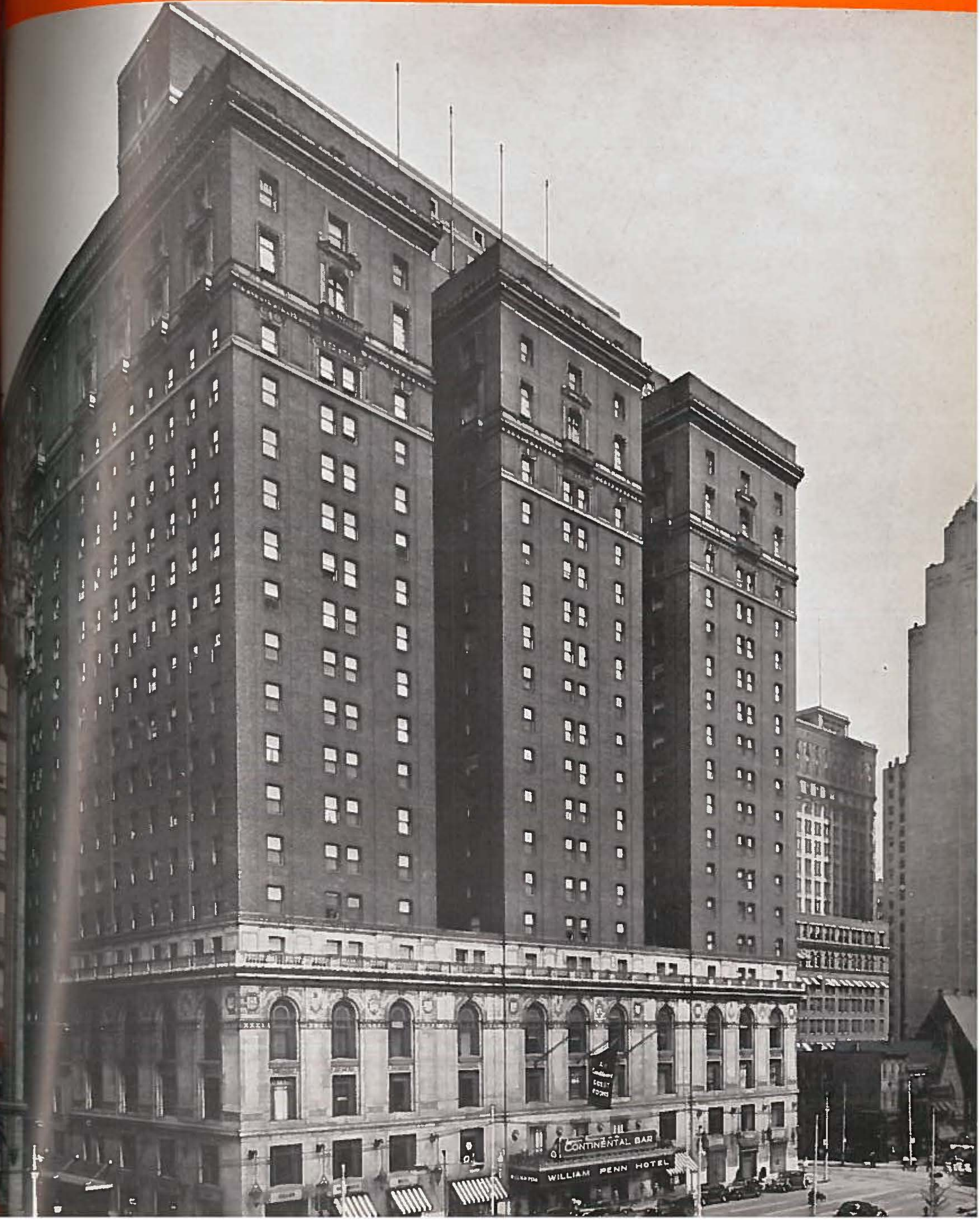
The BULLETIN *of the* NATIONAL DISTRICT HEATING ASSOCIATION

VOLUME XXIX APRIL 1944 NUMBER 3



The Growth of District Heating in Russia and Germany (1)

By A. E. MARGOLIS

THE County of London Plan, recently published, again demonstrates the fact that the great importance of district heating has not yet been realized. Technical development during recent years has considerably improved the economic position of district heating, and the post-war situation will promote conditions favorable for its introduction in this country; firstly, because the reconstruction of devastated areas will make the work easier, and secondly, because the general introduction of district heating will provide employment over a long period and on a large scale. It is opportune, therefore, to give some data showing the development of district heating in Russia and Germany.

In Russia, district heating is a part of the electrification programme which aims at the complete "heatification" of towns and cities. The Russian expression "heatification" demonstrates by itself the broad conception of Russian engineers upon district heating. In the spring of 1929, the author delivered a paper in Moscow on "Heatification and Electrification", and he also had the opportunity of visiting the first district heating plants and of discussing schemes for Leningrad and Moscow. In Leningrad, 34 consumers were already connected, with a heat consumption of 180×10^9 B. Th. U., in the heating season 1928-29, and far-reaching schemes were contemplated. In 1939, the total heat-distribution system of Leningrad had a length of 44 miles, and the total amount of heat supplied in that year was $3 \cdot 3 \times 10^{12}$ B. Th. U. In the same year, there were already seven power stations in Moscow, with a total generating capacity of 187,000 kW, supplying heat, and the total supplied amounted to 6×10^{12} B. Th. U., or 60×10^6 therms.* According to the journal **Teplosilovoye Khosiaystvo** of December, 1940, a heating service in Moscow had been projected for 80 per cent. to 85 per cent. of the total heat demand. The growth of district heating in the U. S. S. R. for the period 1929-39, including industrial heating plants with heat supply to buildings outside, is shown in Table I, herewith. Only 53 per cent. of the total heat was passed through turbines, 47 per cent. being live steam. This was due, apart from the different fluctuations in the electric power and heating loads, to difficulties in obtaining delivery of turbines which had been ordered.

The total capacity of generating sets supplying heat for space heating and process work amounted to 1,747,000 kW, and the total heat delivered in 1939 amounted to $87 \cdot 5 \times 10^{12}$ B. Th. U., or 875×10^6 therms. The significance of this achievement is best realized by comparison with that of the gas industry in this country. In 1933, after 125 years' development, the authorized gas undertakings of Great Britain produced 293×10^9 cubic feet of gas. With due allowance for distribution and combustion losses, however, it is a surprising fact that the total heat supplied to consumers was much

* "Fifteen Years Heatification in U. S. S. R.," by S. J. Belinsky. **Teplosilovoye Khosiaystvo,** No. 10-11, 1939; "District Heating in Russia," by A. E. Margolis. **The Steam Engineer,** February and March, 1941.

(1) Reprinted by permission of "Engineering" of London.

TABLE I.—**Growth of District Heating Plants in U. S. S. R.**

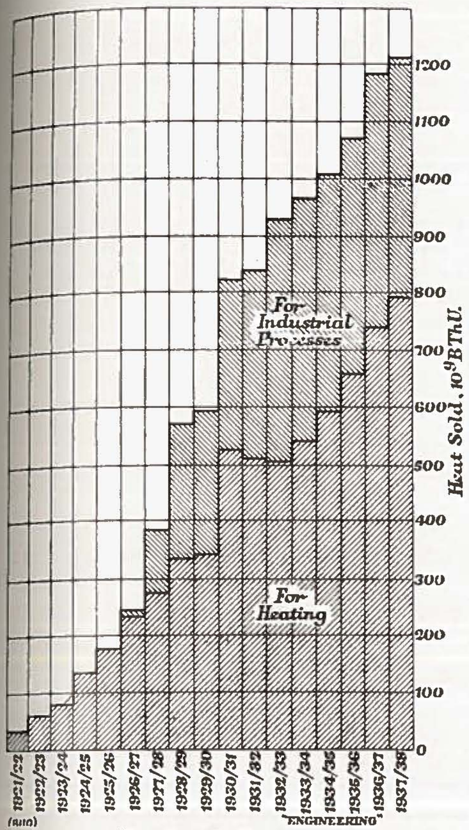
	1929	1933	1938	1939
Number of district heating plants with combined power and heat generation . .	14	53	90	106
Number of district heating plants with live steam distribution	—	—	—	over 50
Total heat supplied—				
10^{12} kcal.	—	5·5	20·46	22·0
(10^{12} B. Th. U.)		(21·8)	(81·2)	(87·3)
From public power stations, included in the above—				
10^{12} kcal.	—	1·99	6·2	7·0
(10^{12} B. Th. U.)		(7·9)	(24·6)	(27·8)
Heat from turbines—				
10^{12} kcal.	—	—	9·85	11·6
(10^{12} B. Th. U.)			(39·1)	(46·1)
Per cent.	—	—	48·5	53·0
Total power capacity, 10^3 kW	60	530	1,397	1,747
Total capacity of public stations included in the above, 10^3 kW	14	179	563	688
Average capacity of public stations, 10^3 kW	4·65	12·8	19·4	20·2
Average capacity of industrial stations, 10^3 kW	4·2	8·5	13·8	14·8

less than that from the district heating plants in the U. S. S. R. in 1939 after a development of only 15 years. According to the Five Years' Plan of 1938-42, the capacity of all thermal power stations had to be increased by 7 million kW, of which 5 million kW were to be installed with back-pressure or extraction turbines for heat supply. The heat-electric capacity would then have been 47·5 per cent. of the total thermal electric generating capacity in the U. S. S. R.

In Germany, the development of district heating has also made considerable progress. The accompanying diagram shows the development of the district-heating system in Hamburg which the author initiated in 1921, and of which he was the manager for 12 years. Started originally from the oldest electric power station in the city, the heat consumption grew so rapidly that, in the course of time, three more power stations had to be added for heat supply. By interconnection of the stations by steam mains, the two oldest stations could be taken out of service. In 16 years, the heat supply increased from 36×10^9 B. Th. U. to $1,210 \times 10^9$ B. Th. U., or about 34 times. The success of district heating in Hamburg encouraged other towns to adopt public heat supply, and according to a report of the Electricity Undertakings in Germany in 1936, there were then 28 district heating plants for public heat supply. Most of the plants were of small capacity; the total heat supplied in 1936 amounted to $5 \cdot 15 \times 10^{12}$ B. Th. U.

According to the latest report to reach this country * district heating has been found

* Z. V. D. I., November 15, 1941.



Hamburg, Germany

suitable for replacing individual central-heating plants and in consequence, large distirct heating schemes are now being worked out, of which one scheme alone has a connected load considerably in excess of the total connected load of all existing plants. Table II, page 122 shows the main particulars of the new town-heating plants as compared with those of the two existing older plants. "Plant I" apparently refers to Dresden and "Plant II" to Hamburg. In the columns headed "Heat Carrier," "H. W." represents "hot water", and "S. H. W." "super-heated hot water", i. e., water at a temperature higher than its boiling point at atmospheric pressure.

Of the new town heating plants, the first sections of schemes I and II were already carried out and the construction of the first sections of schemes III and IV had been sanctioned. It should be noted that each of the schemes III and IV exceeds, in connected load and also in heat supply, the largest district heating plant elsewhere in the world, namely, that of the New York Steam Corporation, which in 1940, consumed 775,000 tons.

The total annual heat supply of the four new town-heating plants amounts to $7,670 \times 10^9$ kcal. $= 30 \cdot 5 \times 10^{12}$ B. Th. U., or 305×10^6 therms, and the total annual electric power generation to $1,760 \times 10^6$ kWh. At a total connected load of $4,990 \times 10^9$ kcal. per hour ($19,810 \times 10^9$ B. Th. U.) the number of full-load hours amounts to

$$\frac{7,670 \times 10^9}{4,990 \times 10^6} = 1,537,$$

corresponding to a load factor of $17 \cdot 5$ per cent. The actual load factor is higher, owing to a certain diversity of the individual loads, but it is comparatively low and shows that the new plants, like the two older existing plants, are mainly for the heat supply of Government and office buildings.

Owing partly to the steam distribution of schemes I and IV and, apparently, to the lack of heat storage, the electric power generation is not satisfactory. In an up-to-date heat-electric station with hot-water distribution it is possible to generate on an average 100 electrical units per 10^6 B. Th. U. of exhaust-heat output. Assuming the heat distribution losses to be 10 per cent., the electric power generation per annum would be increased to

$$\frac{30 \cdot 5 \times 10^{12} \times 1 \cdot 1 \times 100}{10^6} = 3,355 \times 10^6 \text{ kWh.}$$

This great increase in electric power generation, with a corresponding saving in coal consumption, sufficiently demonstrates the advantages of hot-water distribution and heat storage.

In conclusion, it may be useful to show the wider economic basis of public heat supply under conditions of this country. Owing to the predominant method of heating by coal fires, the average efficiency of individual heating in towns can be assumed at a maximum of 35 per cent. The heat losses of the distribution systems for large areas

TABLE II—Growth of District Heating in Germany.

	Boiler Pressure at Station.	Connected Load 10^6 kcal. per Hr.	Connected Load 10^6 B.Th.U. per Hr.	Heat Carrier Long-Distance Transmission.	Heat Carrier Short-Distance Transmission	Heat Carrier At Consumer's Premises	Length of Distribution System Km.	Length of Distribution System Miles	Annual Heat Supply 10^9 kcal.	Annual Heat Supply 10^9 B.Th.U.	Annual Electric Power Generation 10^6 kWh.	Annual Saving in Fuel, tons.
Existing Town-Heating Plants												
Plant I	Medium Pressure.	126	500	Steam	Steam and S.H.W.	Steam and H. W.	20	12 · 4	120	476	25	26, 000‡
Plant II	High and medium pressure	192	762	Steam	Steam and H. W.	Steam and H. W.	32	20	315	1, 250	33	9, 000§
New Town-Heating Plants												
Scheme I, 1st Section*	High	190	755	Steam	S.H.W.	Steam and H. W.	15	9 · 3	220	870	50	16, 000§
Scheme II, Total	High	200	795	H.W.	H.W.	H.W.	—	—	300	1, 190	90	23, 000§
Scheme II, 1st Section* .	High	46	182	H.W.	H.W.	H.W.	—	—	—	—	—	—
Scheme III, Total . . .	High	1, 600	6, 360	—	—	H.W.	—	—	3, 150	12, 500	800	260, 000§
Scheme III, 1st Section† .	High	300	1, 190	H.W.	H.W. and S.H.W.	H.W.	14	8 · 7	700	2, 780	160	53, 000§
Scheme IV, Total . . .	High	3, 000	11, 900	Steam	Steam	H.W.	104	65	4, 000	15, 880	820	290, 000§
Scheme IV, 1st Section† .	High	700	2, 780	Steam	Steam	H.W.	32	20	840	3, 340	173	61, 000§
Total		4, 990	19, 810						7, 670	30, 440 say 30, 500	1, 760	589, 000

* Carried out. † Sanctioned. ‡ Brown coal. § Coal.

can be assumed at 20 per cent., and for the same heat supply as above the annual electric power generation would amount to

$$\frac{30 \cdot 5 \times 10^{12} \times 1 \cdot 2 \times 100}{10^6} = 3,660 \times 10^6 \text{ kWh.}$$

The heat in the steam that would be required for the generation of this power in heat-electric stations amounts to $3,700 \times 3,660 \times 10^6 = 13 \cdot 5 \times 10^{12}$ B. Th. U. · and the exhaust heat output of the turbines, for heat supply, to $36 \cdot 6 \times 10^{12}$ B. Th. U., making a total of $50 \cdot 1 \times 10^{12}$ B. Th. U. At a boiler efficiency of 85 per cent., the total annual coal consumption of heat-electric stations would amount to

$$\frac{50 \cdot 1 \times 10^{12}}{0 \cdot 85} = 59 \cdot 0 \times 10^{12} \text{ B. Th. U.}$$

The generation of the same quantity of electric power in up-to-date condensing stations, with a heat consumption in coal of 12,000 B. Th. U. per kWh., would require $12,000 \times 3,660 \times 10^6 = 43 \cdot 9 \times 10^{12}$ B. Th. U.; and the same quantity of heat by individual heating, at an average efficiency of 35 per cent., would require

$$\frac{30 \cdot 5 \times 10^{12}}{0 \cdot 35} = 87 \cdot 1 \times 10^{12} \text{ B. Th. U.},$$

with a total annual heat consumption in coal of $131 \cdot 0 \times 10^{12}$ B. Th. U.

The annual saving in coal by the adoption of heat-electric stations would thus amount to $(131 - 59) \times 10^{12} = 72 \cdot 0 \times 10^{12}$ B. Th. U., corresponding, at a calorific value of 12,600 B. Th. U. per lb., to

$$\frac{72 \times 10^{12}}{12,600 \times 2,240} = 2,550,000 \text{ tons of coal,}$$

showing an increased annual saving of $2,550,000 - 589,00 = 1,961,000$ tons of coal in favour of district heating in this country with up-to-date plants.

The final goal of district heating is the supply of the whole urban population with ample and cheap heat and the complete elimination of fuel combustion in urban areas. The total demand for heat for space heating, domestic hot-water supply and process work will be met, in the future, from large combined heat-electric stations situated outside the towns. More than half of the coal now burned in towns for heat and electric power supply would then be saved and the smoke nuisance would be completely eliminated; in consequence, the frequency and density of fogs would decrease, and the amount of effective sunshine would be increased. Owing to the improved atmospheric conditions, the distribution of the urban population would be modified, leading to a reduction of the distances between places of employment and of residence, a simplified traffic system, and, consequently, less strain, less waste of time and reduced traveling expenses. Furthermore, first costs and running expenses for new railways, roads and streets and also for all supply services would be considerably reduced. The coordinated heat and electric power generation would also free the streets and roads from the transport of coal and ashes, and the numerous dumps of coal would disappear. As a consequence of the greater cleanliness and the abolition of the countless stacks and chimneys, the aesthetic appearance of towns will be considerably improved. Thus the importance of district heating in town planning can hardly be over-estimated.