27,666 TJ, of which back-pressure heat developed in combined heat and power stations amounted to 61%, the rest being produced by refuse incinerators, directly fired furnaces, etc.

The biggest system in Finland is that operated by the Helsinki Electricity Company, which has a network of 260 km. During peak loading it is supplied by three CHP stations with a total capacity of 557 MW, and three peak load and reserve stations with a combined capacity of 676 MW. The network also uses heat from a refuse incineration plant.

It must be pointed out that the Helsinki system uses CHP generation to cater for only 45% of the required capacity of the system, yet CHP supplies more than 90% of the heat need of the city.

This is an important feature of all European district heating systems and is the reason why these systems are economically viable. Yet none of the reports which have been published in the United Kingdom (on combined heat and power generation) which the author has read, make any mention of this most important principle. This is almost certainly the main reason why British costing reports show CHP to be uneconomic, when European practice shows them to be eminently viable.

It is estimated that fuel savings due to district heating in Finland were equal to 415,000 tonnes of heavy fuel oil in 1975. The heating value of the fuel saved corresponded to two-thirds of the district heat delivered to consumers, and was equal to almost 10% of the heavy fuel oil consumption of the country. The average price charged for heat by the various Finnish district heating networks during 1976 varied between 53 Finnmarks per 1000 kwh for very large consumers such as schools and hospitals, to a maximum of 69 Finnmarks per 1000 kwh for small domestic consumers.

As the rate of exchange as given on September 20, 1977 equals 7.26 Finnmarks to the English Pound, this means that even the small consumer is paying only 0.95 pence per kwh of heat, and this in a country which has very much higher wage (and price) levels than the United Kingdom. It is interesting to note that these costs are worked out on the basis of a cost of 43.65 Finnmarks per 1000 kwh of heating value in the heavy fuel oil, which cannot, of course, be used by the consumer without further refinement. This indicates that the consumer is only paying the district heating companies between 21 and 58% more than the fuel oil costs the district heating companies to purchase. Yet, overall profitability of the systems is very high in spite of high network costs.

It is estimated that by 1980, 12.6% of all the electricity produced in Finland will come from CHP stations as against 6.7% now. (Compare with the Pinkston report, which says that CHP is uneconomic.)

Holland

The two biggest Dutch district heating systems are at Utrecht and Rotterdam. Both use CHP stations, which were modified from existing coal-fired power stations. These are situated nice and centrally, but have been made obsolete as pure power producers by the march of time and progress. The Utrecht system is the largest and had a capacity of about 470 MW in 1970, while the Rotterdam system had a capacity of

302 MW in the same year. In the past, the development of district heating in Holland was hampered somewhat by the very high water table in the country and the highly saline conditions in the soil. In addition, the find of enormous quantities of "Aardgas" at Groningen provided considerable competition. Today this is no longer so. There is every indication that the resources of underground natural gas at Groningen are very limited and, in addition, the new types of pre-insulated pipelines can be laid into waterlogged ground without trouble.

For this reason there has been an enormous revival in interest in recent years in district heating, particularly with the employment of CHP stations, of which a large number are currently being built. Holland, like the United Kingdom, has ideal climatic and topographical conditions for the establishment of district heating, and in consequence very considerable progress is being made there. However, the Dutch do not suffer a nationalized power industry as is the case in the United Kingdom.

Poland

Poland has today a population of 34 million with about 55% of the population living inside cities. As everywhere else, ITOC turbines or CHP is the basis of district heating. Forty per cent of the maximum demand for heat is covered by CHP, although again well over 70% of the actual heat delivered is covered by ITOC turbines. The largest new ITOC stations are built with a thermal output of 1170 MW and an electrical output of 300 MW, with an annual use factor of 3000 hours. In 1973 the total heat delivered by ITOC stations in 40 towns equaled 113,000 TJ.

Six per cent of all the electricity produced in Poland is made in ITOC stations, nearly all of which run on coal. It is estimated that CHP saves now about 2.3 million tonnes of coal equivalent each year. New installations are being built now at the rate of about 2200 MW per annum (the capacity of about 20 Nottingham schemes).

As is usual in Communist countries, great detail is given regarding future development plans. By 1990 it is estimated that only about 5-10% of dwellings in cities will not be connected to a district heating network. After 1985, Polish district heating will be coupled to nuclear power stations, which will then carry an increasing load. It is calculated that by 1990, 13 million tonnes of coal will be saved by the various ITOC stations which will then be used.

In Poland today, ITOC stations are being standardized in order to cheapen productions, into 50 and 100 MW_e sets.

Yugoslavia

District heating using CHP stations is used in the major cities of Zagreb, Belgrade and Ljubliana. The Belgrade system is being run by means of a 125 MW urban ITOC station, and the district heating capacity using CHP is now being trebled. The fuel used in the Yugoslav ITOC stations is heavy fuel oil, but increasingly natural gas is also being employed. The Ljubliana CHP station burns poor grades of lignite and brown coal. By 1985 it is estimated that the Jugoslava CHP stations are going to save 360,000 tonnes of coal equivalent per annum. High-temperature hot water with mains temperatures of 140 C flow and 70 C return are mainly used, although steam lines are employed in hilly areas. The annual number of degree days is much lower than in the UK and climatic conditions are very extreme, all circumstances which do not favor the economic operation of district heating. For this reason, Yugoslavia has less district heating than countries north of the Alps.

Soviet Union

District heating is particularly successful in the Soviet Union, where again they seem to have failed to read either the Pinkston or the Marshall report, because everything there is based upon CHP. At the end of 1975 there were 970 ITOC stations called "TEZ" (Telploelektrozentralii), of which the largest have an electrical output in excess of 500 MW. These CHP stations carry about 57% of the heating load. The total capacity of the Russian CHP stations is the staggering figure of 45,000 MW, which compares with a total installed electric power capacity of 207,000 MW, so that 22% of all Russian power station capacity is in the form of CHP stations.

In most of the Western countries, the supply of power and heat is being carried out by private and semi-private companies which operate CHP because it gives the best return on investment and therefore keeps the shareholders happy. In the Soviet Union, of course, power production is nationalized as in Great Britain, yet district heating using CHP is still so very popular.

There is a very considerable difference in the way British power is nationalized and the way this is done in Russia. In Great Britain, the nationalized industry retains an absolute monopoly over both production *and* marketing of electricity. In the Soviet Union, electricity may be produced by the nationalized power company, but within the cities and other urban areas the various city authorities have complete authority as to how they will purchase their electricity and how they distribute it.

The various city authorities either make their own electricity, which they find is done most economically by CHP, or they purchase power from the state-owned industry, whichever they find more economic. This introduces a degree of competition which is absent in Britain. In other words, in the field of energy production and marketing, Britain is more communist than the communists.

District heating turbines are produced in the Soviet Union in fairly large production runs. Small ones are constantly pensioned off to be replaced by larger and more economical types. The most popular are turbines with a power capacity of 135 MW and 250 MW, which are installed in satellite countries as well.

Capital investment costs are about 217 roubles per installed kw. Most Soviet district heating networks have radii of connection between 10 and 20 km; but the new single pipe systems which are intended to be used with nuclear stations, which have to be built a long way from urban areas, will be much longer, perhaps up to 125 km.

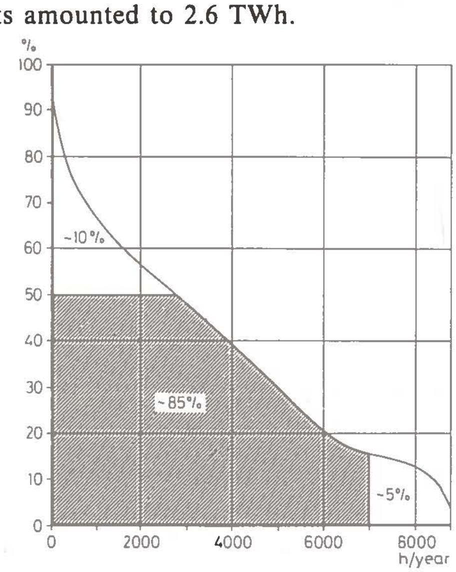
By 1980 the total connection of district heating will be as follows:

Below 1160 MW systems	668 600 MW
Above 1160 MW systems	576 700 MW
Total	1 245 300 MW

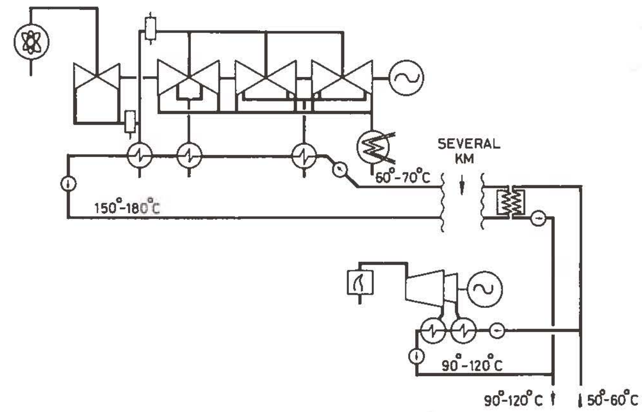
It is considered that it is extraordinarily wasteful to supply district heating systems from directly fired stations, and for this reason every attempt is being made to use CHP instead. By the end of 1975, 37.2% of all the heat produced for space heating in the Soviet Union was from ITOC stations, which is a very high figure indeed, if one considers the enormous size of the country and the fact that district heating for farming areas is obviously not an economic proposition. The latest modern large ITOC stations are being erected at a cost of about 190 roubles per kw, an improvement of 27 roubles on the medium sized standard ones.

Sweden

By the end of 1971, 35 Swedish cities were provided with district heating and the total connected capacity was 7000 MW. As everywhere else, CHP is the main way the heat is being produced. In 1971, the total amount of heat delivered by Swedish district heating companies was 12.4 TWh and the electricity produced by the ITOC turbines of the Swedish district heating networks amounted to 2.6 TWh.



Typical district heating load.



Nuclear turbine for district heating in parallel with smaller conventional units.

Sweden was a pioneer in the use of nuclear power for district heating purposes. Farsta was the first town ever heated in this way, and the system worked well for about 16 years. It was scrapped, finally, because it could not compete with the, then, rock bottom oil prices. Although there is at present the same kind of opposition to the development of nuclear power as is found in Great Britain, France and Germany, Swedes are realists.

By 1990 it is forecast, that some 60% of district heat in Sweden will be provided by ITOC turbines driven by nuclear power. Already several schemes of this type are either in construction or at the final design stage. A nuclear CHP station of 2000 MW at Haninge will supply heat to the Stockholm conurbation, and the 950 CHP nuclear station at Barseback will supply heat and electricity to the two cities of Lund and Malmo.

Both are confidently expected to be operational by 1986. Another nuclear CHP station of 800 MW ($_{el}$) is projected for the Gothenburg area.

In Sweden there are 50 district heating companies which supply heat and electricity via a mains system of 1960 km using a total installed ITOC capacity of 1450 MW ($_{el}$).

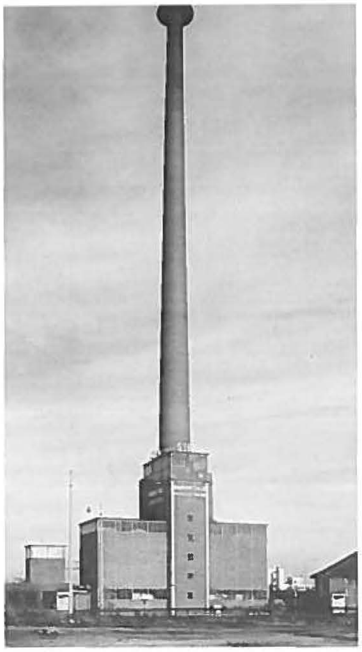
West Germany

West Germany is the country with most district heating systems, outside the Soviet Union. On January 1, 1974 there were 109 different organizations in West Germany which between them operated 98 CHP stations, 369 group heating plants, and 472 district heating networks.

Of the various district heating undertakings in Germany:

3 had a connected capacity greater than 1160 MW
5 between 580 and 1160 MW
15 between 290 and 580 MW
21 between 116 and 290 MW
14 between 58 and 116 MW
22 between 29 and 58 MW
29 between 6 and 29 MW

(Nottingham, the only British district heating network, has a connected capacity of 110 MW) *(Continued)*



A coal burning district heating station owned by STEAG, Essen, West Germany.

The total connected capacity in West Germany at the end of 1974 was 22,268 MW, with an annual supply of 142.74 million GJ to the various consumers.

Sixty-five per cent of the total connected capacity is served by hot water networks, 25% by steam networks, and the rest by mixed networks. The average supply temperature of the hot water is between 110 and 140 C, and in some isolated cases as high as 180 C.

The supply temperature is usually varied according to the external ambient temperatures.

District heating systems, including the running of the ITOC stations, are carried out either by private limited companies or by so-called "Stadtwerke," municipal companies which in addition to making their own electricity and hot water, also deal with the preparation and distribution of gas, water, sewage, etc., as well as the administration of urban transport in their areas.

This very much simplifies the laying of underground lines as the positioning of district heating pipelines can be coordinated with other services, unlike the United Kingdom, where all these authorities operate in water-tight compartments, each with their massive bureaucracy.

The biggest West German district heating network is the one in Hamburg with a connected capacity of well over 3000 MW. There are, in fact, two systems in Hamburg side by side: one operated by Favorit GmbH, a private company; and the other by Hamburger Elektrizitatswerke, a municipal one. Severe competition exists between these two organizations, and the consumer benefits by the fact that this has helped reduce costs.

In Berlin there are two district heating networks: one operated by the communist authorities in East Berlin; and one by the BEWAG company of West Berlin. The BEWAG network is 231 km long and has a connected capacity of 1482 MW. At present, preparations are being made in Germany to adapt the district heating network to the coming nuclear age by the construction of a super-grid system, which will encompass every urban area of the country, and in which the hot water will be supplied by nuclear ITOC stations. This scheme has run into some temporary trouble because of the fanatical opposition of some pressure groups to the development of nuclear energy in Germany, which has up to now already cost some lives, not, needless to say, due to radioactive causes but due to some good, old-fashioned mob violence.

Prospects of District Heating in Britain

To start with, district heating without combined heat and power generation is in the author's opinion, a complete non-runner. There is no advantage at all. But when combined heat and power generation is practiced, it is by far the best and most economical way of supplying heat to the consumers, be they domestic or industrial. CHP has been an enormous success wherever it has been tried. So let us start off with by dismissing all the various reports which have been written in Great Britain by the Central Electricity Generating Board, various consultants, Government bodies, etc.

No costing exercise is valid unless it is based on existing schemes which work. As there is no such scheme in Great Britain, while in other countries there are hundreds which operate so very successfully, it is necessary for any costing exercise to be carried out there and not here.

Why has it so far been impossible to operate a viable CHP district heating scheme in the UK? The reason is neither technical nor sociological. The British climatic conditions, which constitute a fairly high annual degree-day figure without extremely low-temperature conditions, and a long heating season, are virtually ideal for the operation of suitable CHP district heating systems. The real reasons why there is no district heating with CHP in Great Britain are 100% political. In the author's opinion, a mistake was made in the immediate post-war era, when the various municipal authorities which used to administer power, gas and water distribution, were stripped of this; and unwieldy bureaucratic nationalized industries such as the CEGB, the Gas Board, etc., were established instead. This, and only this is the reason why CHP cannot be operated in the UK. District heating must be run entirely by either a private enterprise company or by a municipal organization which must be free to produce its own power as it sees fit and to sell it as it can, at a competitive price. The CEGB should be restricted only to the manufacture of power and that marketing of electricity should be open to all comers. At the same time the absolute monopoly of the CEGB must be broken. Any organization, whether private enterprise or municipal, should be allowed to make electricity and to sell it, if they believe that they can compete in price with the product made by the CEGB.

If a private company made its power in a CHP station and was able to market the heat and electricity it produced freely, without legal hindrance, the CEGB would also be forced to become more efficient, i.e. produce energy by Total Energy means and not by its present inefficient methods. *(Continued on 40)*

(Continued from 34)

At the present moment when Britian is harvesting the enormous reserves of North Sea oil, and when even future prospects for coal seem more hopeful with the discovery of the Selby coalfield, one may be tempted to think that the nation can afford the CEGB. This is a fallacy, because none of the fossil fuel reserves will last forever. At the same time, high home heating costs have a very adverse effect upon living standards, while the fact that the British manufacturer has to pay through the nose for his electricity, reduces the profitability and competitiveness of British industry. It must be recognized that the establishment of the CEGB, which in its overall structure is a unique type of organization throughout the entire capitalist or communist world, was probably a mistake. The sooner something is done about undoing this blunder, the better for all of us. ✷

References

Numerous articles and papers in journal, *Fernwarme International*, Stresemannalle 23 6000, Frankfurt 70, West Germany.

(Continued from 22)

ic Monitoring Service. This plant, in common with all larger plants operated by BP, is monitored from the master console via a G.P.O. landline. The boiler house unit monitors the likely critical alarm conditions (up to a maximum of 20) and in the event of a malfunction sends a call via the G.P.O. line to the central console; this is received and given a visual, verbal and type-out record of the condition. The engineer is then contacted to attend to and rectify the fault. ✷

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