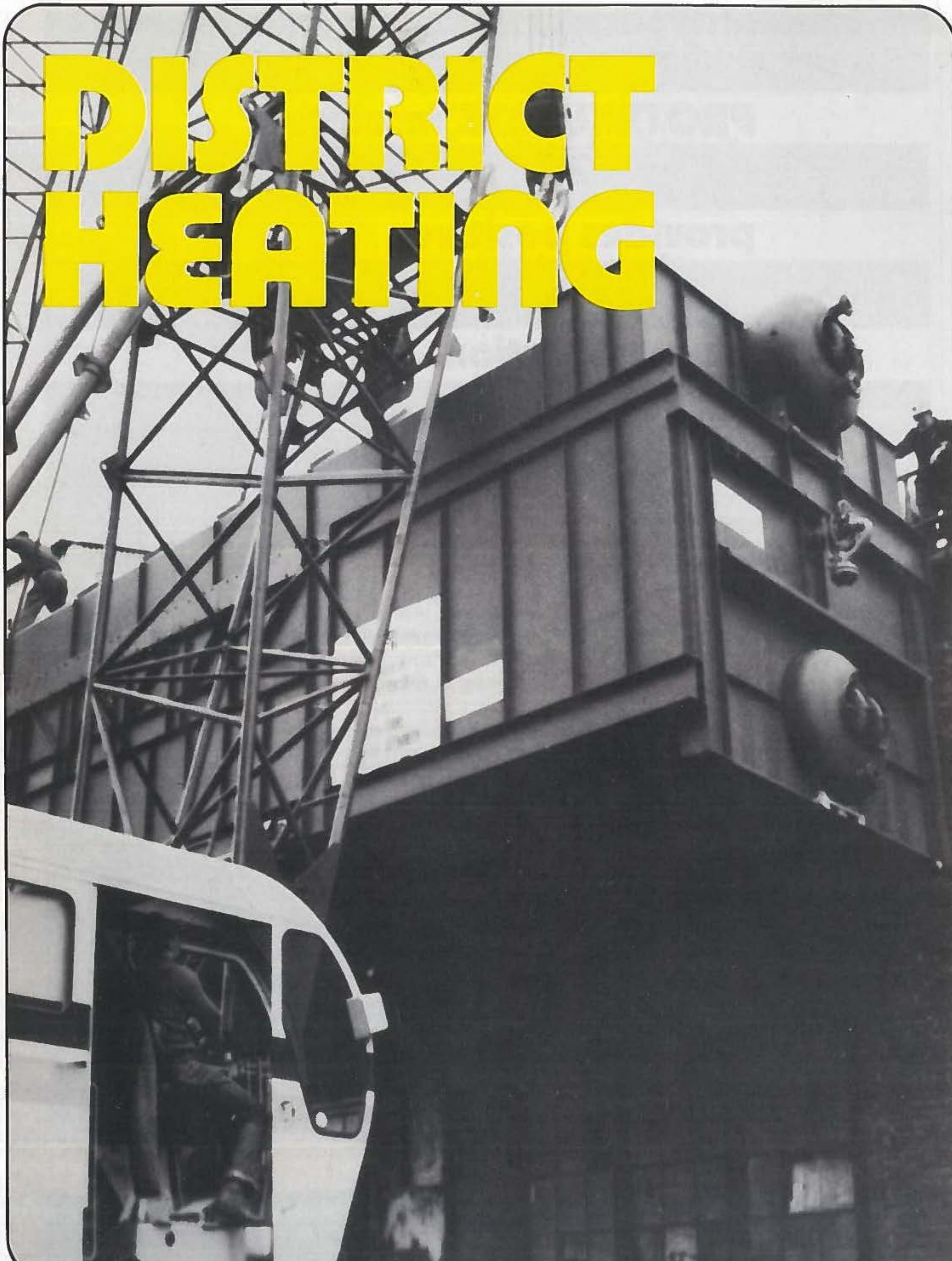
DISTRICT HEATING



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Refuse and Coal Fired Boilers Team Up at Duesseldorf To Cogenerate Electricity and District Heat

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This is a continuation of the article started in the 2nd Quarter 1984 District Heating Magazine.

Integration of Refuse and Coal Fired Boilers

Figure 4 depicts the manner in which the Duesseldorf RPP is coupled with the Flingern Cogeneration Station (FCS) for the purpose of forming the Flingern energy complex (notice the shaded area). Up to six refuse fired boiler systems deliver high pressure, superheated steam from the RPP to a variety of turbines at the nearby FCS via a system of cross country steam lines. Both condensate and electricity are returned from the FCS to the RPP. Additional steaming capacity is provided at the FCS in the form of several coal fired boiler systems.

Most of the district heating output is delivered to the inner city district heating network (DHN) by means of a recirculating, pressurized hot water system. In addition, a smaller quantity is sold directly as steam to several nearby older customers. In recent years, the Lausward cogeneration station (LCS) was also connected to the same DHN to provide much additional thermal capacity. In this context it is important to note that the same municipal power company operates all three facilities, the RPP, the FCS and the LCS thus favoring a common purpose in long range planning.

Table 5 shows the development, on an annual basis, of the trends in thermal and electrical outputs from the Flingern Energy Complex. The amount of refuse-derived energy which ultimately can be supplied in the form of heat and electricity varies, depending on several factors. Most important among these are the network requirements for heat and electricity, both in absolute terms and relative to each other. The equipment mix of boilers and turbines operated during any given period in order to meet these requirements is equally important.

The Flingern Energy Complex depends on three forms of primary energy: bituminous coal, refuse and lignite. For example, during 1982 about 48 percent of the gross energy input came from bituminous coal, 43 percent from refuse and 9 percent from lignite. This percentage break-down did not vary by much over the years, a fact which is demonstrated by the relatively narrow spread around the 41 percent average for the refuse fraction.

Further perusal of Table 5 reveals that most parameters followed a fairly stable pattern during the first 12 years. In sharp contrast, major changes occurred during the last 5 years which can be summarized as follows:

- Amplified energy input from refuse firing in the RPP
- Reduced heat output to the district heating network
- Enlarged electrical output to the electrical network
- Increased cogeneration ratio
- Decreased combined energy output

To a large extent, this upheaval in energy marketing is the result of two important structural changes within the Duesseldorf utility system both of which happened during approximately the same period of time: connection of the LCS and expansion of the RPP. A contributing factor may have been the upward trend in Duesseldorf's market for electricity.

Because of this extraordinary upswing in cogeneration, utilization of the refuse-derived energy declined during 1982 to an all-time low of 27.4 percent. Still, this is probably better than any small refuse fired power plant could do on its own. It is also to the credit of the planners of the Flingern Energy Complex that sufficient flexibility had been designed into the system. As a result, not a single ton of refuse derived steam needed to be dumped over the years in spite of significant shifts in energy marketing strategy.

Conclusion

Figure 1 and Table 1 both indicate that the kind of major construction associated with the installation of additional processing lines did not seriously impair the Duesseldorf RPP's essential waste disposal capability.

With structural and equipment changes and/or additions made, the Duesseldorf RPP can easily accommodate near future growth in the supply of refuse. For any distant future growth, at least two options may be considered.

One may be the replacement of the older and smaller

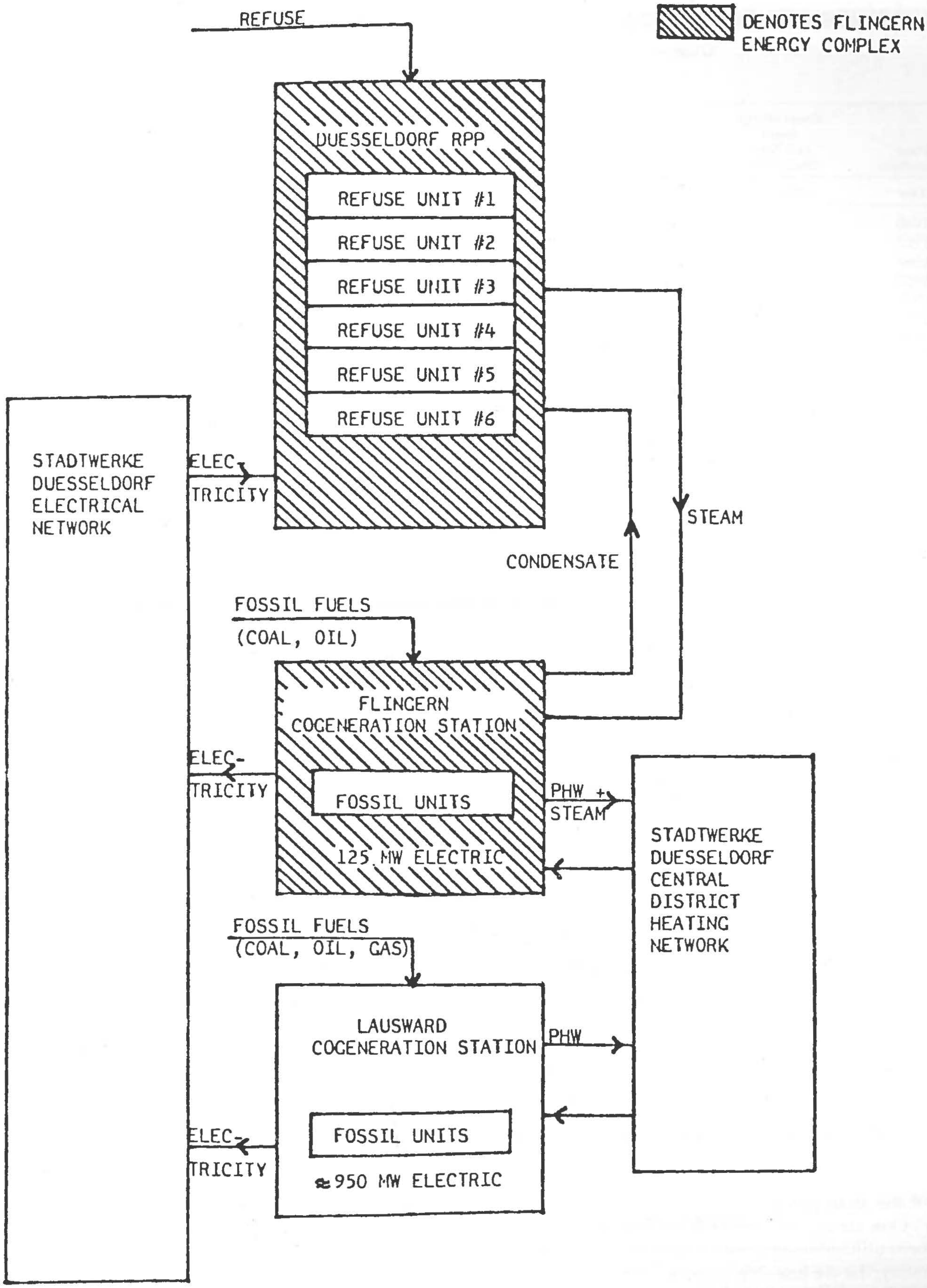

Figure 4
Duesseldorf RPP—Interfaces with Electrical Network and District Heating Network

Table 5:
Duesseldorf RPP and Flingern Cogeneration Station:
Refuse Energy Utilization

Plant Operations	Gross Energy Input (All Fuels Combined)(1)	Refuse Energy Input (2)	Refuse Fraction (3)	Heat Output (4)	Electrical Output (5)	Cogeneration Ratio (6)	Combined Energy Output(7)	Refuse Energy Utilization (8)
Year	MWh × 10^3	MWh × 10^3	%	MWh × 10^3	MWh × 10^3		MWh × 10^3	%
1966	1,619.8	399.0	24.6	128.6	372.0	2.89	500.6	30.9
1967	1,274.2	486.5	38.2	163.5	259.2	1.59	422.7	33.2
1968	1,091.1	555.9	50.9	198.7	186.1	1.57	384.8	35.3
1969	1,170.6	586.9	50.1	224.8	208.7	0.93	433.5	37.0
1970	1,355.9	598.2	44.1	263.1	249.7	0.95	512.8	37.8
1971	1,381.4	572.5	41.4	265.9	266.1	1.00	532.0	38.5
1972	1,572.5	645.8	41.1	273.3	318.7	1.17	592.0	37.6
1973	1,696.1	672.5	39.6	275.5	355.2	1.29	630.7	37.2
1974	1,631.5	659.1	40.4	238.0	357.5	1.50	595.5	36.5
1975	1,675.6	712.6	42.5	250.0	368.4	1.47	618.4	36.9
1976	1,758.8	704.9	40.1	263.4	390.3	1.48	653.7	37.2
1977	1,920.9	705.7	36.7	261.3	440.9	1.69	702.2	36.6
1978	1,722.0	704.7	40.9	295.9	373.0	1.26	668.9	38.8
1979	1,782.4	729.3	40.9	236.2	386.5	1.64	622.7	34.9
1980	1,876.5	746.3	39.8	168.4	419.1	2.49	587.5	31.3
1981	1,925.0	843.2	43.8	123.3	457.5	3.71	580.8	30.2
1982	2,120.8	920.1	43.4	67.1	513.4	7.65	580.5	27.4
17-Year Totals	27,575.1	11,243.2	—	3,697.0	5,922.3	—	9,619.3	—
17-Year Averages	1,622.1	661.4	41.1	217.8	348.4	2.02	565.8	35.1
17-Year % Changes ±	−30.93	−130.6	−76.82	−47.82	+38.01	+164.71	+15.96	−11.33

NOTES: (1) Use 10^6Btu = 293 MWh for conversion. Heat release from refuse burning at the RPP and heat release from coal burning at the cogeneration stations combined.
(2) Heat release from refuse burning only, based on higher heating value. For approximate conversion of heating values, the relationship HHV≈LHV + 1,040 (w) Btu/Lb was used in which w represents the refuse water fraction. A constant w = 0.55 was assumed for the summation of free water and chemical water. The electrical energy equivalent is defined as Btu × 10^{12} = 292.8 MWh × 10^3.
(3) [(Refuse Energy Input) ÷ (Gross Energy Input)] × 100%
(4) Sendout of district heat both by hot water and steam combined.
(5) No deductions are made for in-plant usage, neither at the RPP nor at the cogeneration station. The RPP requires about 41 KWh/ST while the equivalent use for the cogeneration part is substantially less.
(6) (Electrical Output) ÷ (Heat Output)
(7) Combined Energy Output = (Heat Output) + (Electrical Output)
(8) [(Combined Energy Output) ÷ (Gross Energy Input)] × 100%

boilers, #1 through #4, with larger boilers of the #6 type. This would raise total RPP steaming capacity by 100 percent, a move which would be compatible with the improvements already recently completed.

A second option would be to build a second plant on the present sports field adjacent to the old one. In this case the old and the new plants could share the ash processing system and the steam transfer lines.

The extensive design study which preceeded installation of the sixth processing line has paid off handsomely. One strong indication is the unusually high equipment utilization observed during the first 3 years of operating the #6 line. Not only did the equipment utilization factor increase during each consecutive year, but its 3-year average is also substantially higher than the comparable averages for the other five lines previously installed.

In view of the trendlines developed during the course of 17 continuous operating years, see Figure 1, there appears to be little reason to doubt that the Duesseldorf RPP will continue to perform equally well during the next three years. The authors feel confident that within a few years they will be able to provide a complete 20-year operating record for a major refuse burning plant with energy recovery. Since life cycle costing in the resource recovery industry is generally based on a 20-year term, such an expanded data base should be of great value to the technical and financial planners charged with developing new resource recovery projects.