Electricity from town refuse—three quarters of a century ago

by Prof. D. G. TUCKER, D.Sc., Ph.D., C.Eng., F.I.E.E.

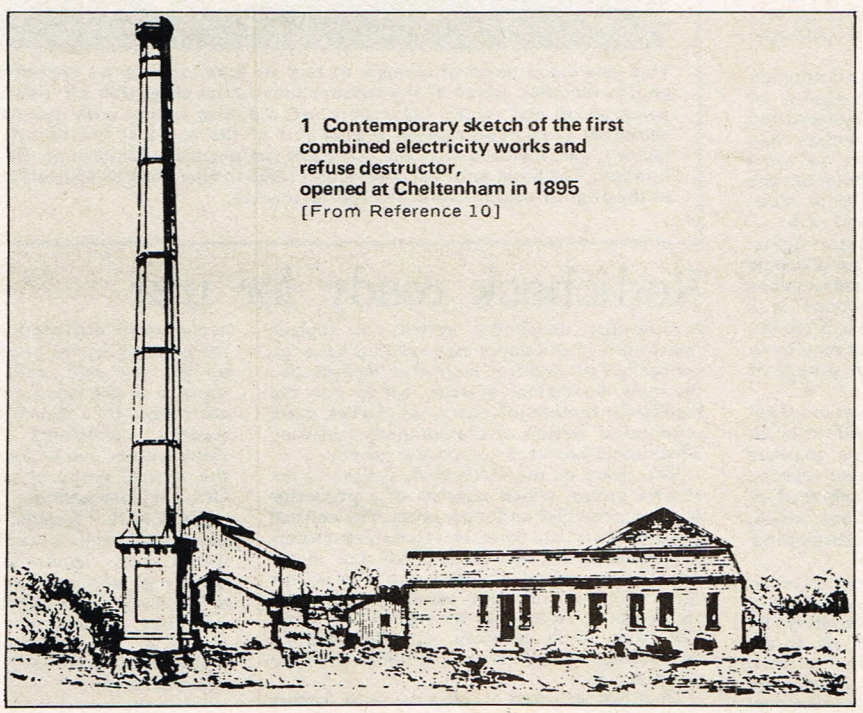
At the turn of the century, maximum electrical demand came during the evening period when all the domestic lighting was switched on—a far cry from today's heavy industrial demands. Small wonder that generation from domestic refuse was so popular

Now that the world is faced with the threat of an energy shortage, attention is being given to alternative sources of energy for the generation of electricity. The sun's radiation, the wind, the waves, the tides—all natural sources of energy—are being considered, and possible means of harnessing them are being devised. They have been used in the past, before the days of electricity supply, and were indeed thought about in connection with electricity generation in the early days of electricity, around 1880–90; the wind and the tides were actually used on a very limited scale for this purpose at that time. The problems nowadays are, however, of a quite different nature because of the vastly increased scale of demand.

Another proposal that has been recently put forward is the use of town and industrial refuse as a source of energy for electricity generation. It is being presented as though it were a new problem, needing a great deal of fundamental research to establish the calorific value of refuse as fuel and to determine efficient means of burning it. But it is not a new problem at all; all this was thoroughly investigated at the turn of the century, and refuse (otherwise called dust or garbage) was used very extensively for the generation of electricity, there being no fewer than 40 plants in operation in 1904, with another 20 under construction. Many towns were able to get most of their electricity from refuse, and a saving of cost was established in most cases. Britain seems to have been the pioneer in this field.

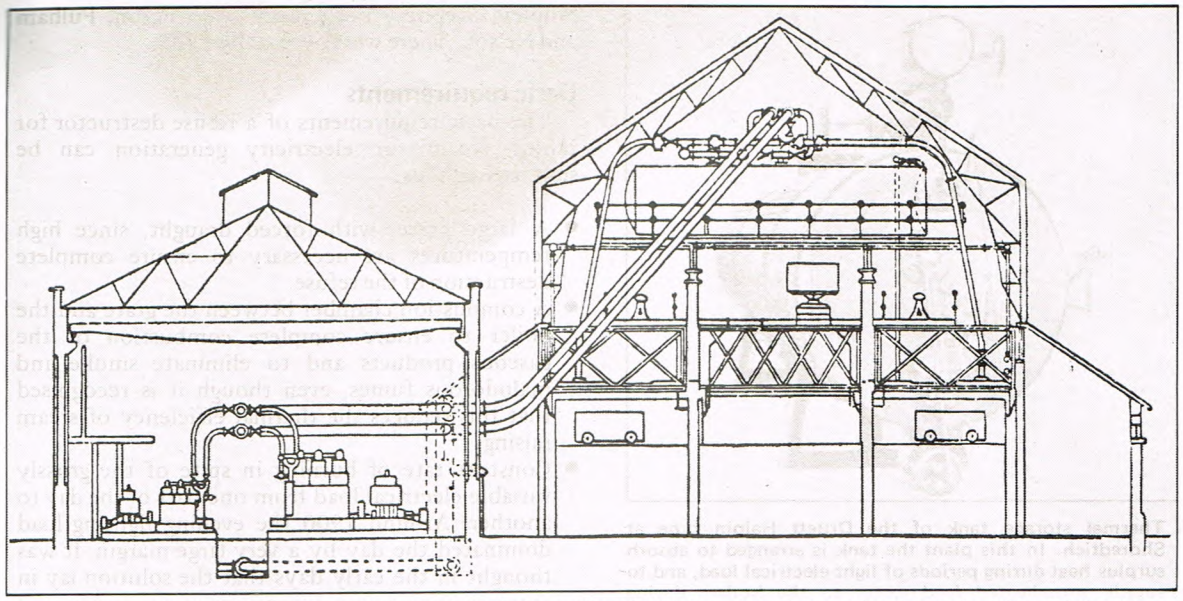
Outline of history

There was no proper means of disposing of town refuse, including sewage, until about 1870. By then it was becoming apparent that health was being seriously endangered by the practice of leaving the garbage to decay naturally in piles on the outskirts of the towns. To dispose of it by dumping it into estuaries meant heavy expenses for cartage and barging. So naturally attention was turned to the possibility of burning it in special furnaces where it could be rendered completely innocuous, and complete installations came into service from 1876 onwards. The gaseous output was harmless if



1 Contemporary sketch of the first combined electricity works and refuse destructor, opened at Cheltenham in 1895
[From Reference 10]

Gordon Tucker is senior fellow in the history of technology and honorary professor at the University of Birmingham. He was, until his recent retirement, Head of the Department of Electronic & Electrical Engineering there



2 Transverse elevation of the Shoreditch combined plant. The electricity generating station is on the left, and the refuse destructor on the right. The grates are at ground level, the tipping platform (shown with wagons) above, and the thermal storage tanks at the top
[From *Electrician*, 1897, **39**, p.336]

complete combustion had taken place, and the solid residue, or clinker, could be sold for such purposes as making up roads.

Some time later, it was realised that a lot of heat was being wasted, and that it would be economically advantageous to use it for generating steam, which could then be used for a variety of municipal purposes, not least for providing hot baths for the townspeople in special public bathhouses. Thus the very material that had presented such a health hazard could be used to provide the final stage of hygiene! The steam was also used for supplying steam engines, and it was only natural that, with the introduction of public electricity supply during the 1880s, attention should be turned to the practicability of using the steam for driving electrical generators. Serious studies began to be published from about 1892 onwards.[1–8]

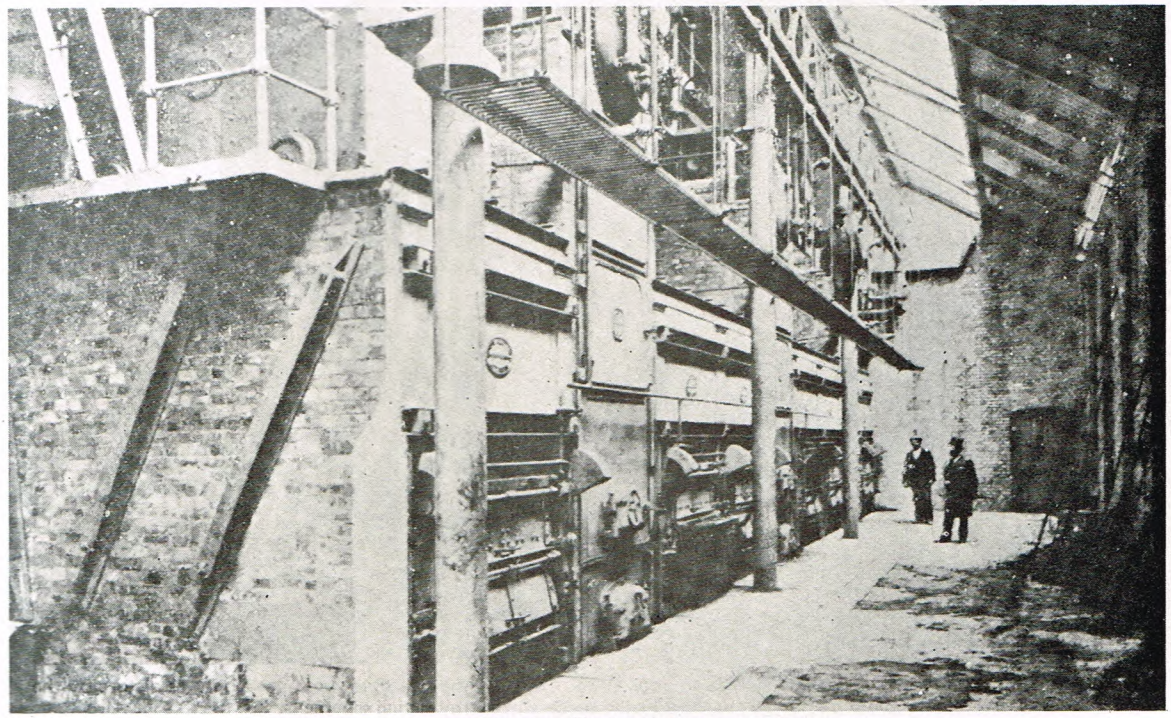
First demonstration

The first demonstration of the generation of electricity from town refuse took place in Halifax in late 1893. A contemporary report[9] said:

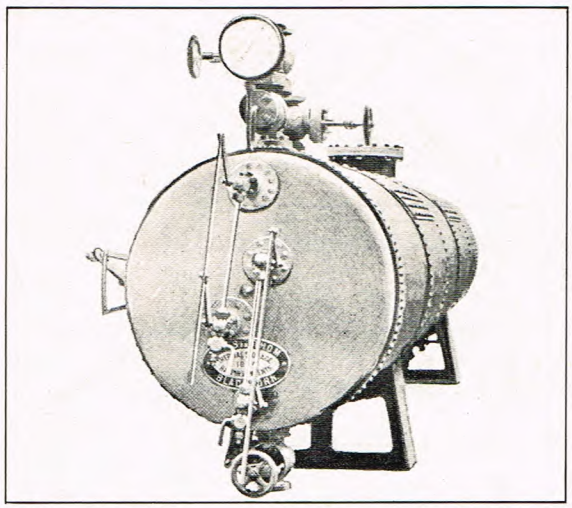
'An interesting exhibition is now being shown at Halifax for the purpose of demonstrating the feasibility of generating steam for electric lighting etc., with ashbin refuse as the only fuel. The installation, approximate to the Northern Engineering Co. Ltd., Parkinson Lane, consists of Livèt's expanding-flue steam generator (two-furnaced) capable of giving 300 hp when town refuse is burnt. The electric plant comprises a powerful Parsons turboelectric generator, which energises a searchlight of 25 000 candle power, and a full complement of arc lamps . . . . This exhibition will prove not only interesting, but also that it is possible to produce in any city the electric light at low cost by simply burning rubbish.'

The Livèt boiler was fully described a little later[3]—it was very much like what was known as an 'elephant' boiler—but it did not catch on.

For some reason the articles and reports published on combined refuse destructor/electricity generation schemes in the 1890s and early 1900s all refer to Oldham as the first town to introduce such a scheme.



3 Refuse-destructor grates (or cells) and boilers at the Shoreditch plant [From Reference 8]



4 Thermal storage tank of the Druett Halpin type at Shoredtich. In this plant the tank is arranged to absorb surplus heat during periods of light electrical load, and to supply superheated feed water to the boilers during periods of heavy load [From Reference 8]

However, Cheltenham preceded it by nearly a year, opening its electricity station in May 1895 adjacent to the town's refuse destructor and taking a good deal of its steam from it (Fig. 1). It was said that 60–70 hp was available from the destructor. The scheme was stated to be a success both technically and economically.[10] In this case, the refuse destructor was already available when the electricity station was built; this was also the case at Oldham, opened for combined operation in March 1896.

The first combined scheme designed as such from the beginning was at Shoreditch, London, opened in June 1897 (Figs. 2–5).[11,12] This was reasonably successful, and led to a rush of other combined stations, no fewer than six opening in 1900, at Shipley, Stepney, Beckenham, Accrington, Fulham and Nelson. There were over 40 by 1905.

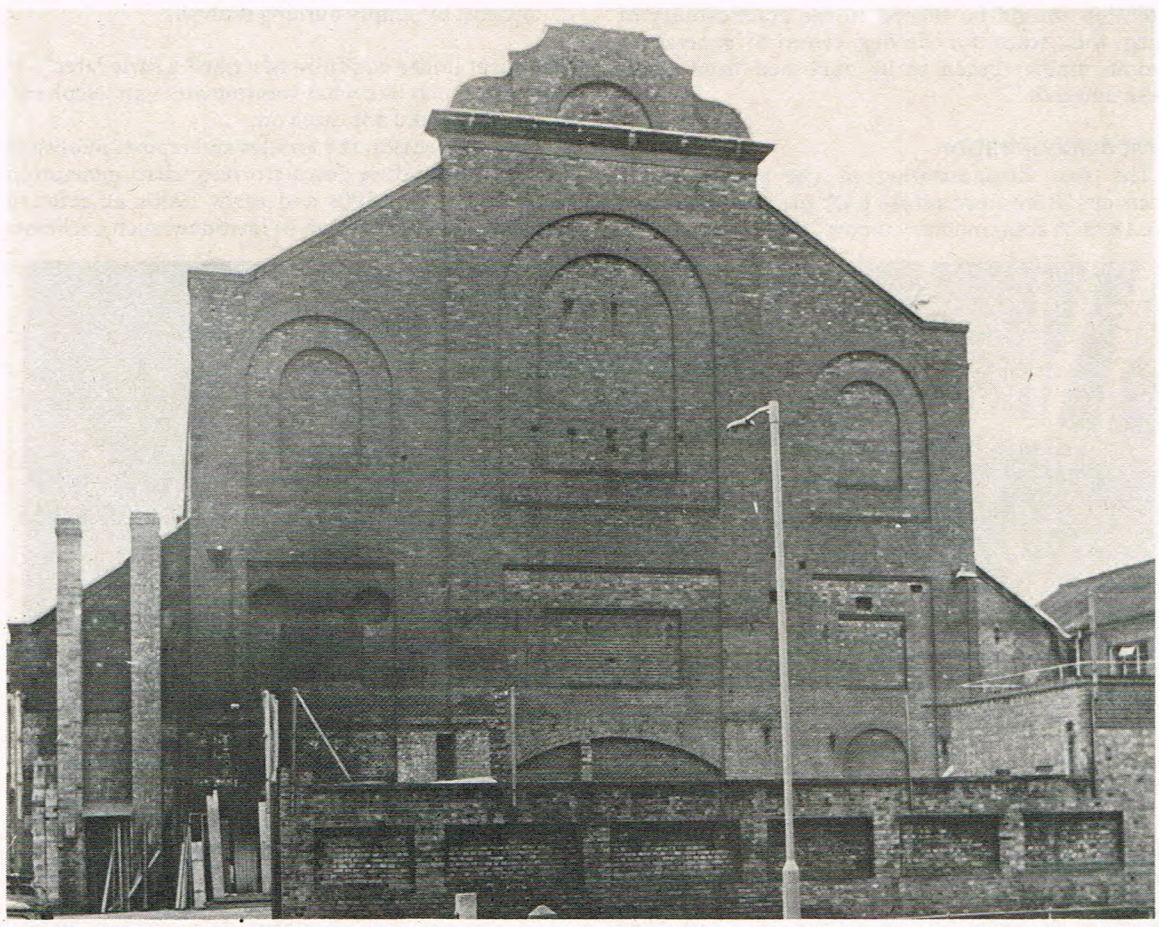
Basic requirements

The basic requirements of a refuse destructor for raising steam for electricity generation can be summarised thus:

- A large grate, with forced draught, since high temperatures are necessary to ensure complete destruction of the refuse.
- A combustion chamber between the grate and the boiler to ensure complete combustion of the gaseous products and to eliminate smoke and malodorous fumes, even though it is recognised that this reduces the thermal efficiency of steam raising.
- Constant rate of burning in spite of the grossly variable electrical load from one part of the day to another. Around 1900 the evening lighting load dominated the day by a very large margin. It was thought in the early days that the solution lay in thermal storage, and designs were produced for the storage of heat in large hot-water tanks, under pressure. This system was actually used at Shoreditch (Fig. 4), but it seems that it was generally found better to rely on electrical storage in batteries, probably since nearly all direct-current systems used them anyway.

Several makers sold this kind of plant, and there were great variations in design. Requirements 1 and 2 above were common to all, but several did the burning in a series of 'cells', so that some flexibility in rate of burning could be achieved by varying the number of cells in use. This much reduced the storage capacity required, and made reliance on batteries more attractive.

It was recognised that coal burning would often be



5 North elevation of Shoreditch combined station in July 1975. The building is a shell, now used only as a store by the Highways Dept., and forms a gaunt monument to an early and successful energy-saving scheme
[Photo: by author]

necessary at times of peak load, and suitable separate grates were therefore provided for this.

Estimates made in the early 1890s assumed that there would be a saving of about two shillings per ton in the cost of cartage of the refuse, since it had only to be taken to the destructor. This meant that, in effect, the fuel had a negative cost. The cost of the burning plant was much greater than for coal fuel, and the whole steam-raising process was less efficient. Nevertheless, it was thought that, as there was such a big saving on fuel cost, there would be a large overall saving. W. H. Preece, brought in as an independent consultant at Cheltenham to comment on the main consultant's report, considered that the saving would amount to 0·5 or even 0·75 d/kWh in a total production cost of 4 d/kWh.

In many cases it was hoped that there would be a sale for the clinker produced and that this would therefore lead to a further small saving on the cost of producing electricity. And it was reasonable to argue that since the refuse was to be burnt anyway, some of the costs should not be charged against electricity production. Moreover, in many cases, as at Shoreditch,[12] the exhaust steam from the engines was used to heat the public baths, and this was a bonus which ought to be credited to the electricity costs.

Difficulty was experienced in assessing whether, in practice, these economies were achieved because of the various and peculiar accounting systems used by different authorities, but Adams[13] concluded that, in 1902–03, there was a substantial saving by using the combined scheme; in respect of fuel and wages costs this saving generally lay between 20 and 50%.

Some actual performance figures

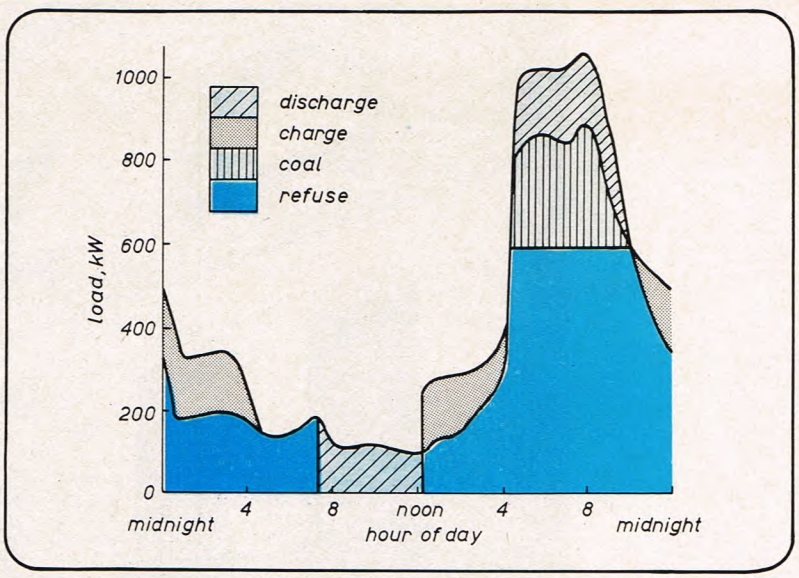
Adams[13] analysed the performance of 17 combined stations, very carefully and in great detail, mostly for 1902–03. He found that, despite the reputedly great variations in the content of the refuse from one town to another, the average steam-raising value of the refuse at each place examined was quite close to one pound of steam per pound of refuse from and at 212°F (100°C).

For an electrical engineer, perhaps a more useful index of performance is the amount of electrical energy produced per tonne of fuel. This depends, of course, on the efficiency of the whole combined plant, and, as would be expected, varies rather much from one plant to another. Shoreditch, tested in 1899, yielded 55 kWh per ton of refuse when working under optimum conditions, and about 30 kWh when averaged over the year; these figures must be compared with the performance when burning coal in the boilers' own grates which is 280 kWh/t. Fulham in 1903 achieved 91·5 kWh/t of refuse as a peak performance, with 53 kWh/t as the average over a week (i.e. including the warming up period), and 30–40 kWh/t averaged over a year. Here the figure for coal was about 300 kWh/t.

Hackney, tested in 1902–03, was a more efficient station. We examine its mode of working in more detail below, but can say here that its peak performance on refuse was 105 kWh/t, the average over a week was 60 kWh/t, and over a year 40 kWh/t. The figure for coal was 448 kWh/t. One important factor leading to these high figures was that it had a much larger storage battery than any other station examined by Adams.

Operation of the Hackney combined station, 1902–03

A more detailed account of the operation of the Hackney station will emphasise the way in which the load varied, not only from one part of a day to another, but also between different days. Thursday, which was early-closing day for the shops, had the lightest load of the week except for Sunday—30%



6 Hackney combined electricity works and refuse destructor: Load curve for the 18th December 1902

total kWh generated	9198
kWh generated by coal	1165
coal burnt	2·6 tons
refuse burnt	144 tons

Charge/discharge relates to storage battery

lighter than Wednesday, Friday, and Saturday, although 50% heavier than Sunday. As the refuse burning was at peak on Thursday to Saturday, it sometimes proved possible to carry the whole of a Thursday's load on refuse. On the other hand, this was never possible on Sunday, since the supply of refuse was then at a minimum, Sunday being a day when no refuse was collected, and storage being not permitted.

A most interesting load diagram, obtained by Adams,[13] is given in Fig. 6. This was for the 18th December 1902, which was a Thursday, so that the coal-generated units were rather fewer than on other weekdays. The use of the battery is clearly shown. It was a Tudor battery that could store 1200 kWh. The generating plant was shut down, as it often was, during the morning period of minimum load. The refuse destructor was probably operated at variable output during the rest of the day by the use of a variable number of grate cells, of which there were 12 altogether. As already stated, this station was relatively efficient. It had a Hughes and Stirling destructor, Babcock boilers, vertical high-speed engines (some by Belliss, some by Willans), and used condensers.

It is perhaps worth noting that, even in this efficient station, efficiency could have been improved quite easily. At the peak period the battery discharged only about 600 kWh. Had its full charge been taken, hardly any coal at all would have been needed.

Requiem—and rebirth?

Prof. Forbes, a leading consulting electrical engineer, estimated in 1893 that town refuse could provide a 16 candle power electric light for 2 h every night for every person in the town. This seemed a marvellous provision at that time. But demand for electricity—for homes, for streets, for industry—has grown continuously since then, and 100 Wh per day quickly became a negligible part of the demand per head. So as the old generating stations became obsolete or inadequate and were replaced, they were replaced by stations without associated refuse destructors. When the last combined station went is not known, but the original Shoreditch station was in regular use up to 1940[15] and was still workable up to

7 Shoreditch combined electricity works and refuse destructor. Front entrance through office wing, in July 1975. Latin motto above the entrance reads E PULVERE LUX ET VIS (Light and power from dust)
[Photo: by author]

1948. The refuse-destructor part of the station continued to produce heat for the adjacent public baths until the early 1960s, and all the original buildings of the combined station still stand (see Fig. 7).

Modern power stations are gigantic things, serving a large region, and the collection of refuse and its transport within a safe period of time to them would be a massive undertaking. Of course, since the Second World War, our affluent society has been producing refuse on a greatly increased scale, and the amount of it may just possibly be significant even in relation to modern electricity demand. Experience on a limited local scale in the modern context (albeit many times larger than the scale of the Shoreditch and Hackney stations) is being gained in two refuse-incineration schemes, at Edmonton (London) and Nottingham, where some of the heat is used for electricity generation.[16] Probably the technical problems of burning refuse are little different from those which our grandfathers appear to have solved so effectively. But the logistics of the problem, both outside and inside the power station, present a formidable challenge.

The concept of utilising refuse to generate electricity is an old and proved one, but it died a natural death. It has been reborn, but whether it can live and grow in a different world is problematical.

The historical references quoted here are all readily accessible items in the contemporary technical journals, but there were in addition numerous government and private reports, many of which are listed in Reference 14 and which are now difficult to find.

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