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ATOM

CHP IN THE UNITED KINGDOM

INQUIRIES INTO NUCLEAR ENERGY

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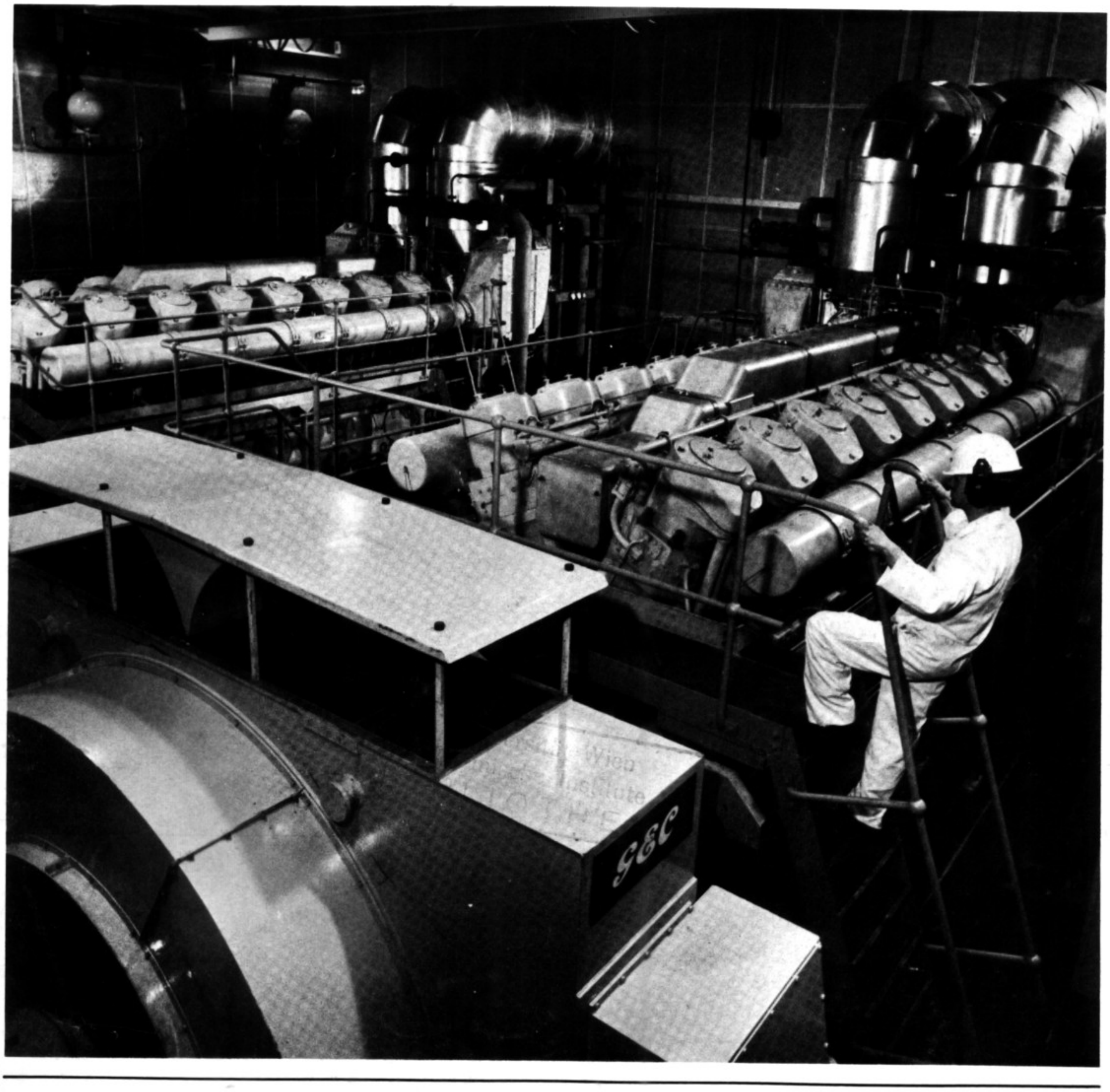
BOOK REVIEWS



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ATOM contents

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Front cover: The Midlands Electricity Board's diesel-engined Combined Heat and Power Station at Hereford.

CHP IN THE UNITED KINGDOM

The reports of the Department of Energy's Combined Heat and Power Group, chaired by Dr Walter Marshall, have focussed attention on the long term savings in national primary energy consumption which could be obtained by installing district heating (DH) in cities, in association with combined heat and electrical power (CHP) generation. Recommendations have been made for the Government to initiate such a programme in one or more UK "lead" cities. Keith Main* here reviews the background and some implications of these proposals and the contributions that nuclear energy might make to heat supplies.

The combined production of heat and electricity is a well established technique which is attracting renewed interest on account of its fuel conservation potential, in the light of fuel shortages and price increases in recent years. CHP generation in the UK has been concentrated mostly in the industrial sector of the economy and if it is to make a major contribution to fuel saving it must be extended to meet space and water heating needs in the domestic, commercial and institutional sectors. This would require the development of extensive district heating networks in large towns and cities, whose aggregate heat loads would be compatible with full scale CHP stations.

Although there are many small to medium size group heating or district heating systems operating in the UK, in nearly all of these the heat is supplied by hot water boilers, without power generation. Fuel and power scarcities in the aftermath of the second world war gave rise to a number of schemes, of which the Pimlico-Battersea power station scheme was regarded as a forerunner, but interest waned during the 1960s, when oil fuel became cheaper and more abundant.

Nuclear establishments pioneered the use of reactor heat for space and process heating, with examples at Harwell (the BEPO reactor) and Windscale (Calder Hall). In France, a project was recently announced to recover and utilise heat for site use from two experimental reactors at Cadarache.

In Britain, CHP has been developed to meet process requirements in a number of industries, notable among them being chemicals and allied trades, the metal industries and the paper and board industry. Its penetration outside the industrial sector has remained small in comparison to that in some other countries in Europe, Scandinavia and the Soviet Union. To assess the reasons for this and the future prospects for CHP in the UK, the former Secretary of State for Energy in 1974 set up the Combined Heat and Power Group, under Dr Marshall's Chairmanship. Following consideration of the CHP Group's report, the present Secretary of State announced Government support for feasibility studies of one or two CHP/DH schemes in "lead" cities to be selected after consultations with local authority associations and other interested organisations.

The Combined Heat and Power Group studies

Results of more than four years of study are summarised in the CHP Group report, Energy Paper No. 35 (EP 35)[1] and the reports of the District Heating Working Party, (EP 20)[2] and the Heat Load Density Working Party, (EP 34)[3]. This work shows that although CHP has a clear energy saving potential its implementation is not always economic under present conditions. Fuel price escalation is

*Economics and Programmes Branch, UKAEA.

Battersea power station

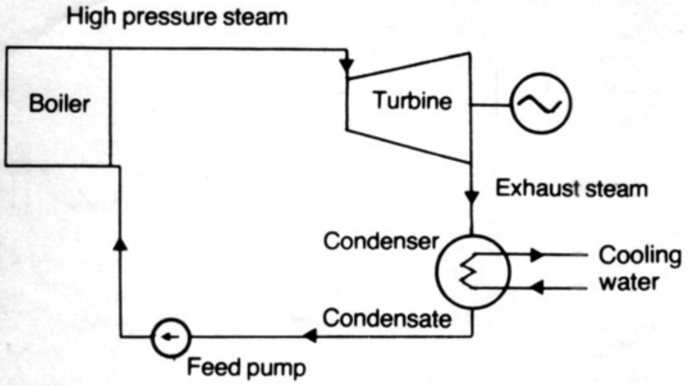

Fig.1 Steam turbine plant generating electricity only

EP35

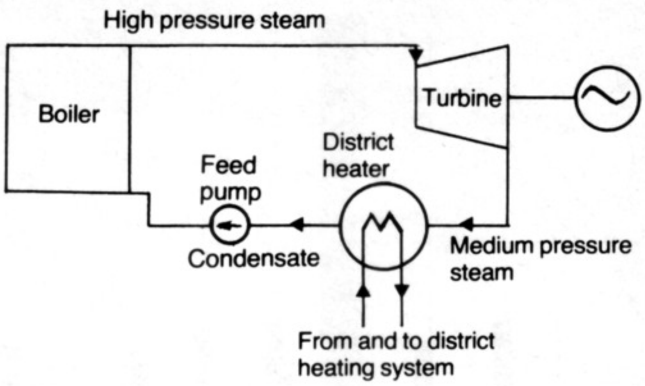

Fig.2 Combined heat and power operation: back pressure turbine

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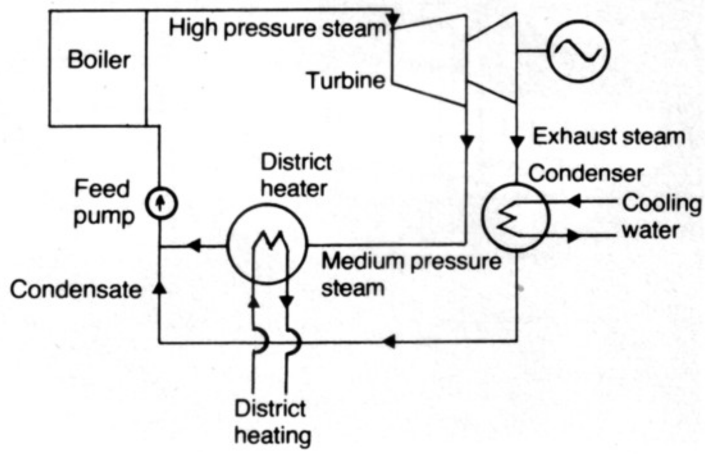


Fig.3 Combined heat and power operation: pass out turbine

EP35

expected to tilt the balance in favour of CHP systems in time, however, and in view of the long period needed for large-scale implementation of CHP/DH, the majority of the Group has recommended an early start to the conversion of one or more UK cities to this method of heating. These cities would provide the necessary demonstrations and experience to establish CHP/DH as a valid option for longer term development. The Group suggests Government financial aid should be extended to these schemes to enable them to compete with existing heating systems at current fuel prices, in order to attract the majority of consumers in the areas served without having to resort to compulsory connection.

A smaller majority of the CHP Group recommended the creation of a National Heat Board to produce an overall strategy, select the lead-city schemes, set up local organisations to implement and run them, establish a financial framework and deal with standards, legislation, R&D and further studies. The remaining recommendations of the Group were concerned with the encouragement of additional schemes in industry, where CHP is already quite well established.

Industrial combined heat and power

Large quantities of steam and/or hot water are used in production processes in some industries, which also consume electrical power. Much of this heat is required at temperatures up to about 200°C for distillation and evaporation purposes, and steam is readily obtained from back-pressure or pass-out condensing turbines at these conditions (see Figures 1, 2 and 3). Heat may also be recovered from diesel engine or gas turbine exhaust gases by means of waste heat boilers and other methods. When the heat and power demand profiles are of broadly similar shape and offer the possibility of reasonably high load factor operation, industrial cogeneration, employing one or other of the above-mentioned prime movers (dependent upon the ratio of heat to power requirements), often provides a satisfactory and economic solution.

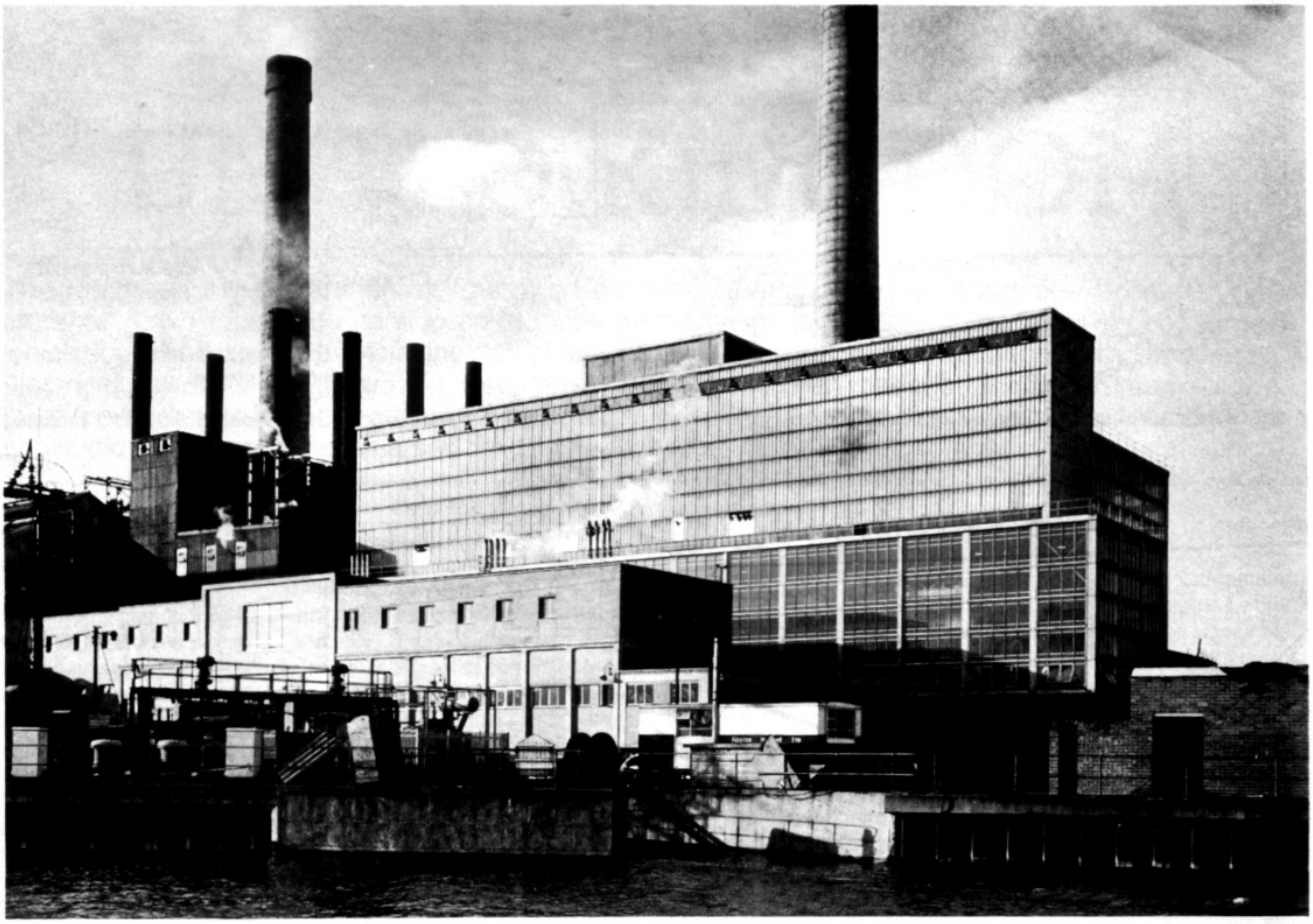
Industrial CHP systems are normally compared against the alternative of heat obtained from local fossil fuel boilers and electricity purchased from the public supply, because electricity generation from small scale private plant without heat production is rarely competitive. A recent survey of the private generation of electricity by industry in Great Britain found that over two thirds of the electricity was generated in CHP plants[4].

Several types of modern industrial CHP plant can convert up to about 80 per cent of the fuel energy into output energy in the form of electricity and usable heat. This figure is similar to the thermal efficiency of contemporary industrial boilers. The question faced by managements is whether the extra capital and operating costs of the CHP plant will be adequately recovered by the expected savings in electricity purchases.

CHP plant investment may be classed as avoidable expenditure, in the sense that it is not essential to the production process. In that case it may be required to show a higher rate of return on capital than other productive investments and this will almost certainly exceed the 5 per cent (in real terms) specified for UK public sector investment. The actual return on CHP investment will depend on the future price of public supply electricity relative to that of industrial fuels. As the proportion of nuclear power in the public supply grows the price should become more competitive and industrial CHP investments would then appear less attractive.

Statistics show that between 1950 and 1970 the percentage of industrial electricity generated privately roughly halved and has since remained relatively constant at about 16 per cent[5]. The CHP Group has recommended further government measures to encourage industrial investment in CHP plant[1]. One possible solution, where industrial CHP schemes could save primary energy but fail to meet private sector investment criteria, is for the project to be owned and financed by a public sector utility which then sells the heat and power produced to the consumers. The Midlands Electricity Board's diesel engine CHP station at Hereford is an example of this approach. If this station operates at high load factor it will effectively supplant base-load generating capacity elsewhere on the national grid. Although the Hereford diesel engines run on a heavy grade of fuel oil, it may appear not to be in the long term national interest to displace coal or nuclear generation by oil consumption, even though primary energy is saved in the process.

In the Hereford scheme process steam will be supplied by pipeline to local factories, the steady output from the CHP plant being augmented at the station by steam from oil-fired boilers to meet demand variations. Low grade heat from cooling water jackets and oil coolers will be used to preheat the boiler feed water for the exhaust gas boilers and oil-fired boilers. In this installation the CHP plant is freed from the constraints of maintaining a balance of heat and power output to match the instantaneous demands of an indi-



Spondon H power station is a coal-fired CHP station

vidual factory, the electricity produced being fed into the local distribution network and credited at the appropriate Bulk Supply Tariff rates. The Area Board might justify higher prices than would be paid to a private organisation exporting surplus electricity to the grid, on the grounds that it is a firm supply under their own control. The success or failure of schemes like that at Hereford depends on local factors and each proposal has to be carefully assessed on its own merits.

The CEGB's Spondon H power station near Derby is a coal-fired CHP station equipped with back pressure steam turbines. Bulk supplies of steam are piped to an adjoining chemical works for process use, while the electricity produced is fed into the local grid.

Another possibility, of a longer term nature, is to establish process steam supply systems, fed by nuclear reactor heat sources, for large industrial agglomerations[6]. Depending on the type of reactor, its coolant temperature and the required process steam temperature, the reactor station might be of the CHP or of the heat-only type. A more detailed study of a system of this kind for the Liverpool and Merseyside industrial area has been reported[7].

The greatest savings of primary energy are obtained from those industrial CHP systems which achieve high utilisation of the fuel energy and which have a relatively low ratio of heat to power output. The energy utilisation (sometimes called thermal utilisation factor) is defined as the ratio of the combined outputs of useful heat and electricity to the energy content of the fuel and may be denoted u. In effective systems, u may have a value between about 0.5 and 0.8. The heat to power ratio, denoted k, ranges from less than 1 for diesel engine/waste heat boiler systems, through values of about 2 to 3 for gas turbine/waste heat boiler systems, to higher ratios for back pressure steam turbines (in which k increases as the back pressure and temperature increase).

For two systems of equal u, that with the lower k saves the most fuel because the electrical output is displacing electricity generated in condensing turbines with an efficiency of not more than about 35 per cent. Consideration should also be given to the type of fuel used, however. While boiler/steam turbine systems can burn coal or residual oil, as used in central power stations, gas turbines require gas or distillate oil. For plant with a design life of 20 or 30 years, future fuel price and availability rank high in importance.

Combined heat and power for district heating (CHP/DH)

CHP/DH unit size Although small internal combustion engined CHP units have been developed, using car engines adapted to run on natural or bottled gas, it is improbable that such small-scale systems will be adopted in the high-density housing areas where most of the demand for space and water heating is concentrated. In such areas it is more likely that medium size DH systems will nucleate and grow until they coalesce into networks with aggregate heat demands large enough to justify connection to CHP stations. During this build-up period heat-only boilers will be employed and after conversion to CHP these may be retained for peak load and standby duties.

The level of heat demand at which CHP is considered feasible is a matter to be decided on economic, environmental and energy considerations. For smaller communities in countries with decentralised energy supply systems local diesel engine CHP stations with heat and power outputs of about 10 MW are in use. In the UK there is a centralised electricity supply system which has allowed the development of large power stations with economies of scale, high efficiency in generation and transmission, and the use of nuclear and low-grade fossil fuels, especially coal. CHP from these large stations would substitute uranium or coal for the increasingly scarce and expensive gas and oil now being consumed in individual heating systems. It could also displace some of the electricity used for space and water heating in the areas served. Studies carried out by the CEGB indicate that a heat output of about 350 MW from a single steam-cycle CHP unit would be compatible with the cost and performance targets for economic operation[8].

Unit heat supplies of 350 MW are too large for all but the largest cities and conurbations, but as about 80 per cent of the national high density heat load is associated with the five largest conurbations in Britain this is not a serious objection[3]. It is unlikely, however, that any system would be designed to be dependent upon a single plant for its entire heat supply, or even its base-load supply. Peak demands of several times the unit output are therefore required. It is implicit in this scenario that bulk heat transmission would be required from the larger CHP stations to the city networks, and in the CHP Group studies allowances were made for transmission distances of 15 km and 50 km for fossil fuel and nuclear stations, respectively. Timing the introduction of such large increments of heat supply might present difficulties of matching supply and demand in an efficient and economical manner, with some detriment to system operating costs.

The choice of CHP/DH system temperatures DH systems can operate with supply water temperatures in the region of 100°C, considerably below the temperature needed by most industrial process heat systems. The thermodynamic advantage of low supply temperatures is that heat can be extracted at later stages of the expansion of steam in a turbine-generator, after it has performed more useful work for electricity generation. One consequence is that k, the heat-to-power ratio, is lower than in similar industrial CHP steam plant. The lowest temperature at which heat needs to be delivered to dwellings to heat domestic hot water indirectly is about 65°C while the maximum temperature for shielded radiators is limited by safety considerations to 95°C.

The DH mains temperature then depends on whether a direct or indirect (heat exchanger) system is to be used. In either case the delivery temperature is defined within a fairly narrow range. It may be designed to vary seasonally; and allowance must be made for temperature losses in the distribution system. Return temperatures are kept as low as possible in order to minimise flow rates, pipe sizes and pumping power requirements. The distribution system pressure is kept as low as possible to save piping wall thickness and if the temperature can be kept below about 100°C the pressure will be determined chiefly by pumping considerations and local topography.

The mains temperature in an indirect system is increased by the unavoidable temperature difference in the heat exchangers. However, these serve the useful purpose of isolating the consumer installations from full mains pressure and reducing leakages from and contamination of the main circuits.

Recent computer studies to find a minimum overall cost optimisation of system temperatures, from the CHP turbine to consumers' premises, suggest the use of direct systems with flow and return temperatures of about 90°C and 50°C, respectively. Under the assumed conditions the cost is not extremely sensitive to small changes in these temperatures, however[9]. The requirements of commercial, institutional and industrial consumers must also be considered and these may lead to the selection of a supply temperature higher than that needed for domestic premises alone.

CHP/DH supply and demand profiles Like electricity system demand, the aggregate heat requirements of an area will display hourly, daily and seasonal variations. To avoid having to size the CHP plant to meet peak demands of short duration, either auxiliary boilers or heat storage can be provided. The volume of water in the DH mains represents quite a large quantity of stored heat and this can be augmented by installing insulated storage vessels. Short-term heat storage is efficient and sometimes economic but the viability of seasonal storage is more difficult to establish.

Aggregate heat demand is the sum of demands from separate classes of consumer (domestic, commercial and industrial) each of which has a different time profile. If, as is likely, the peaks of demand of each class are not coincident, the peak system demand will be less than the sum of the separate peaks and there can be a saving of installed capacity. Similarly, within a class the demand patterns of individual consumers are not identical and the class aggregate is always less than the individual demand multiplied by the number of consumers, even at peak times. This diversity factor is assumed in the CHP Group report to have a value of 0.8 in the domestic sector and 1.0 in the commercial and institutional sector.

In any given area the demand profiles for heat and electricity will also differ from each other and if all supplies of both forms of energy had to be obtained from CHP plant the heat to power ratio k would be changing continuously, making operation difficult. When the local electricity system is connected to the national grid this problem is less acute and in practice the separate loads are usually satisfied by using a mixture of single and dual purpose plants of different types.

Figure 4 shows profiles of electricity demand in England and Wales on different days in a recent year, including the day of

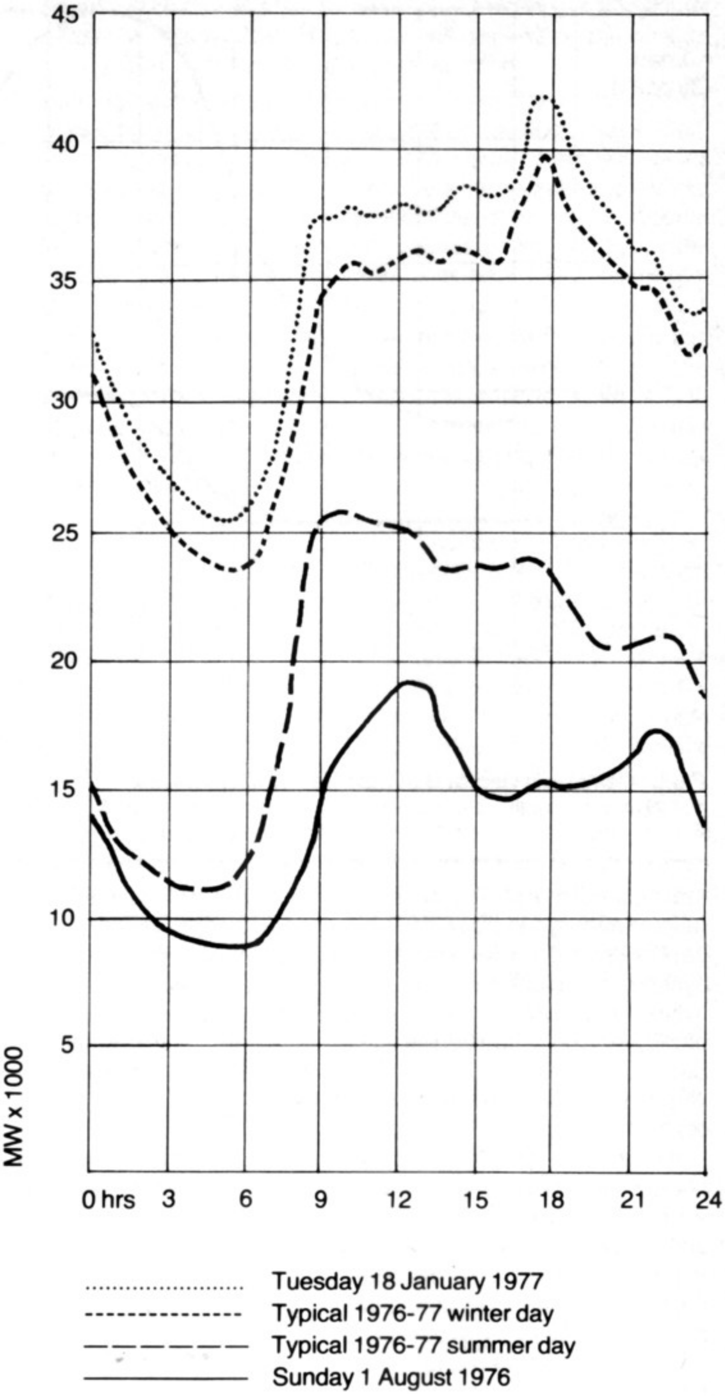


Fig.4 Summer and winter demands on the CEGB system in 1976-77 including days of maximum and minimum demand
CEGB Annual Report 1976-77

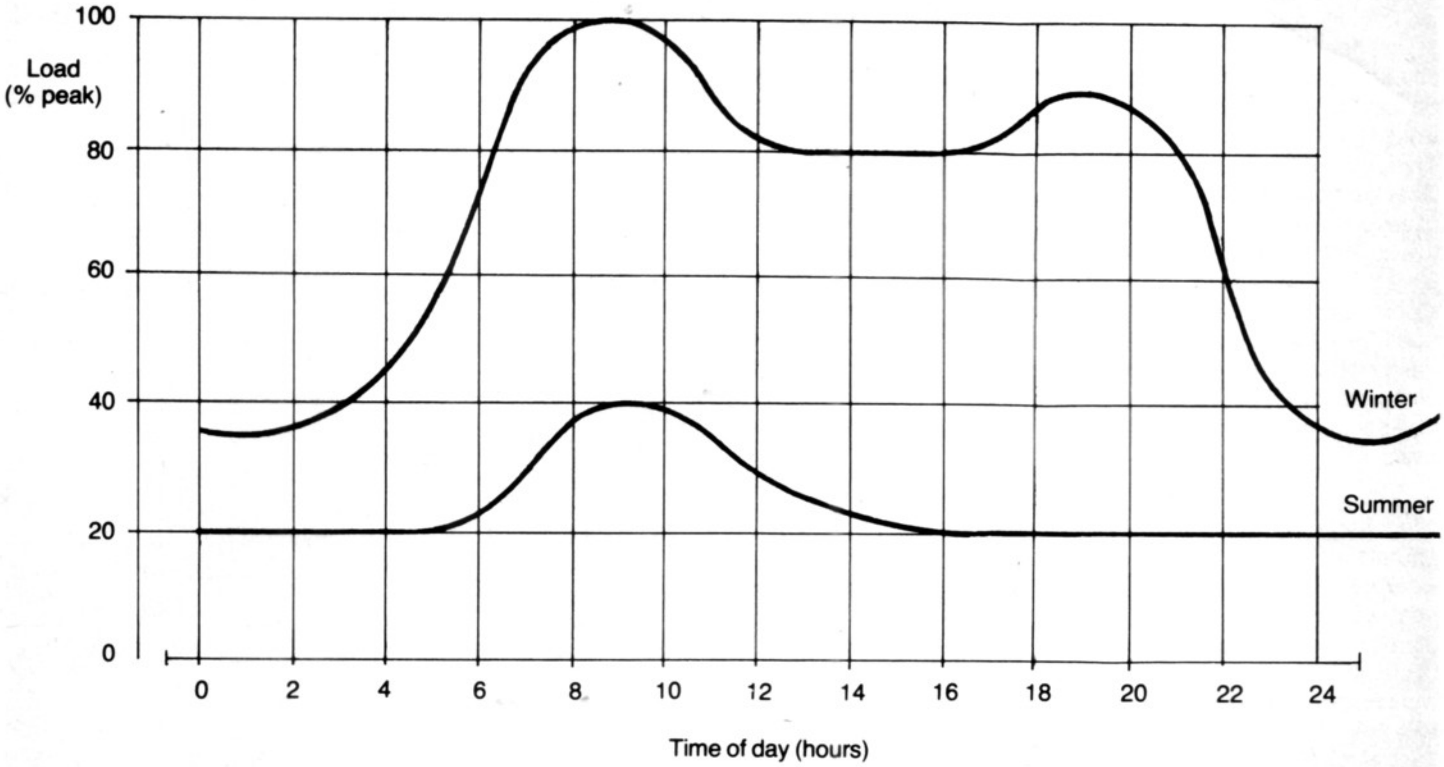


Fig.5 Daily heat demand of district heating scheme
P.T.W. Arnott, Electrowatt Engineering Services (London) Ltd, Topical Meeting on Low Temperature Nuclear Heat, Otaniemi, Finland, August 1977

maximum demand. The system annual *load factor* (defined as the ratio of average to peak annual demand) is approximately 57 per cent. Figure 5 shows estimated heat demand profiles for a DH system on typical winter and summer days. Without storage the system capacity must exceed the winter peak but with diurnal storage it could be reduced to about 70 per cent of peak load. Seasonal variation of heat demand, smoothed for clarity, is illustrated in Figure 6; the annual load factor in the UK is said to be about 40 per cent[1].

It is usual to convert the demand profile into load duration curves of the type shown in Figure 7, which brings into focus the short duration of the maximum demand and the low minimum for summer water heating. If heat-only boilers are installed to meet a fraction (usually less than half) of the peak demand they can also be used to meet the summer load during the annual maintenance of the CHP plant and for standby at other times. By this means the CHP capital investment is reduced and its operating *capacity factor* (defined as the ratio of average annual output to installed capacity) improved to around 80 per cent. The fuel cost penalty of the boiler heat output is not severe because its capacity factor is only 20 per cent or less.

CHP/DH fuel savings Some fuel can be saved by DH systems with heat-only boilers, because the efficiency of a central boiler-house is higher than that of individual heating appliances, but this saving is reduced by heat losses from the DH pipework. Annual losses of about 10 per cent of the heat sent out are typical of correctly insulated, reasonably compact systems. It is only when the heat is supplied by a CHP plant that substantial fuel savings can be realised, encouraging planners to aim for a rapid build-up of the precursor DH networks.

The following composite statements are representative of criticisms which have been levelled at the electricity supply industry:

- "Electricity generation consumes a quarter of UK primary energy and two-thirds of this is wasted in the form of cooling water. This waste can be avoided in CHP stations".
- "The average efficiency of UK power stations is only 31 to 32 per cent whereas CHP stations are about 80 per cent efficient, so a lot of fuel could be saved by converting power stations to CHP operation."

Such statements are potentially misleading and the following points are relevant:

1. Of the fuel energy consumed in a power station roughly 10 per cent is lost in combustion, mainly in the flue gases, and about 5 per cent more in miscellaneous heat and energy losses. In a modern station of 35 per cent net efficiency, this leaves only some 50 per cent to be rejected to cooling water, which is at such a low temperature that it is useless for space heating. A CHP station has irrecoverable losses very similar to the stack and other loses of the conventional power station.
2. The average system efficiency includes stations which are old and inefficient and those which are necessarily run intermittently

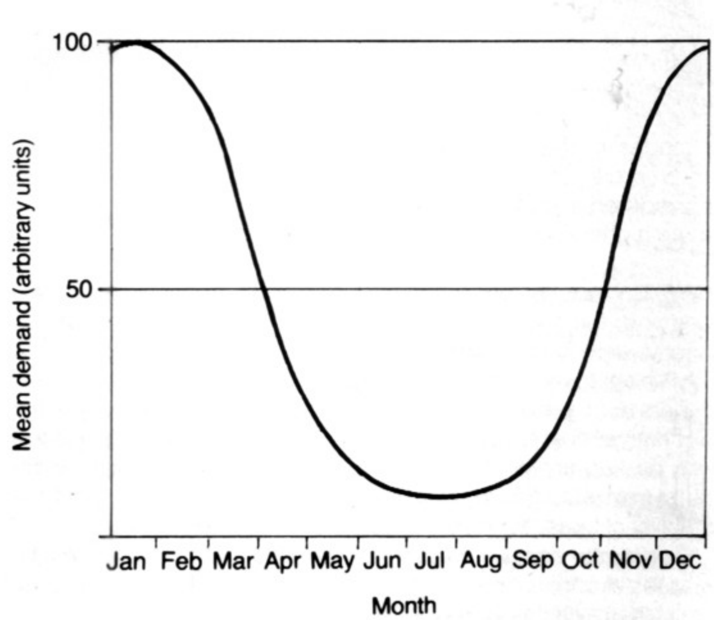


Fig.6 Seasonal variation of district heating demand

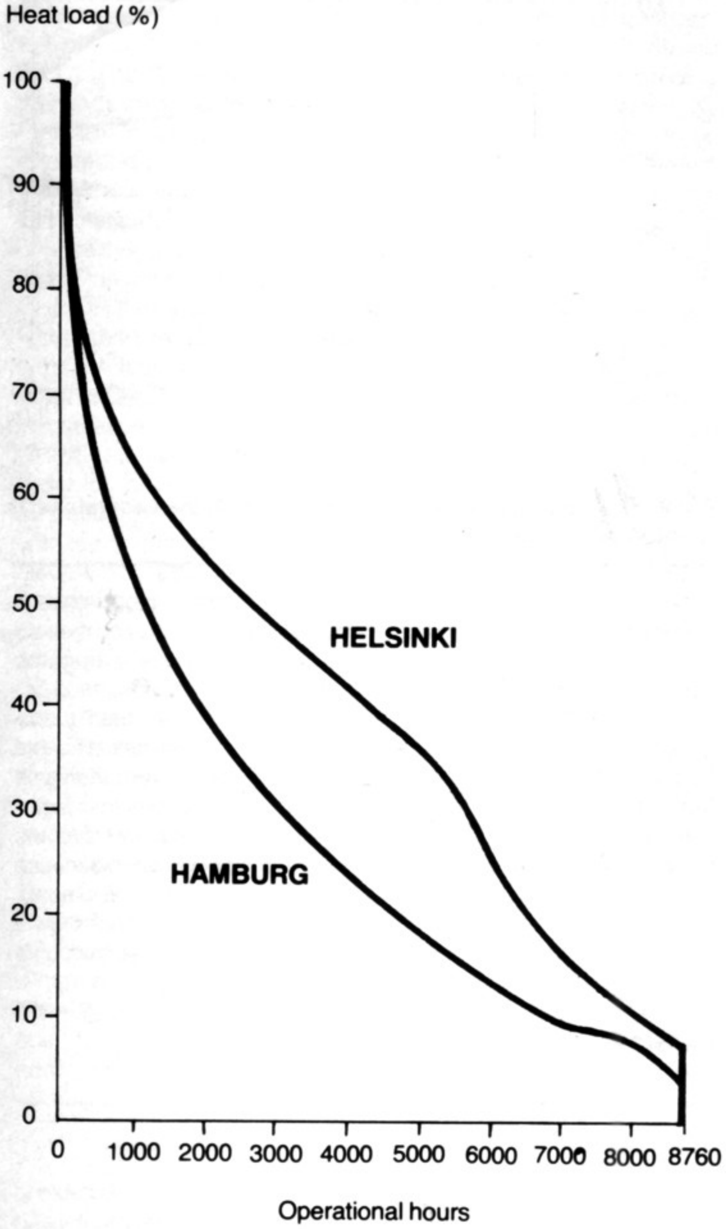


Fig.7 Load duration curves for district heating schemes
V. Scholten (KWU) and Dr M. Timm (Hamburgische Elektrizitäts-Werke), Topical Meeting on Low Temperature Nuclear Heat, Otaniemi, Finland, August 1977.

or at part load. As noted above, a new station has a net efficiency of at least 35 per cent.

3. The definition of power station efficiency is the net electrical energy produced as a percentage of the fuel energy consumed. Electricity is a high-grade form of energy with important uses for lighting, motive power, electrolysis and other industrial processes, which cannot be matched by low-grade heat. Simple addition of the outputs of a CHP station blurs the distinction between these very different energy forms and the result is not directly comparable with power generation efficiency as defined. It is not difficult to obtain heat from fuel at high efficiency on a large scale and, as noted above, power station boilers do this with about 90 per cent efficiency. The conversion of this heat to mechanical or electrical energy is the more difficult process, in which the rejection of heat at low temperature is an inescapable part. The generating efficiency of a power station is optimised and is inevitably reduced if the heat rejection temperature is increased, as for CHP operation.
4. The fuel saving of a CHP station should be calculated by comparing its fuel consumption with the fuel required to produce the same net outputs of heat and electricity, in domestic boilers at an efficiency of, say, 65 per cent and in power stations at 35 per cent efficiency, respectively. The result will depend on the heat-to-power ratio, k, of the CHP station in question.
5. Although some types of CHP plant can have an overall energy utilisation, u, of some 80 per cent, not all can achieve this. Controllable pass-out turbines, similar to Figure 3, are sometimes used to obtain flexibility of the ratio k in operation; electrical output can then be increased when little or no heat is needed. Because only part of the steam is extracted and the remainder passes to a condenser, these turbines have lower values of u (and k) than back pressure machines (Figure 2).
6. Many modern power station sites are remote from population centres, which has environmental advantages but is inconvenient for CHP/DH operation. Urban or near-urban siting of CHP stations could have adverse environmental impacts; if flue gas desulphurisation is a condition of such siting it would incur a further loss of efficiency.

Following the calculation procedure outlined in point 4 above, values of u for CHP and non-CHP alternatives are plotted against heat-to-power ratio, k, in Figure 8. The knee of the CHP curve corresponds to a back pressure turbine suitable for a DH system having a rather low water supply temperature. Lower values of k represent pass-out condensing turbines with the same water supply temperature, k becoming zero in the full condensing mode, when no usable heat is extracted. Higher values of k correspond to back pressure operation with increasing back pressures and water supply temperatures.

The percentage fuel savings of the idealised CHP/DH systems represented in Figure 8, compared with the separate production alternative, are shown in Figure 9. The results illustrate general performance characteristics, although they do not necessarily correspond to any particular plant. Fuel saving is seen to attain a maximum of approximately one third, in the case of a back pressure turbine working at the lowest feasible back pressure. Actual fuel savings may therefore fall short of those which could be expected from statements of the type quoted earlier.

To determine the appropriate value of k for a specific case, an estimate would be made of the local heat demand and a study

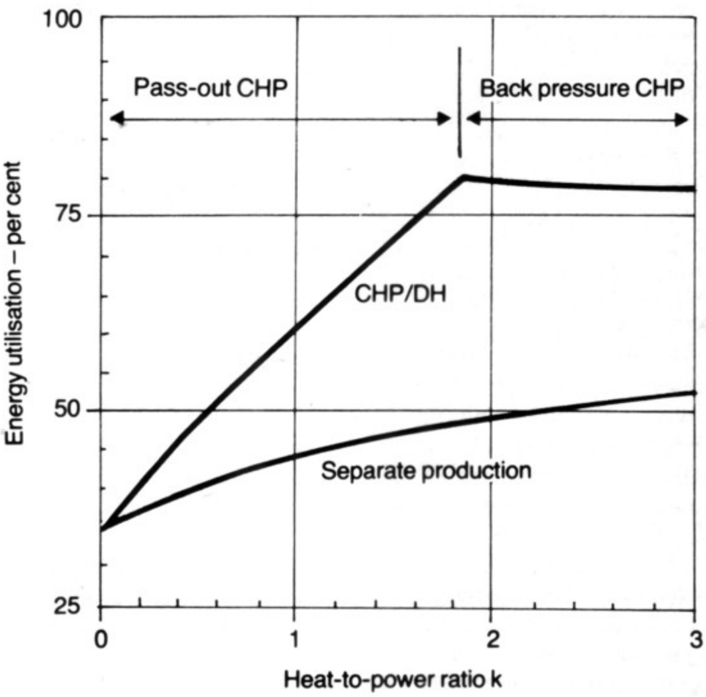


Fig.8 Energy utilisation of CHP/DH and separate production of heat and electricity

carried out of the existing or potential power station sites in the locality and of their associated electrical capacity. Suitable plant could then be selected.

The saving of fuel achieved in practice will depend on current thermal insulation and comfort standards. These factors interact with the cost of heat and whether or not the heat consumption of individual dwellings is metered. Accurate and reliable metering is expensive and consumers need adequate controls to allow them to adjust heat consumption. The omission of meters increases annual heat consumption by as much as 30 per cent, although it may have relatively little effect on peak demand and therefore on supply capacity, because most heat will be wasted during spells of mild weather. If, as expected, the marginal cost of CHP heat is low the provision of meters and controls may appear uneconomic and could even affect the economic viability of an entire scheme. If the case for CHP/DH in the UK rests primarily on energy conservation then provision of meters seems essential and they were, in fact, included in the schemes studied by the CHP Group.

The economics of CHP/DH A large CHP/DH system requires major capital investment in CHP station plant and equipment, DH transmission and distribution systems and installations in consumers' premises. This expenditure will be incurred by different groups such as the heat and power utility, the district heating organisation and, finally, individual consumers. In making economic assessments, their treatment of costs and benefits will differ according to the perspectives of the organisations and individuals concerned. If it is assumed that DH supply is to be a public sector responsibility public sector investment criteria will apply to much of the expenditure, but not to that incurred by private organisations and individuals.

While the CHP Group studies include economic assessments in overall national terms, some further analysis of the incidence of costs and benefits will therefore be needed. Only if the economics appear attractive to all the interested parties will the level of support and cooperation needed for successful implementation of large scale CHP/DH be forthcoming.

For a supply organisation making a financial appraisal of an isolated CHP/DH investment project, it might be sufficient to compare the total capital and operating costs with the expected total revenue from sales of heat and electricity, all suitably discounted. There could be difficulty, however, in defining the sales values of the products; in the case of heat, because of the diversity of existing alternatives and their changing relative costs and, in the case of electricity, because it may be absorbed into a complex national grid system having a range of time and demand dependent on production costs and selling prices.

A broader approach is to compare total system costs, with a CHP/DH scheme in operation, with those of the alternative of separate electricity generation and individual heating appliances. A convention which is often adopted is that there should be no cross-subsidisation from consumers of one product to those of the other but this principle is more easily stated than applied, because of the lack of a simple method of dividing the total CHP costs between the joint products. One solution to this problem is to assign a cost to the CHP electricity corresponding to that from a typical condensing power station, all the remaining costs being allocated to the heat produced. If this method has a weakness it is that, if it is used to determine selling prices, it protects electricity consumers from an increase in their costs but does not ensure that they share in any overall savings (if the CHP/DH option does not produce such savings it is unlikely to be built).

Figure 10 illustrates these points in a simple model. AD is the CHP co-product cost line such that prices corresponding to any point on it will yield total revenue sufficient to recover total costs (Appendix 1 gives the derivation of this line). The nominal price of electricity generated in condensing power stations is represented by e and that of heat from conventional appliances by h. A CHP system is potentially economic if the line AD passes between the origin O and the intersection E. In practice the choice of prices, while arbitrary, is limited to the range BC, as it would be unrealistic to assign a price to either product higher than that of separate production. The method of pricing CHP output described in the previous paragraph corresponds to point B in this diagram.

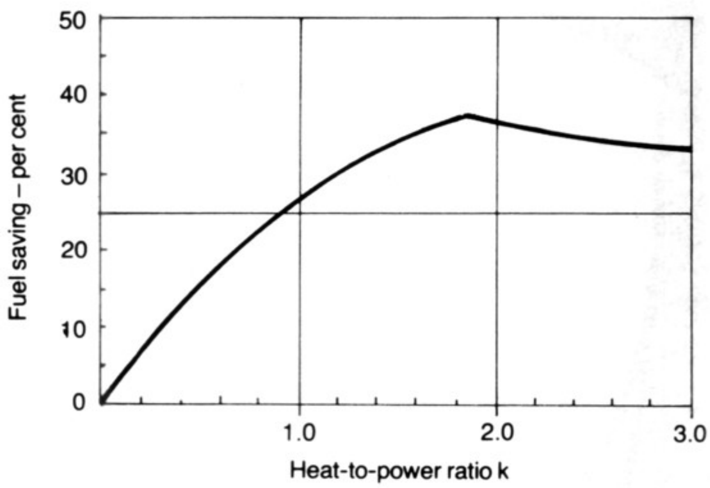


Fig.9 Fuel saving of CHP/DH compared with the separate production of heat and electricity

A crucial factor in the economics of CHP from large steam turbo-generators is the reduction of electrical capacity per unit rate of usable heat extraction, taking a condensing power station, with the same fuel consumption, as the reference standard. This power loss factor (denoted z) may lie in the range 0.1 to 0.2 and the lower its value, the greater is the probability that the system will be economic (because a unit of electricity is worth several times as much as a unit of heat). One way to secure a low value of z is to extract the heat at as low a temperature as practicable. It can be shown that the fractional power loss is given by the following expression:

$(P_c - P)/P_c = zk/(1+zk)$. . . (1)

where P_c = power rating of condensing station
P = power rating of CHP station at heat rating H
z = power loss factor = $(P_c - P)/H$
k = heat/power ratio of CHP station = H/P.

Following the convention described earlier, the costs attributable to the heat supply from a CHP station are the incremental capital and operating costs of the station above those of a condensing power station of the same electrical output (subject to any necessary adjustment of the annual load factor changes as a result of CHP operation). A substantial part of these costs will be proportional to the fractional power loss given by equation (1).

In the procedure adopted in the CHP Group studies it was assumed that the CHP power loss would be fully compensated by the construction of additional condensing plant, sufficient to restore system capacity to its unperturbed level (i.e. without CHP). The capital and operating costs of this incremental capacity were charged to the heat supply. The two methods produce the same end result but the former is free from the constraint that the electrical system capacity is necessarily maintained when an area is converted to CHP/DH. Because some of the premises connected to the DH system would previously have used electric heating, a reduction in demand is quite possible.

The CHP Group made economic comparisons of four medium-term options as follows:

- heating with the existing mix of appliances and fuels
- all gas-fired central heating
- DH with heat-only boilers
- CHP/DH

Four parameters, namely the size of development, the dweling density, the discount rate and the fuel price escalation, were each assigned three possible values, giving 81 different cases in which the four options were compared.

CHP/DH systems, with relatively large capital costs and low net fuel consumption, show the lowest overall costs in large, high density, developments when discount rates are low (5 per cent) and fuel prices high (doubling or tripling in real terms between 1980 and 2000). The DH option with heat-only boilers appears more costly than individual gas-fired central heating, whilst consuming roughly the same quantity of fuel. This option is however, expected to be adopted in the development phase of a CHP/DH scheme, before the system heat demand is compatible with the supply from a large CHP station[1].

Sensitivity studies have been carried out to determine optimum levels of house insulation for minimum total heating costs with CHP/DH and alternative heating systems. In most cases total costs were found to be relatively insensitive to the amount of insulation although increased loft insulation and cavity wall insulation, where appropriate, were cost-effective. The poorest return on investment in insulation is obtained in large-scale CHP/DH systems but where CHP/DH is the economic choice at existing insulation levels, this order of preference is unchanged by the installation of extra insulation[10].

In the longer term (post 2000) the CHP Group studies show that electric storage heaters using off-peak nuclear electricity represent the cheapest option, although the quantity available will be limited. Coal-fired and nuclear CHP/DH are the next cheapest options, followed by electric heat pumps using nuclear electricity and then by heat pumps using substitute natural gas (SNG) derived from coal. The costs of these and other options are shown in Figure 11, from reference 1; coal-based systems appear on the left of this diagram and nuclear systems on the right.

Nuclear heat sources Nuclear reactors produce heat which is used in nuclear power stations to raise steam and generate electricity. The extraction of steam to provide heat for a DH system is basically similar in a nuclear power station to that in a fossil fuel station but siting requirements may mean a greater heat transmission distance. Where nuclear energy is the most economic method of generating base-load electricity one would expect it also to supply heat at low cost. This is evident from Figure 11, which includes the cost of 50 km heat transmission from the nuclear CHP station, compared with only 15 km from the coal-fired CHP plant. Heat transmission represents about 15 per cent of the marginal delivered cost of heat in the nuclear case.

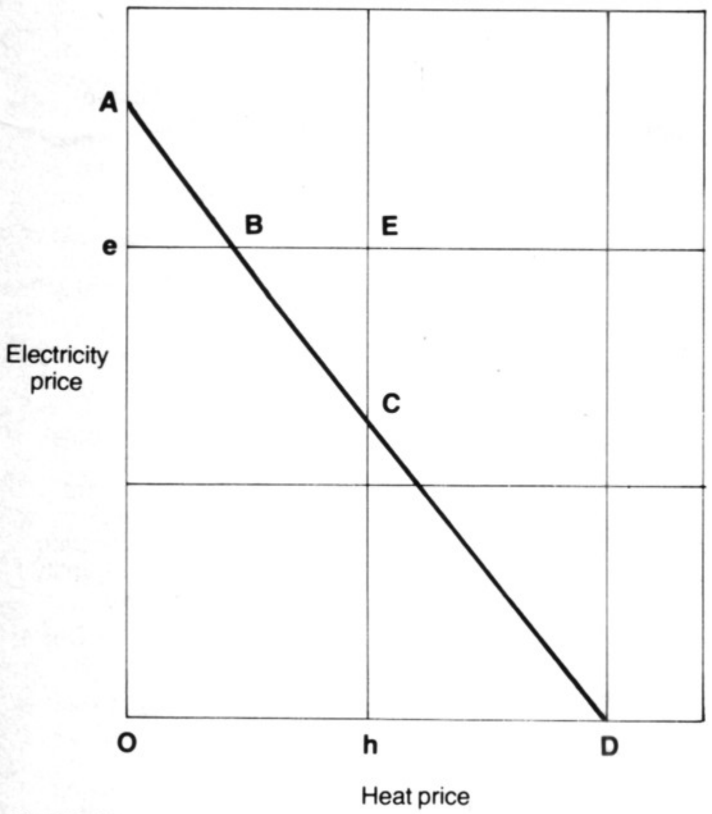


Fig.10 Co-product costs of heat and electricity

Several proposals have been made for small nuclear CHP plants, to be located near demand centres for DH or industrial process heat. These have been based on either scaled-down versions of established power reactors or adaptations of marine propulsion units. For example, the Rolls-Royce organisation has a design for a transportable reactor, with an electrical output of 200 MWe, which could possibly be adapted to CHP operation. Present reactor siting criteria may not permit such plants to be deployed in an optimum manner, however.

An alternative approach is represented by designs for small reactors dedicated entirely to heat production at temperatures and pressures much lower than those necessary for power generation. With the emphasis on simplicity and inherent safety, such units have been proposed for near-urban locations. They are slightly pressurised light water reactors of moderate power density, with self-acting shutdown features and provision for natural circulation heat removal in the event of circulating pump failure. In France, consideration is being given to the construction of a prototype 100 MWth THERMOS reactor, to supply the DH system of Grenoble. Finland and Sweden have supported design studies of the 200 MWth SECURE reactor for urban heating supplies. It is thought that although the small unit size of these heating reactors would tend to raise the specific capital cost this would be counteracted by ease of manufacture and savings arising from series production. It would need over a hundred reactors of 200 MWth to supply the estimated high density heat load of the five largest conurbations in Britain, for example.

Reference has already been made to the feasibility of supplying process heat from larger nuclear reactors to industrial demand centres by bulk steam transmission[6,7]. The establishment of a process steam supply would offer interesting possibilities for the connection of DH systems at suitable points. A greater diversity of consumer categories could benefit the overall load factor and system economics.

National differences Notable progress has been made with CHP/DH in West Germany, Scandinavia and eastern Europe. It has frequently been suggested that these examples should be emulated by the UK. There are however many reasons, apart from the obvious climatic differences, for the different evolution of energy systems in such countries. Economic, environmental, social and political factors all have an important role.

Several of the Scandinavian countries are heavily dependent on imported fuel and its maximum utilisation has been a feature of national policies for some time. Scattered population centres have encouraged relatively localised energy supply systems, in some cases associated with hydroelectric power. This infrastructure and the associated costs may have favoured the adoption of fairly small-scale CHP/DH schemes initially.

DH systems have an advantage in urban communities in which the built form is predominantly that of large blocks of flats and apartments, which is more usual in the countries mentioned than in the UK. Where these dwellings are municipally or state owned, the decision to provide a common heating system — and the selection of such a system — is centralised and simplified. In societies in which centralised planning is the norm and where owner-occupation is unusual, such standardisation is more likely to be accepted than by a population accustomed to freedom of individual consumer choice.

Prospects for CHP/DH in the UK

The CHP Group studies have shown the potential of CHP/DH as an energy conservation technology and that it could be economic in national resource terms if certain assumptions relating to market penetration, costs and fuel price escalation are fulfilled. The assumption of complete market penetration in areas to be provided with DH is particularly sensitive to complex factors and therefore difficult to test. Public authorities faced with the capital expenditure

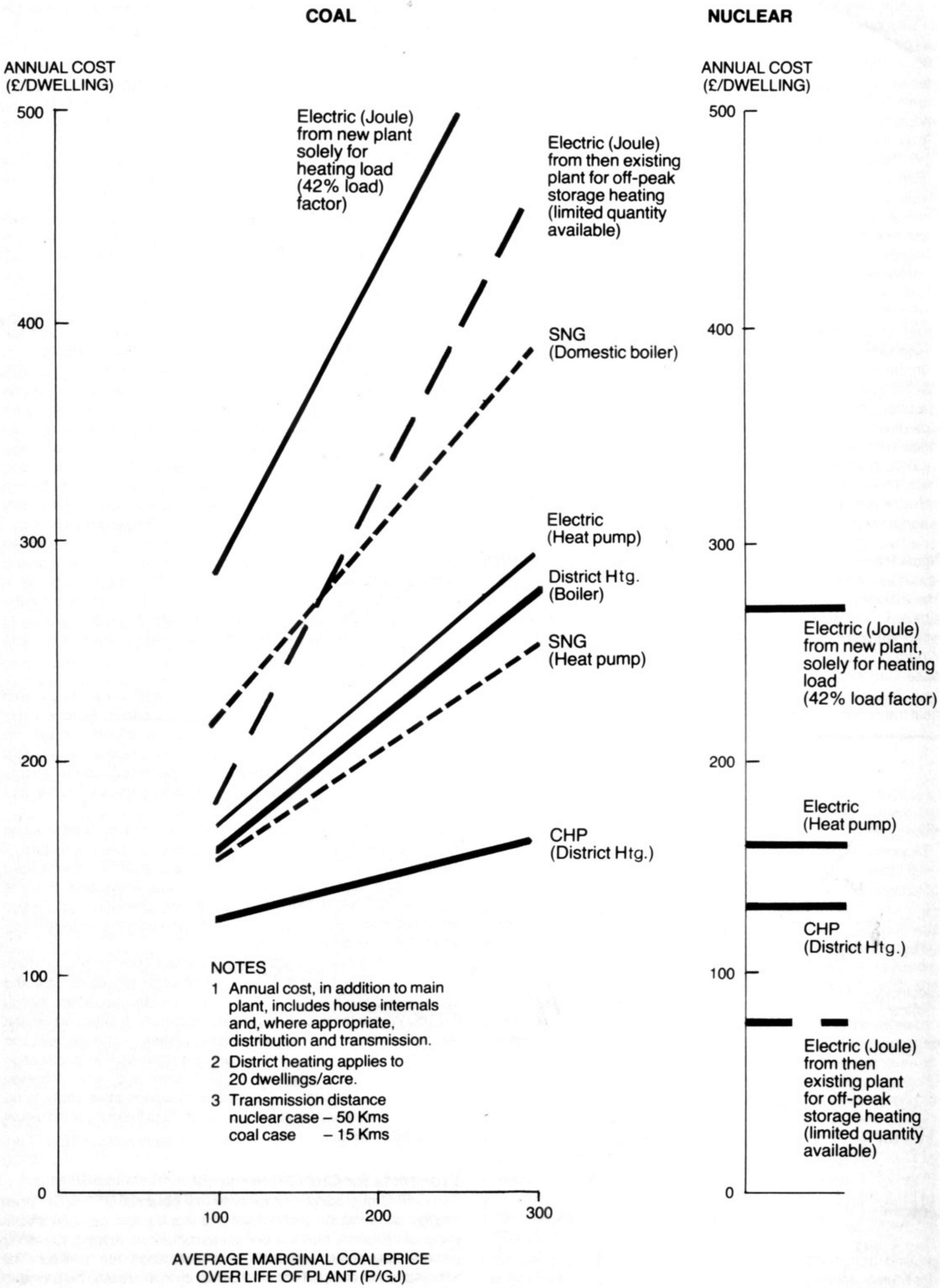


Fig.11 Marginal cost of long-term (post 2000) alternatives (5% discount rate) *EP35*

on CHP/DH systems will require assurance on this point, yet it depends on the individual decisions of many potential consumers to whom it will remain a hypothetical question until supplies actually become available. The circularity inherent in this problem is evident. According to EP 34, the commercial, institutional and industrial heat demand exceeds that of dwellings, in the high density heat load areas studied. The response of these consumers is therefore of great importance to the success of any scheme and will call for detailed market research.

Table 1 summarises ten aspects of CHP/DH which will influence its future prospects in the UK, grouped according to whether they are primarily of concern to supply authorities, consumers, or both. A brief discussion of each of these aspects follows.

Table 1. Some issues relating to CHP/DH

A. Aspects of concern to supply authorities
1. Investment alternatives
2. Scale of installations
3. Cash flow
4. Management skills

B. Aspects of concern to suppliers and consumers

5. Disturbances during installation
6. Investment time horizon

C. Aspects of concern to consumers

7. Cost of heat
8. Capital expenditure
9. Security of supply
10. Freedom of choice

1. *Investment alternatives*
   It is insufficient to demonstrate that a public sector investment project will meet the Treasury's required rate of return, to ensure that it will receive funds. In principle, limited funds are allocated to those competing projects offering the highest rates of return. Even on a more restricted basis a proposal should be compared with alternative methods of attaining the same objective, which in the case of CHP/DH would mean other energy conservation measures.
2. *Scale of installations*
   The CHP Group studies concluded that small-scale installations would be less economic and would save less primary energy than larger units. Limited funds and resources may be better devoted to developing a lesser number of larger schemes but these involve large investment decisions and corresponding risks.
3. *Cash flow*
   CHP/DH schemes are characterised by large initial investments and deferred returns. The former may be estimated reasonably reliably but the latter depend on uncertain future fuel prices.
4. *Management skills*
   UK experience of large scale heat distribution systems is very limited and a shortage of expertise is likely to occur at all levels of local organisations.
5. *Disturbances during installation*
   The installation of heat mains in existing cities will interfere with movements of vehicles and pedestrians and may disturb existing services. In premises receiving up to five services (water, drainage, telephone, gas and electricity) the addition of a further underground service could cause problems.
6. *Investment time horizon*
   Public investment decisions, of which CHP/DH is an example, are discounted at relatively low interest rates with lifetimes measured in decades. Private spending decisions are typically based on pay-back times of a few years. Some reconcilation of these approaches will be necessary where the two interact.
7. *Cost of heat*
   CHP/DH systems must deliver heat to consumers at lower cost than their existing methods or alternatives available to them. For large consumers, some of whom may recently have installed CHP plant of their own, substantial discounts may be necessary.
8. *Capital Expenditure*
   Consumers will expect to recover their initial capital expenditure and connection charges from reduced running costs in the course of relatively few years (see 6).
9. *Security of supply*
   With individual heating systems, partial immunity from external interruptions can be secured by fuel storage or other means. Consumers, especially businesses, would need to be convinced that connection to the public heat supply would not increase their exposure to such risks.
10. *Freedom of choice*
    Some consumers, even if offered heat supply at a substantial discount, may not respond favourably. In a free society it may be necessary to accept this and to make allowance for a percentage of non-subscribers.

The development and well-being of society is strongly conditioned by the capital stock and institutions which each generation passes on to its successors. Decisions made now on the implementation of CHP/DH systems in British cities will have long-lasting effects on the organisation and quality of life in those cities.

It is apparent that there are many complexities and uncertainties which need to be resolved if an enduring solution is to be found to the problem of heating our homes and other buildings in the next century. □

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APPENDIX 1

Derivation of equation of co-product cost line (Figure 10)

If k = heat-to-power ratio = H/P = constant
x = unit price of heat
y = unit price of electricity
m = fixed (e.g. capital) annual costs
n = variable (e.g. fuel) costs, per unit of electricity produced
L = plant load factor (hours per annum)

Total production costs = $m + nPL$
Total sales revenue = $(Py + Hx)\,L$
Equating these, $y + kx = (m/PL) + n$

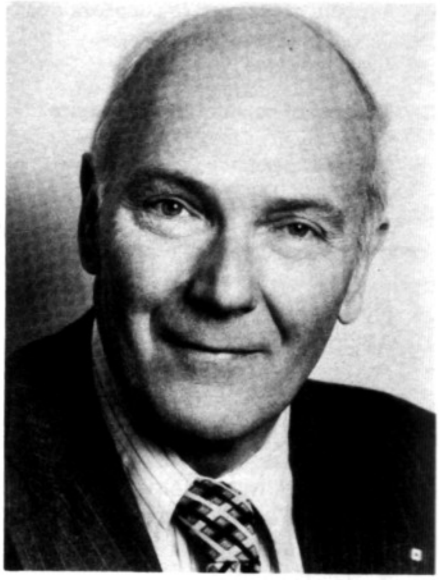
INQUIRIES INTO NUCLEAR ENERGY

"One major mistake often made by the technical community is to assume that it is the technical merits or otherwise of the technology that are the real and only subject of scrutiny. That is very often peripheral; the heart of the matter is social and political, it is much more related to values, life-styles and dictates of the heart, not the head."

Alan Wyatt, a former vice-President of CANATOM, Toronto, and a man with an impressive record in the nuclear industry, looks at inquiries which have been conducted in four countries — Australia, Canada, New Zealand and the UK — since 1974.*

Since 1974 there have been seven major inquiries in Canada into nuclear energy matters. In addition there have been hearings by the Quebec National Assembly and by the Federal House of Commons Standing Committee on National Resources and Public Works; I have been involved in all of these hearings, on behalf of the Canadian Nuclear Association, with the exception of the two Ontario mining inquiries and the Quebec National Assembly Hearings. There have also been major comprehensive hearings in Australia, Britain and New Zealand. I have deliberately restricted my examination to these four countries, though even more inquiries have been conducted in the USA and in Western Europe, since they all share the same form of parliamentary government, even though two are federal forms (Australia and Canada) and two are central forms (Britain and New Zealand).

Inquiries can be of two main forms — continuing or *ad hoc*. The continuing forms are best exemplified by Standing Committees of the Legislature and by permanent regulatory boards; the *ad hoc* forms are exemplified by Select Committees of the Legislature and by Royal Commissions and Commissions of Inquiry. Both forms of inquiry have their pros and cons. All inquiries involve the weighing-up of the evidence presented. This in turn requires a blend of technical expertise and judicial appraisal.



Mr Alan Wyatt

Findings

The success of an inquiry and of its final report can be judged by the extent to which its findings are technically correct and the degree of acceptance by those directly concerned with the subject of the inquiry or who are perceived to have a concern. Both of these criteria are themselves difficult to assess. Since most inquiries are set up in the first place because there are widely conflicting and strongly held views about the subject matter, it is naive to expect unanimity about the final report. At best, an inquiry report should more clearly define the issues and recommend logical courses of action for stated reasons so that those with the responsibility to make decisions are better equipped to do so.

The continuing process, as exemplified by the regulatory board, is in a better position to build up its own staff of independent experts. However, if the industry or activity being regulated is fairly unique then it is very likely, and probably inevitable, that the regulatory staff will have obtained their background experience from employment within the industry at an earlier stage of their careers. Many of the more extreme intervenors at regulatory hearings use this to impute bias and seem unable, or unwilling, to grasp the concept of professional responsibility to the public good. In the *ad hoc* inquiry it is easier to utilise a wider variety of expertise, on a consultancy basis, though the knowledge of the experts used may not have the same depth in the specific area under consideration as would that of the staff of a regulatory board. In the continuing process there is a greater danger of inbreeding or of the excessive influence of strong personalities within the regulatory body.

Judges as Commissioners

In the *ad hoc* process it is much more likely that new people with different ideas will be brought in as commissioners. Since the appointments are on a non-continuing basis it is possible to appoint judges as commissioners. This is of great advantage when it comes to the weighing of evidence and assessing the credibility of witnesses.

Another major advantage of the *ad hoc* process is that it is easier to select and appoint commissioners who can appear to the public to be free of direct responsibility to any governmental interest. A truly impartial inquiry must be scrupulously fair to all.

This aspect of fairness must perforce pervade the entire inquiry. Establishing rules for the conduct of the inquiry is one thing, applying them impartially to all who participate, throughout protracted hearings, is another. Failure to do so seriously undermines the credibility of the final recommendations and constitutes a great waste of people's time and public and private money.

A normal external restraint on all inquiries lies in the terms of reference laid down. They can be very specific, as is often the case

*This article is a shortened version of a paper given by Alan Wyatt at the Annual Conference of the Canadian Nuclear Association in Montreal on 17 June. Wyatt's book *The Nuclear Challenge* was reviewed in ATOM No.276, January 1979, pp 24-26.

for a legal inquiry set up into specified wrong-doing by an individual or organisation; they can also be very broad, as is often the case where public policy is involved as for long-term planning issues of matters of general societal concern. A common problem, particularly with the more specific inquiry, is that some intervenors may have concerns with an earlier stage that is outside the terms of reference of the specific inquiry. An example of this is an inquiry into the best site for a project. Some intervenors may wish to present their views on the need for the project. This process can be ratchetted back a very considerable way. If the terms of reference are to establish need in a province, some intervenors might wish to discuss national need, if national then some would want to discuss international, if international some would want to debate the philosophical base and ethics of the need. Since inquiries and their terms of reference are established by governments the normal political considerations of pragmatism, expediency and party advantage also play a role.

The inquiries

[In his paper Alan Wyatt considered a total of 12 inquiries, of which seven were Canadian]

The UK Report on 'Nuclear Power and the Environment', usually referred to as the Flowers Report after the Royal Commission's Chairman, Lord Flowers, is probably the most widely misquoted and misinterpreted nuclear inquiry report, particularly on the Canadian side of the Atlantic. The report's concerns about the future deployment of fast breeder reactors are attached by Canadian nuclear critics to the CANDU reactor, regardless of the fact that the report supports the continued use of thermal reactors.

The two New Zealand reports are broadly supportive of nuclear power as and when needed. Since they have no nuclear programme at present their reports are more detached and in many ways more interesting and valuable for so being.

The Windscale report, often known as the Parker Report after its chairman Mr Justice Parker, is a beautifully written, lucid and logical judgement on the very specific question of granting, or withholding, planning permission for the construction of an oxide reprocessing plant. He was scathing in his comments on some of the tactics of the nuclear critics and wrote:

> I reject completely suggestions made that the control institutions were serving the interests of the nuclear industry in disregard of the public and the workforce. . . I have no doubt as to the integrity of those concerned in all of them and I regard the attacks made on them as being without foundation. Such attacks did nothing to further the cases of those who made them and at times reached a level of absurdity which was positively harmful to such cases. . . (Section 10.130)

Mr Justice Parker who conducted the Windscale Inquiry (centre) with his two Assessors, Sir Frederick Warner (left) and Sir Edward Pochin

Costs are paid largely by the taxpayer. How does one measure the benefits? A very good question, to which I have no good answer. The cynical might suggest that the only measure is tonnage of paper consumed or produced. I might suggest a refinement of that: the benefit should surely be in some inverse proportion to the amount of words in the final report. On this scale Mr Justice Parker with his Windscale report would win by a country mile!

Funding of intervenors

There are significant differences in the funding of intervenors which, in the context of nuclear inquiries, mainly means funding anti-nuclear organisations. This has not been done in any of the inquiries in Australia, Britain or New Zealand. In the cause of equity and in its ideal form I can whole-heartedly support the idea of intervenor funding, though in that case it should be extended to all private organisations, pro and con. In its actual practice I am much more dubious. Some of the leaflets and newsletters printed with funds provided in connection with the Bayda Inquiry [the Cluff Lake, Saskatchewan, Board of Inquiry] were certainly defamatory and verged on the libellous. To try to control the use of funds, after they have been given, would be regarded by the recipients as censorship. However, it must be galling to many taxpayers to see public money used for such purposes. A sounder concept is the payment of witness fees and the commissioning of specific research reports, which has been done at a number of inquiries.

The role of the media

The following quotation is from the final report of the Royal Commission on Nuclear Power Generation in New Zealand, and in many respects is an impartial assessment that says it all about the media and nuclear power.

> We were disappointed at the extent and quality of the coverage given by the news media. We do not underestimate the difficulties of obtaining reporters or news commentators sufficiently conversant with the technical problems of nuclear energy to enable balanced reports of submissions, nor of those of maintaining a continuous attendance at an inquiry of great length. Nevertheless, we felt that with some exceptions the media, in addition to the intermittent character of their participation, were over-inclined to give prominence to the views of some witnesses rather than to the better balanced evidence of more knowledgeable people. As a result the media did not help as fully as we would have wished the Government's objective of promoting an informed public debate by means of our inquiry. We found that this was often the experience of overseas inquiries into nuclear power, though now that this technology is established in North America and Europe, the media there appear to be improving their coverage of developments and unresolved issues.

The above quotation was written in the spring of 1978. After Three Mile Island and my own experiences I wish I could concur, in full, with their view that media coverage of nuclear developments in North America is improving. I have sat through entire days of testimony at the Porter Commission [the Canadian Royal Commission on Electric Power Planning] and the Ontario Select Committee and, on the rare occasions when newspaper reports appeared the next day, wondered whether I and the reporter had been at the same hearing. Far too often the five per cent of the proceedings that puts nuclear power in a bad light is the entire substance of the so-called report and the other 95 per cent that may well have so modified the picture as to put it in a good light is suppressed.

Bad news

The media seems completely hung-up on the idea that the only news is bad news and have got most people conditioned into believing it. Perhaps I am one of the last optimists left who still believes that most people behave for the best out of good motives. I would like to see good news in the same proportion with which it occurs relative to bad news, not in inverse proportion.

The media has played a leading role in recent years in highlighting the shortcomings of institutions. However, it is an institution itself and I have no reason to believe that it is any worse or any better than the institutions it attacks. At the risk of being platitudinous, I can only pray that the media collectively could be more constructive and less destructive, and that applies to many other areas than their treatment of energy questions.

Expectations

A more serious problem, relating to public inquiries in general, is that different groups in society have widely differing expectations of what the inquiry will achieve, either for themselves or for others. Since many of these expectations are mutually contradictory it is scarcely surprising that the results of inquiries are never universally and equally acclaimed on all sides. The general public may have expected enlightenment but may end up more confused by conflicting views than before; portions of the media may have expected exciting confrontations but instead found the proceedings monumentally dull; the government that set up the inquiry may hope for the topic to sink under a load of inertia, paper and indifference but find instead that the issues capture the public imagination; the political opposition may hope for ammunition to use against the Government but find instead only duds or blanks; the extremist may expect a platform from which to launch himself and his views but instead finds a quicksand of disinterest; the educator may hope that it will lead to the spread of knowledge and wisdom but finds that the entire proceedings are largely ignored; and so the list goes on.

The most common expectation, even from some of the participants, is that the inquiry is a decision-making body. This is never the case: no government is going to abdicate totally its prerogative to govern, even in a narrow area, to a subordinate appointed body *without* that government reserving the right to itself to modify, accept, reject or quietly ignore the recommendations that emanate from the inquiry. Hopefully the inquiry will bring to light facts and the range of opinion on what those facts mean so that the decisions then made by others will be wiser and more in the public interest than if the inquiry had never been held.

If some of the recommendations are unsound even ignoring them could, on occasion, be in the public interest. It is rare indeed that an inquiry does not leave some questions unanswered, either by accident or design. A broad-ranging inquiry could be accounted successful if it was able to narrow the areas of dispute to the point where some reasonable specific recommendations can be made.

Conclusions

In terms of response from the nuclear industry I feel that there is absolutely no other course than giving inquiries the best that you have. That means using your best resources, both in the technical and the public affairs fields. We tend to think of nuclear energy as a purely technical challenge that can only be solved by engineers and scientists. That is only partly true, but only in a technical sense; the real points at issue are only rarely purely technical. We do not make the best use of our people in public affairs; in many ways they are the unsung heroes and heroines of the nuclear inquiry business — derided by the anti-nuclear forces and largely ignored by our own people. (I am an engineer who came to public affairs via the academic world.) We have misused this valuable resource in the past. I think it is changing with the realisation that public affairs people have to become more familiar with the technical end and technical people with public affairs. We pride ourselves on our engineering competence and professionalism; let us also recognise that our public affairs people are just as competent and just as professional in their own field.

Nuclear inquiries can be enlightening, a distiller of wisdom, the generator of new ideas, a catalyst for constructive change; at worst they could become little better than a kangaroo court. How well they perform depends on many people, the commissioners, their staff, the participants, the media, the decision-makers and many others. It can work well, but that requires dedicated effort by these many people. If it does not work well it may be due to the ill-advised actions of some individuals in the process, but is more often a reflection of shortcomings in our democratic system. The challenge is there for all of us to make it work, since failure to do so would be a step toward a totalitarian society. □

AMERSHAM THE FIRST FORTY YEARS

The Radiochemical Centre at Amersham celebrates this year its fortieth anniversary of work with radioactive materials at this site. By Dr Charles Evans, Deputy Managing Director.

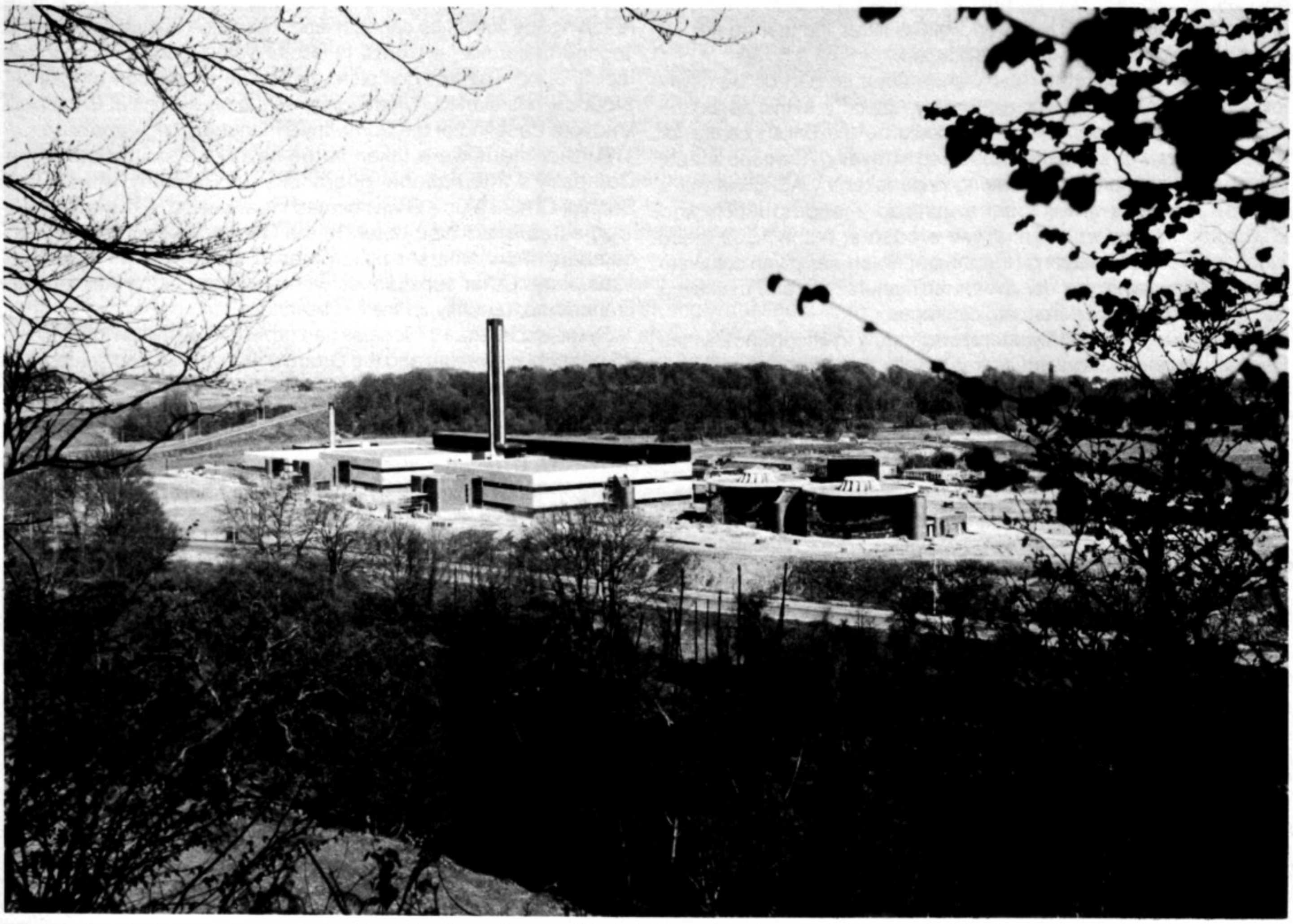
In the early days of World War II the British Government invited a small company, Thorium Limited, to undertake the refining of radium and the manufacture of radium-based self-luminous paint for use in compasses, gunsights and aircraft instruments. Overseas supplies, from Canada and Belgium, were at risk and a secure domestic source was essential.

The company recruited a young chemist, Patrick Grove, then aged about 26, and purchased a house called Chilcote in the country town of Amersham: fortuitously near to what was to become one of the world's largest international airports and to the future Atomic Energy Research Establishment at Harwell. Work with radioactive materials started in May 1940. So began a development which was to link the name of Amersham synonymously with radioactive substances worldwide.

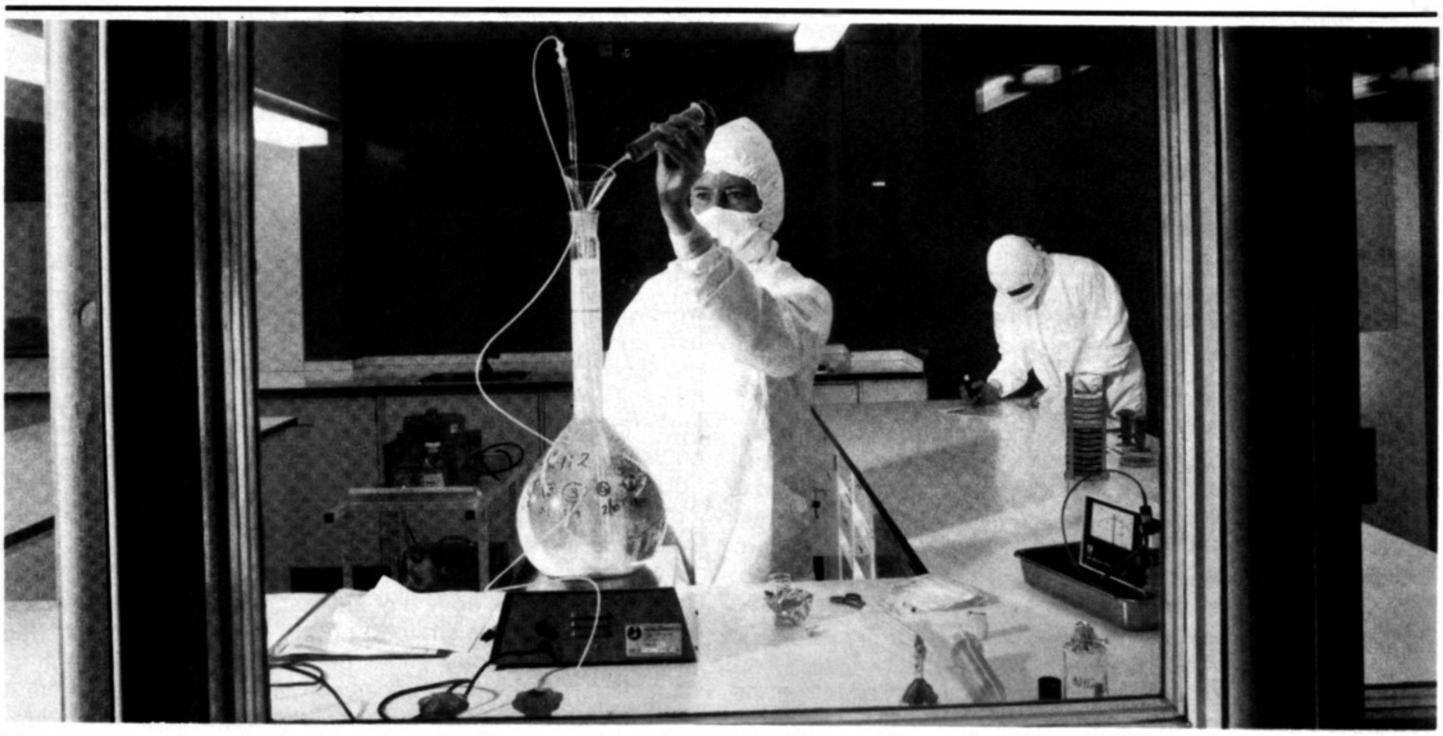
Between 1940 and 1944 some 35 grams of radium were refined and 1000 kilograms of luminous compound prepared. When this work was running smoothly thoughts naturally turned to the longer term and to considering how war-time skills might be applied to the provision of radium for medical purposes. The idea of establishing a national centre for radium and radon began to emerge. Also at about this time the significance of the war-time developments in nuclear energy was becoming more widely appreciated. An opportunity to broaden the work with radioactive materials to include products derived from nuclear reactors and accelerators was becoming evident.

In 1946 the decision was taken by the Lord President's Committee, on the advice of several distinguished scientists, doctors and administrators of the day, to establish The Radiochemical Centre under public ownership. Although its immediate purpose was concerned with natural radioelements, it was envisaged that when artificial radioisotopes became available the Centre would undertake the processing and distribution of them also. The basic purpose of the Centre was clear: to provide a dependable supply of these important substances for medicine, industry and research in the United Kingdom.

Radium and its associated products dominated the work at Amersham until well into the fifties but reactor-produced isotopes became progressively more important as pharmaceuticals and



The Radiochemical Centre's laboratories and offices being built at Cardiff



The clean area formulation laboratory for the preparation of scanning kits used in conjunction with Technetium-99m generators

research chemicals incorporating these materials were developed and manufactured.

Considerable expansion began to take place on the Amersham site. New manufacturing processes were established for the more important isotopes such as phosphorus-32, iodine-131, sulphur-35 and carbon-14; the biosynthesis of vitamin B_{12} labelled with cobalt-58 was developed; 200 carbon-14 labelled research chemicals were synthesised and by the end of the fifties the first 40 tritium-labelled chemicals had been introduced.

In 1954 The Radiochemical Centre became part of the newly formed United Kingdom Atomic Energy Authority. In this period the original intention that Amersham should be the British centre for radioisotopes was somewhat obscured by rivalry. A second stream of isotope development was being undertaken by AERE Harwell's Isotope Division which had organised the production and distribution of a number of these products; but in 1959 these functions were taken over by the Centre, which was given complete responsibility within the UKAEA for the manufacture and marketing of all products derived from radioisotopes.

Sales developed rapidly and exports grew in importance as the Centre became recognised internationally as an important source of supply. Distributors were appointed in the major markets, notably Nuclear Chicago in the United States and Brown, McFarlane in Japan. By 1959 sales exceeded £1 million per annum with 60 per cent going overseas to some fifty countries.

The sixties were a period of further vigorous expansion of the technical resources at Amersham. New laboratories were built for carbon-14 and tritium work, for the manufacture of radiation sources and for two of the technical services — quality control and physics. New offices were built to accommodate the increasing number of commercial staff and the Centre's first cyclotron was installed. From 1964 onwards a comprehensive marketing organisation was built up to take on the growing competition and to move towards the ownership of overseas subsidiaries. Many more distributors were appointed and the export business continued to prosper. The Company went into partnership with G D Searle in the United States to form Amersham/Searle.

In 1967 the Company received its first Queen's Award for Export Achievement and Technological Innovation: it was later to receive three further awards.

At about this time the first clinical assay kit, for insulin, based on radioimmunoassay was launched. A major new market for such diagnostic kits was beginning to emerge; within the next ten years it would account for a quarter of the Centre's sales.

In 1971 the Centre became a private limited company whose shares are wholly owned by the United Kingdom Atomic Energy Authority. Further investment was made in laboratories for medical product development, for pharmaceuticals manufacture and for product finishing and despatch. Offices and stores were added and a freeze-drying unit for non-radioactive preparations opened at Gloucester. By 1973 it was clear that the Amersham site was reaching the limit of its capacity and a decision was taken to start a second major site at Cardiff in South Wales. Construction of that facility is now almost complete and some production of medical products has started. When complete the operations at Cardiff will lead to a doubling of the Company's manufacturing capability.

Further steps were taken in the seventies to strengthen the Company's international operations. In Germany, Amersham Buchler GmbH & Co KG was formed in partnership with the Centre's long-established distributor. In the United States the American company, now Amersham Corporation, became a wholly-owned subsidiary. Other subsidiaries were incorporated in Australia, in France and, recently, in the Netherlands.

By the end of the 1970s sales had grown to £40 million per annum, 85 per cent overseas, and the Group directly employed some 1800 staff in seven countries. All three main centres of the business, medical diagnostics, research products and radiation sources, were growing healthily.

In May 1979 Dr Patrick Grove, founder and leader of the organisation for 40 years, retired. He was succeeded as Group Managing Director by Dr Stuart Burgess.

1980 sees the fortieth anniversary of the first work with radioactive materials on the Amersham site. Few in those early days could have foreseen that the use of radioisotopes in medicine, research and industry would grow so rapidly or that the Centre would become the substantial international business which it is today. Its success seems to disprove two assumptions often made about British businesses, namely that the country can develop but not successfully exploit new technologies and that publicly-owned enterprises are by nature inefficient. It is fair to say that during the period of its long association with the Company the UKAEA has provided just about the right mixture of control and autonomy required to ensure that the Company developed its resources and organisation into a fully viable business entity.

The contribution to the quality of life from the beneficial uses of radioactive products is enormous and there is no slackening in the rate of discovery of worthwhile new applications. The Company is well placed to meet the growing demands for these products and can look forward with confidence to continuing success. □

BOOK REVIEWS

Energy Risk Management

Edited by G.T. Goodman and W.D. Rowe; *Academic Press Inc. (London) Ltd; 351 pp (indexed); £14.80 or $34.50. ISBN 0 12 289680 7.*

This book contains selected papers from an international review seminar held in September 1978, whose main purpose was to identify those areas of risk analysis that would benefit from further intensive study. It is a book to refer to rather than to read at one sitting. As with most conference reports or reviews, there will be papers with which some people will be familiar, others which they will find new or exploratory and others which may be challenging or not wholly convincing. This is what I find here.

It is worth listing the topics covered:

- Introduction to risk assessment — W.D. Rowe
- Environmental Impact Analysis and risk assessment in a management perspective — T. O'Riordan
- The problem as seen from the point of view of the decision-maker — C. Tham
- The risks of energy strategies, an ecological perspective — J. Harte
- Policy issues in standard setting — a case study of North Sea offshore oil pollution — D.W. Fischer
- 'Real' versus perceived risk: implications for policy — R.G. Kasper
- The burden of technological hazards — R.C. Harriss, C. Hohenemser and R.W. Kates
- Health and economic factors affecting mortality — L.A. Sagan and A.A. Afifi
- The problem of quantification — T. Thedeén
- Keeping score: an actuarial approach to zero-infinity dilemmas — T. Page
- Insurance and low probability risks — H. Bohman
- Development of standards related to received dose: the radionuclide case — B. Lindell
- On the assessment of genetic and carcinogenic effects — chemicals/combustion emissions/oxidation fuel cycle — L. Ehrenberg and G. Löfroth
- Images of disaster, perception and acceptance of risks from nuclear power — P. Slovic, S. Lichtenstein and B. Fischhoff
- Social cost benefit analysis and nuclear futures — D.W. Pearce
- Behavioural aspects of cost-benefit analysis — B. Fischhoff
- The role of modelling, a means for energy/environmental analysis — R.L. Dennis
- Administrative aspects of environmental risk assessment: the case of lead in Britain — S.H. Staynes
- Politically acceptable risks from energy technologies: some concepts and hypotheses — E. Vedung
- What is acceptable risk and how can it be determined? — W.D. Rowe.

The scope of the seminar, and of this book, is clearly too wide for detailed treatment; instead, I offer comments which may be helpful.

The sections on risk assessment and measurement are biased toward human responses. I do not agree that "one cannot evaluate risk without considering human responses", nor entirely that "man is by nature risk adversive", or that "the last few years have shown rapid increase in both the levels of risk to which people are exposed." So much has been written about risk in the last decade that some ideas, repeated too often, need re-examination.

I like Tham's paper on the point of view of the decision-maker. It is good to read about decision making by one who makes them.

It is asserted that "the identification and estimation of these [technological] risks have become highly specialised procedures which have led to interim but controversial findings and caused great public alarm. There is no doubt that this anxiety is fanned by the seeming impotence of informed lay people frustrated at their inability to change the course of events." I have some doubt.

The form and benefit of an Environmental Impact Analysis is strongly challenged; I cannot believe that an EIA had much to do with the US moratorium on the fast breeder reactor.

Then there is a claim that risk assessment has advanced further in countries where an adversary approach is adopted, whereas in countries with a consensus approach (such as the UK) risk assessment is an unfriendly device. I reverse both propositions: where is the looking glass?

It seems extremely difficult to assess risks to our ecology. "Small errors in the initial specification of say the state of the atmosphere or a marine ecosystem can grow so fast in time that detailed prediction beyond a few weeks would require an initial conditioned data base so large as to exhaust the capacity of even the largest computers." This moves into the field of the standard setter. "To what degree does chronic oil pollution endanger the ecological balance in the marine environment? The basic answer is — we do not know."

Most potential readers of this book will be familiar with the "real" v. "perceived" risk arguments; now we have the good man and the bad man: it is bad to be an expert in real risk evaluation and good to be an expert in perception. The examples here reflect this view, particularly in the context of the American scene. Harriss *et al.* report a study of technological hazards and conclude that "hazards arising out of technological practices have in the industrialised world significantly surpassed natural hazards in impact, cost and general importance. At present in the USA technological hazards account by our estimate for 15-25 per cent of human mortality." I am hesitant to accept this analysis and question what to do with it. It calls for the application of an Index of Harm, with some assessment of success rate for remedies or prediction of alternative hazards. It is interesting.

The study of health and economic developmental factors affecting mortality is an interesting contribution. Many variables used as indicators of economic development were studied and all showed some relationship with health, but with the exceptions of literacy, energy and medical care the relationships were neither strong nor consistent enough to show a causal relationship.

We are familiar with problems of quantification. The paper dealing with zero-infinity dilemmas discusses some aspects of the difficulties of assessing events of low probability but of high consequence. It is suggested that a score should be kept of the success of individual risk assessors — this implies scoring the more frequent events, as otherwise we would wait for decades to get a score. The suggestion also implies the giving of a greater weight to the numerically-expressed answer than to the merit of the assessment in itself, in improving design and so on.

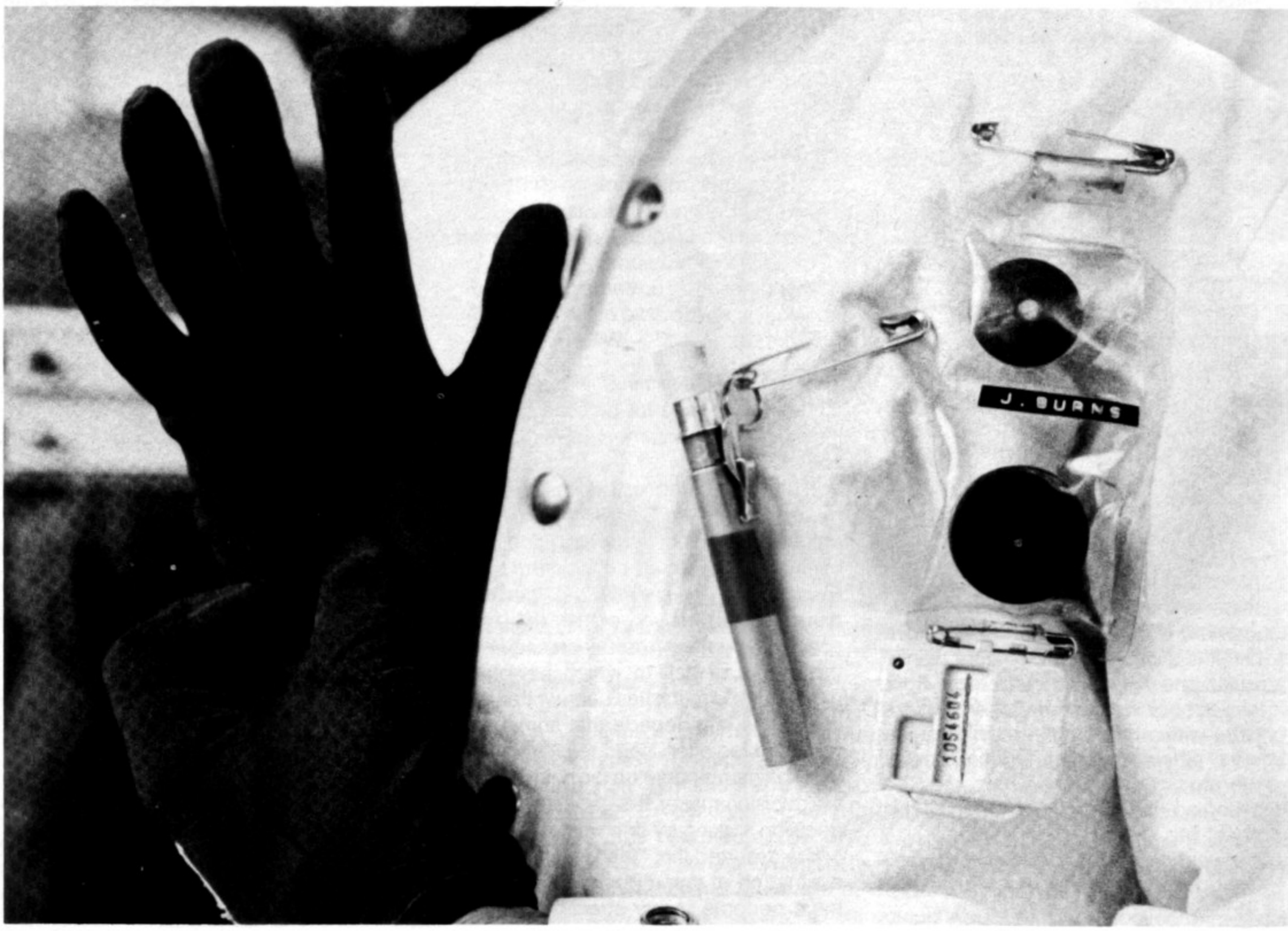
The insurance paper is not helpful; it says that insurance risks with very small frequencies create such a problem to the insurance industry that it tries rather to avoid insuring against such risks.

For the rest, the paper on genotoxic compounds stresses the present lack of knowledge and urges more work to arrive at a measurement of genetic risk from a given chemical in terms similar to those used for measuring radiation, such as sieverts.

The work of Slovic and his colleagues (the paper on images of disaster, perception and acceptance of risks from nuclear power is by them) is well known in the field of risk perception, and needs no further discussion, here.

Social cost-benefit analysis is said to be largely, though not entirely, irrelevant to the evaluation of energy futures, for several reasons:

- first, that any analysis would have to be 'stretched' in time;
- how to accommodate future risks is another component of an Index of Risk. Arguments considering the application



Personnel radiation protection equipment

of cost-benefit analysis to a nuclear fuel cycle are well-presented.

- and cost-benefit analysis has a distinct use on "ordering" thoughts.

The paper on risk administration gives as example the control of lead pollution in the atmosphere. It is clear and consistent with the later report of Prof. Lawther's committee. Finally, it seems appropriate to have a paper from Sweden on politically acceptable risks from energy technologies.

Much has been written about what constitutes acceptable risk; the last paper in this book re-examines the problem.

F.R. Farmer
Consultant on safety to the UKAEA

An introduction to radiation protection

By Alan Martin and Samuel A. Harbison. *Chapman Hall (Science Paperbacks), second edition. £4.95.*

This book assumes no previous knowledge of the subject and is set generally at a level equivalent to City and Guilds courses in radiation safety practice. As well as people involved full-time with radiation protection, the book is aimed at people who might want a general review of the subject or who might be interested in certain aspects of the work; to this latter end the chapters have been made self-contained so far as possible. The mathematical treatment is generally simple.

The first edition of the book was published in 1972, and about half the chapters in this edition have been revised to take account of changes since that time, particularly in relation to the modified system of dose limitation recommended by the International Commission on Radiological Protection in ICRP 26, and the introduction of SI units into radiation protection.

To help the practical worker in the radiation protection field, both old and new units have been used, sometimes in parallel, in a large number of examples. However, it seems inevitable that the operational health physicist will have to dispense with his milli-'r' per hour to cover milli-Roentgens, rads or rems per hour and to think more carefully in future — what a pity the powers that be couldn't have chosen new units with the same initial letter!

The first three chapters cover basic nuclear physics including the structure of matter, the properties of the various types of radiation and radiation units in a succinct but readily comprehensible manner. Chapter 4 deals with the biological effects of radiation, covering both somatic and genetic aspects, and discusses the way in which radiation damage occurs. This chapter is generally lucid but the definition of stochastic and non-stochastic effects could well have been clearer.

After a chapter on natural and man-made radiation, the subject of Maximum Permissible Doses and the role and recommendations of the ICRP are discussed. For those who find the text in ICRP 26 difficult to follow, this chapter gives an admirable overview or a useful introduction for those who need to study the text in detail.

The section on Radiation Detection and Measurement covers personal dosemeters as well as the usual radiation protection instrumentation, albeit in rather broad outline; and this is followed by chapters in external and internal radiation hazards. These latter chapters contain some useful examples of typical radiation protection calculation, although there are minor blemishes: e.g. it is stated that thermoluminescent dosemeters can be read only once; in fact recent developments have allowed re-reading via the deeper traps to become a possibility; and there is no mention of recently introduced digital dosemeters or of the enhanced excretion rate of tritium by increased fluid intake.

In the final section of the book the authors have attempted to review more specialised aspects of radiation protection, such as Nuclear Reactor Health Physics, Radioactive Waste, X-rays and Radiography, Radiation Protection in Medicine, Legislation and Regulations, Health Physics Laboratory Techniques, Radiological Emergencies and Health Physics Organisation and Administration. In a book of this length (245 pages) these topics are necessarily considered rather briefly, but apart from a few minor omissions such as there being no mention of the SGHW reactor in the reactor types and the fact that the AGRs use oxide fuel, the principles involved are stated clearly and simply.

The general impression given by the book is that it is well-written and unpretentious and that it broadly achieves its stated aims. The chapter summaries, bibliography and questions (with answers) will prove useful for those studying the subject. If there is to be a further edition of the book it would be useful if it included a section on the public relations aspects of radiation protection, including a discussion on relative risks.

T.E. Blackman
Radiological and Safety Division, AEE Winfrith

"Low energy" revisited

In 1979 the International Institute for Environment and Development (IIED) published a book by Gerald Leach *et al.* which gives a detailed analysis and projection of energy supply and consumption in the UK to the year 2025[1]. It concluded that if conservation measures are introduced vigorously then the economy could grow by a factor of two or three by 2025 with little or no growth in energy supplies.

The book has been studied in some detail by Authority staff, and a discussion paper commenting on Leach's analysis was published last month[2]. The subject is extremely complex and fraught with uncertainty and this in itself leads to the conclusion that since it is not possible to anticipate the net long-term contribution of conservation measures with any accuracy, it would be unwise to prune energy supply projections on the assumptions that the considerable savings described by IIED will in fact be achieved. To do so would be a risky strategy.

While there is no dispute that the UK should seek to use energy as efficiently as possible provided it is done in ways compatible with other important criteria such as economic and social viability, nonetheless the claims made by Leach seem unreasonable. The critique discusses these claims in some detail, section by section, and areas of agreement and disagreement are found. Analysis is made of total energy consumption relationships, economic activity, the various sectors of energy usage and fuel strategy and it is concluded that the IIED strategy is uneconomic and risky to the extent that it could lead to insufficient fuel supplies being available when they are needed, and thereby to higher energy prices. This would increase the UK's reliance on energy imports and so lead to serious constraints on economic, social and individual aspirations.

Energy saving is an important contribution to achieving the goal of reducing the likely UK future dependence on renewed large-scale energy imports, a goal with benefits both to the UK and, to some degree, to all world economies. But a complementary and essential contribution to this goal is to expand indigenous and near-indigenous energy supplies in a timely fashion.

The critique is a detailed study and it is not possible to outline all the findings here; interested readers can obtain copies from the UKAEA.

P.M.S. Jones
Economics and Programmes Branch

References

1. G. Leach, C. Lewis, A. van Buren, F. Romig, G. Foley, *A Low Energy Strategy for the United Kingdom*, IIED Science Review, 1979; initially reviewed in ATOM no. 269, March 1979.
2. G. Day, H. Inston, K. Main, *An Analysis of the Low Energy Strategy for the UK proposed by the IIED*, UKAEA Energy Discussion Paper No.1, 1980.

Safety and Reliability Society formed

A new professional society for people working in the field of safety and reliability engineering has been formed, with headquarters in Southport, Merseyside.

The Safety and Reliability Directorate of the UKAEA brought together academic institutions and industrialists to form and launch the society in response to engineers' demand for a new professional association. The aim is to establish the relatively new field of Safety and Reliability Engineering as a recognised discipline.

In the UK, the University of Bradford is playing a leading role, and will provide courses and academic support, setting examinations which will qualify candidates for membership. Negotiations have been conducted with the Technical Institute of Berlin and with the George Washington University in Washington, DC, with a view to providing similar facilities in Europe and in North America.

The UKAEA and other organisations on the Society's governing Council are providing staff time and facilities to get the Society off the ground; a secretariat has been appointed, and a Chief Executive will be appointed when required to take over the administration.

The secretary of the new Society, Mr Brian Sayers, said that at present reliability engineering was fragmented among many other disciplines. "The broad aim of the Society is to draw together all those involved in the work and to stimulate the development and use of safety and reliability technology," he said in a statement. "The field is expanding as people realise how much there is to gain from safe, reliable and available plant; and it was felt that we should provide a focus for professionals from all disciplines who are grappling with what amounts to a new technology."

The Society will have three grades of membership, and corporate affiliation. Associate Membership will be open to those without specific professional qualifications but who do have appropriate interest or expertise in safety and reliability technology. Full Members would be required to have a relevant degree or similar qualifications, and at least five years' experience.

The highest grade of membership will be Fellow; candidates should be qualified as for ordinary membership but should have as well at least five years' experience in a senior position of responsibility in the safety and reliability field. The Council is considering Honorary Fellowships. Affiliate Membership is open to all corporate bodies, such as registered companies, government departments and professional institutions.

The first President of the Society is Dr Eric Green, head of the AEA's National Centre of Systems Reliability at Culcheth. Bodies represented on the governing Council of the Society include British Gas, Rolls Royce Ltd, Plessey, Sara Ltd, the University of Bradford, the NCSR, the Warrington Research Centre, TR Moss Reliability Consultants, Rex Thompson and Partners, Y—ARD Ltd., and F. Douglas Williams and Co.

Membership and professional enquiries should be addressed to Brian Sayers,
National Centre of Systems Reliability
Wigshaw Lane
Culcheth, Warrington.
Tel. Warrington (0925) 31244 ext. 212;
or to:
Safety and Reliability Society
P.O. Box 25
Cambridge Arcade
Southport, Sefton. □

Stronger energy policies required

Countries which are members of the International Energy Agency should continue to strengthen and implement their energy policies in ways which ensure that structural changes in energy economies actually take place in the medium term, Ministers agreed at a meeting of the IEA Governing Board in late May. Their objective should be to reduce the need for energy and for oil in particular, and also to give protection against short-term market disruptions.

A communiqué issued after the meeting said Ministers recognised that if energy problems were not resolved the ability to manage the general economy effectively would be put seriously in question, and this could damage the prospects for economic growth on a lasting basis.

The Ministers also noted that "the expansion of nuclear power, under appropriate conditions taking into account the progress made in the International Nuclear Fuel Cycle Evaluation, is indispensable for ensuring structural change in the medium term."

Ministers agreed that efforts to reduce oil imports would be continued beyond 1985, for which the group objective is a total of 26.2 million barrels a day including bunkers. They expected that as a result of these efforts it would be possible to reduce the ratio between the rate of increase of energy consumption and the rate of economic growth for IEA countries as a group over the coming decade to about 0.6 and the share of oil in total energy demand from 52 per cent at present to about 40 per cent by 1990.

Annex

In an annex to the communiqué the IEA secretariat analyses areas where energy policies could be strengthened in individual IEA countries. In particular, the analysis concludes that efforts should be made in all countries, but particularly in Italy, Japan, the Netherlands and the USA, to reduce oil-fired electricity generation as rapidly as possible by substituting other fuels and by restricting oil use to middle and peak loads. No new oil-fired electricity plants should be authorised except in particular circumstances where there are no practical alternatives. Existing capacity should be operated with maximum use of fuels other than oil.

The secretariat analysis says strong action is necessary in all countries to reduce the non-feedstock use of oil in industry. Careful reviews were warranted in Greece, Ireland, Japan, the Netherlands and the US, where forecasts suggested that oil use might grow rapidly, and in Germany, Italy and the UK stronger action might be necessary to achieve the expected results.

Non-oil fuels, used either directly (including their use for district heating) or converted to electricity should be substituted for oil in residential use wherever the necessary infrastructure existed or could be provided. Countries now using or considering district heating should consider the greater use of coal for this purpose. The UK should ensure that its current plans to substitute natural gas for oil during the 1980s were realised.

"All countries should give greater emphasis to strong and comprehensive conservation programmes to encourage the rational and efficient use of energy in general and oil in particular," says the analysis. "They must effectively inform the public about why and how to conserve energy, and they must produce results."

The analysis contains a number of other recommendations. In particular, the secretariat says greater efforts must be made "to accomplish projected nuclear programmes, and to create an environment in which discussion of nuclear issues can take place in an objective and balanced way, taking account of economic and energy considerations as well as safety and proliferation aspects" (Germany, Italy, Japan and the United States are singled out here), "and to streamline regulatory processes for the licensing of nuclear plants and for authorisations related to nuclear fuel cycle activities in other Member countries."

[In Parliament: p. 220, this issue.]

OECD echo

Oil price increases which have occurred during 1979 and 1980 "are severely damaging the world economy", OECD Ministers agreed at a meeting in early June. Action was needed urgently to bring about a structural change in world energy supply and demand patterns.

The Ministers noted that the occurrence of two large and sudden increases in the price of oil since 1973 reflected a continuing danger for future economic and social development. "The degree of risk is underlined by the fact that the multiple price increases since the beginning of 1980 have occurred despite falling oil demand, and appear to have been made without taking into account their adverse impact on the world economy," said an OECD Communique on the meeting. "Given the dangers outlined . . . and in particular the currently fragile state of the world economy and the serious damage that would be done by further large and sudden oil price increases, Ministers agreed that adequate arrangements to limit the damaging effects of short-term market disruptions will have to be carried through and adapted to the situation as it evolves."

Ministers agreed that in order to restore satisfactory conditions for economic growth, strong policy action to improve the energy supply/demand pattern in the medium term was an urgent necessity. They agreed that for this purpose the price mechanism had an important role to play in accelerating the more rational use of energy, switching away from oil and increasing energy production from other sources, thus bringing about the necessary structural change. □

IEA "most important forum"

Speaking in London on 5 June Mr David Howell, Secretary of State for Energy, said the IEA was the most important forum for discussion of many major international questions. In particular, that was where they must discuss the wide range of difficult issues associated with the international oil market and the vital need to let price play its full part in restraining consumption. If some countries held prices artificially and thus delayed conservation and inflated demand for oil the efforts of all others were undermined.

In the UK the Government had given a new impetus to nuclear power developments; in December they had announced a programme of orders for the years from 1982 and more recently they had approved the building of two AGRs, and a letter of intent concerning the PWR had been issued. On coal, the Government had introduced a Bill to chart the industry's return to profitability based on an investment programme of £600 million a year. In the North Sea £21 billion had been invested so far, and the Government had announced recently the seventh round of licensing on the UK Continental Shelf. Altogether, probably something like a quarter of total investment in energy in the European Community over the past five years had been made in the UK. Meanwhile, they were beginning to make solid progress in energy conservation. Even when one allowed for the mild 1979-80 winter petroleum consumption was down more than ten per cent over the previous 12 months; this was a start, although much more was needed. Greater efficiency in energy use must become the general habit, not the daring exception.

"The thrust of this whole policy is absolutely in line with our internationally agreed objective of lessening our dependence on imported oil," said Mr Howell. "The European Commission recently estimated that member states already plan energy spending up to 1990 of a staggering £240 billion. These massive national and collaborative investment programmes represent a formidable commitment to our energy future." □

Nuclear waste "is manageable"

Why do we behave as though nuclear wastes pose a new sort of problem with dangers greater than those we already live with?

This was a question Mr Norman Lamont, Parliamentary Under Secretary of State for Energy, put to a conference on the future of nuclear energy in Britain organised by the Rotary Club of Manchester in early June.

"An American psychologist recently drew a distinction between normal and healthy fears, and fears which are exaggerated and unrealistic," said Mr Lamont. "If when you were at a zoo a lion suddenly bounded out of its cage and charged towards you, it would be normal and healthy for you to be afraid. If, on the other hand, you are afraid even to go to a zoo because the sight of a snake — even in a tank — strikes terror into your heart, that is an exaggerated fear.

"Of course, animals do sometimes escape from their cages. But the risk is so small that most people ignore it.

"Many people worry about things to do with nuclear energy which they readily accept in other walks of life where the real danger may be much greater, though still very small. None of us could lead normal lives if we did not take a realistic view of very small risks.

"Nuclear waste has aroused as much fear as perhaps any other aspect. Yet we produce many sorts of unpleasant waste in modern society, often nastier and longer-lasting than nuclear waste. For example, we accept that as part of the process of generating electricity from coal we produce substantial quantities of waste. In fact, a large coal-fired plant can produce about 20 lbs of solid waste per second. By comparison, the high-level wastes produced in one year by a nuclear power station, when suitably treated, amount to only a few cubic metres.

"These wastes can be safely managed, by a variety of techniques, to contain their radioactivity. Most importantly, their radioactivity declines, and at such a rate that after 500 years it is less than that of the original ore from which the fuel was produced — though, of course, much more concentrated.

"Coal wastes, on the other hand, contain at least a dozen toxic metals, including arsenic, admittedly in small quantities, and the waste from our chemical industry includes toxins such as cadmium and cyanide, all of which will be around us forever.

"I am not arguing that these dangers are excessive, and in no way am I attacking the coal or chemical industries. But I think one can reasonably ask why we behave as though nuclear wastes posed a new sort of problem with dangers greater than those we already live with."

Problems and solutions

Mr Lamont looked at three problems associated with the management of nuclear waste: quantity, radioactivity, and long-term disposal. First, quantity. It could be argued that the small quantity of waste which nuclear power produced in relation to the power which was generated was tiny. In particular, the production of the more dangerous high-level liquid waste was tiny. "For instance, a 25 lb Magnox fuel rod, of the type used in Britain's first generation of nuclear stations, produces about as much electricity as 150 tonnes of coal," said Mr Lamont. "After five years in the reactor, only about 1 per cent, that is just a few ounces, is waste. The remaining 99 per cent is unused uranium and plutonium which can be removed and used again. Thus after 25 years of nuclear power generation in the UK, the waste products from used fuel rods would fill little more space than a four-bedroom house. Even if all our electricity were to be produced by nuclear power, the total quantity of such waste produced each year would be equivalent in volume to only about one pencil per person."

Secondly, radioactivity. Nuclear waste comprised a wide range of substances which were by no means all equally dangerous: some short-lived "wastes" extracted from fuel were intensely radioactive and generated large quantities of heat, so requiring cooling and shielding; but ten years after they left the reactor the radioactivity of such wastes was only a fraction of its initial level. The long-lived "wastes" took much longer to decay, but they were consequently much less radioactive — they were regularly and quite safely handled in laboratories in their pure form using only the protection of plastic gloves. The danger from them arose if they were ingested or inhaled.

"As a result," said Mr Lamont, "we can be confident that the combination of appropriate techniques for storing, conditioning and disposing of these wastes will ensure that the quantity of their radioactivity which reaches man will never be more than a small fraction of the naturally occurring background which we cannot avoid."

Thirdly, Mr Lamont turned to disposal. "Technology for conditioning nuclear fuel waste so that it can be safely disposed of is already well advanced. A method of converting liquid waste into a glass solid has been developed on a pilot scale in the UK and in France has reached the stage of semi-industrial operation. The resultant glassified waste is easier to handle and store; and it is safer. Nonetheless, a further period of storage prior to disposal will probably be necessary to allow the more radioactive substances to decay further.

"Disposal will not commence until the beginning of the next century at the earliest, and will depend upon the results of the present research programme, which is looking into disposal options. The industry is also looking at ways of improving existing storage methods, and we are determined that this should continue. Until then the waste, in glass form, will be placed in cooled stores under appropriate supervision. It is estimated that all the high level waste generated by the UK nuclear programme up to the year 2000 could be stored in this way in an area of less than two football pitches." □

"A Magnox fuel element used in Britain's first generation of nuclear stations produces about as much energy as 150 tonnes of coal"

Sir Alan Hitchman, KCB

It was with deep regret that the Authority learned of the death on 2 July of Sir Alan Hitchman, who was Deputy Chairman of the Authority before his retirement in 1966.

Sir Alan was born at Newbury, Berkshire in 1903 and was educated at St. Bartholomew's Grammar School, Newbury and Downing College, Cambridge, where he obtained a first-class degree in History.

He entered the Ministry of Labour as an Assistant Principal in 1926 and was promoted to Principal in 1934. He became Principal Private Secretary to the Minister (Ernest Brown) in 1939 and afterwards to

Sir Alan Hitchman

Ernest Bevin when the latter was brought into the Coalition Government in 1940. He was promoted to Assistant Secretary in 1941 and Under Secretary in 1946. He was transferred to the Treasury in 1947 and became Deputy to the Chief Planning Officer in 1948 and a Third Secretary in 1949. He was appointed Permanent Secretary to the Ministry of Materials in 1951 and to the Ministry of Agriculture and Fisheries in 1952.

In 1959 Sir Alan was appointed to the Board of the Authority as Member for External Relations and Commercial Policy. He succeeded Sir Donald Perrott as Member for Finance and Administration in 1960 and was appointed Deputy Chairman in 1964. He retired in 1966.

Members and staff of the Authority who served with Sir Alan recall the thoroughness with which he tackled the many complicated and difficult issues which arose during his period of office. There is no doubt that the Authority owes much to his statesmanlike guidance and to the wide experience that he brought to bear on the Authority's administrative problems. The unfailing kindness and courtesy which he showed to all his colleagues is remembered with great respect and affection.

Eric Underwood OBE

Eric Harold Underwood OBE, Director of Public Relations for the Atomic Energy Authority from 1954 until his retirement in 1973, died on 8 June aged 67.

He began his career as a journalist and served in the RAF during World War II. He became chief press officer and afterwards director of public relations for the British Control Commission in Germany and Austria. In 1947 he was head of the German Information Department of the Foreign Office. He was made an Officer of the Order of the British Empire in 1950. He became joint director of overseas magazines for the Central Office of Information and was responsible for organising official picture coverage of the Coronation.

Joining the Authority at its creation, Mr. Underwood was responsible for a major exhibition for the 1955 International Atomic Energy Agency conference. In the following year he made the opening arrangements for Calder Hall, the world's first commercial scale nuclear power station.

Mr Eric Underwood

Abroad Mr. Underwood supported the Authority's commercial interests. At home he had to satisfy an extensive demand for information from public and press. He organised exhibitions all over the world, instituted a travelling exhibition within Britain, organised courses for journalists and stimulated a wide range of publications.

Mr. Underwood founded this journal. The first issue of ATOM appeared in November 1956 for those "to whom a record of information on the work of the Authority may be useful."

On his retirement, Eric Underwood wrote a number of books, the last on Brighton, where he lived until his death. He leaves a widow, a son and a daughter.

Radiological consequences of actinide separation

The National Radiological Protection Board (NRPB) has published two reports containing radiological assessments of the effects of separating actinides — generally, long-lived materials such as plutonium and americium — from high-level radioactive waste prior to its eventual vitrification and disposal. The possibility of separating actinides for "incineration" in reactors is being studied in the UK and in other countries, although actinide separation is not part of UK policy for dealing with waste.

One report is a study of the effects of actinide separation on the consequences of disposal on the ocean bed[1] and the other is a similar study in relation to the option of geological disposal[2].

For disposal on the ocean bed the achievable dose reduction would be a factor of about 100, or less for certain pathways, the first report concludes. For geological disposal, actinide separation would reduce the potential radiological impact only to a limited extent and over limited periods. The reductions talked of apply only to doses received by members of the public as a result of waste disposal: the reports take no account of increased doses to workers arising from the separation process itself, or from the necessary management of the separated actinides.

The NRPB reports conclude that substantial further research on actinide separation would be justified only if there could be shown to be a worthwhile net radiological benefit over the whole of the nuclear fuel cycle, and if actinide separation could be shown to be the optimum way of reducing the radiological impact of high-level waste management. They demonstrate that to evaluate actinide separation full radiological assessments of this type are essential — rather than studies based on comparisons of the quantities of radioactive materials in the waste.

Further information is available from the Information Officer, NRPB, Harwell, Didcot, Oxon. OX11 0RQ. Tel. Abingdon (0235) 831 600, ext. 410. □

1. NRPB-R94 *The effects of actinide separation on the radiological consequences of disposal of high-level radioactive waste on the ocean bed*, by W.C. Camplin, P.D. Grimwood and I.F. White. HMSO, £1.50.
2. *The effects of actinide separation on the radiological consequences of geologic disposal of high-level waste*, by M.D. Hill, I.F. White and A.B. Fleishman. HMSO, £1.50.

CEGB issue Letter of Intent for PWR fuel

The Central Electricity Generating Board announced on 5 June that it had issued a letter of intent to British Nuclear Fuels Ltd authorising them to proceed with the fabrication of fuel assemblies for the CEGB's first pressurised water reactor power station.

The CEGB said the fuel assemblies would be based on technology supplied by Westinghouse Electric Corporation under agreements negotiated by BNFL.

The letter of intent is a second major step in line with the nuclear strategy announced by the Secretary of State for Energy, Mr David Howell, in December last year. The CEGB sent a letter of intent to the National Nuclear Corporation in April, authorising them to begin design and manufacture of the nuclear steam supply system for the PWR station [ATOM No.284, June 1980, p.164]. The Government has agreed that the PWR should be established as a valid option and that, subject to the necessary consents and safety clearances, it should be the next power station order. The CEGB aim to start construction in 1982. □

IN PARLIAMENT

BY OUR PARLIAMENTARY CORRESPONDENT

Local voting

3 June 1980

A Labour MP's Bill to provide for local voting on the siting of nuclear power stations was rejected by a majority of more than two to one at its first hurdle, after another Labour MP had opposed it.

Mr Bob Cryer (Keighley) said it was especially absurd for the Government to embark on a programme of ten pressurised water reactors from 1982 when Britain was rich in coal reserves, with at least 300 years' supply, and oil reserves which would make us self-sufficient for at least 20 years.

He quoted Prof. Joseph Rotblat, writing in *The Guardian*, saying that nuclear energy could make only a small contribution to the world's energy needs over the next 50 years.

Referenda should apply only to unusual and special circumstances. Going nuclear in such a massive way was certainly unusual and constituted special circumstances that demanded special consideration.

Under his Bill, there would be a local referendum under a scheme which would be produced by the Home Secretary. The scheme would provide for fair coverage in newspapers and on television of all the issues involved in building and using a nuclear power station. Newspapers would be controlled in much the same way as television was controlled during a general election campaign. This would help stop the bias and distortion that occurred during elections.

A fair allocation of space for each side would prevent any advertising pressure producing bias. Advertising itself in support of a certain view would be curtailed by limitations on expenditure that the scheme would place on the campaigning organisations registered under the scheme.

It might be argued that planning procedures took care of the views of a locality and therefore a referendum was unnecessary, said Mr Cryer. But planning inquiries were invariably weighted in favour of the establishment. The Government had enormous financial resources as did the various nuclear organisations like the CEGB and the Nuclear Power Corporation. Ordinary people felt that planning inquiries were weighted in favour of the decision made by the Government or the planning body making the application. The referendum would give them a direct and clear voice. "Although such referenda are advisory to Parliament, it would be impossible, in practice, for Parliament to ignore the views of the people so expressed," said Mr Cryer.

Opposition

Mr Robert Maclennan, whose constituency of Caithness and Sutherland includes the UKAEA's site at Dounreay, urged that the House should refuse permission "to what I venture to describe as a somewhat mischievous attempt to put forward a view about the nuclear industry that perpetuates popular misconceptions and does nothing to enlarge the understanding of the British people of the great issues at stake in providing for our power needs in an age when fossil fuels are no longer available."

The kind of referendum proposed was profoundly undemocratic, and would create anomalies and prove unworkable. The proposal gave further support to the idea that popular agitation should be encouraged to lead to decisions that may have national importance being overridden. Local community interests were well protected by the planning laws. Where wider considerations were involved, it was open to the Government to set up inquiries analogous to that which was held in the case of Windscale, allowing full consideration of local and national interests to be canvassed at length and giving local people a full opportunity to express their views.

The motion that the Nuclear Power Stations Sites Bill should be presented and read a first time was rejected by 188 votes to 75 — majority against, 113. □

QUESTION TIME

Welsh surveys

2 June 1980

Mr Delwyn Williams asked the Secretary of State for Wales to what stage surveys in Wales had progressed in connection with the possibility of dumping nuclear waste.

Mr Wyn Roberts: The Institute of Geological Sciences is at present carrying out its surface reconnaissance studies.

Research reactor

2 June 1980

Mr Arthur Lewis asked the Secretary of State for Education and Science when the research reactor at Queen Mary College, Stratford, East London, was established; what consideration was given, in allowing its continued operation, to the fact that it was in a heavily populated area; and what precautions existed to deal with any possible accident or terrorist takeover.

Dr Boyson: Queen Mary College forms part of the University of London, and is an autonomous institution, responsible for administering its own affairs. I am advised by the Chairman of the Health and Safety Commission that the college research reactor is operated under a nuclear site licence which was granted in July 1966 in accordance with the provisions of the Nuclear Installations Act 1965. The college is responsible as the licensee for the safe operation of the reactor in compliance with the conditions attached to the licence by the Health and Safety Executive in the interests of safety. One of these conditions requires the college to make arrangements approved by the Health and Safety Executive for dealing with any accident or emergency on the site. There is however no risk of a significant release of radioactivity outside the licenced site and no hazard to members of the public.

I understand from the college that a security system, approved by the local police and the UKAEA security service, is in operation.

Hong Kong

2 June 1980

Mr Parry asked the Lord Privy Seal:

- what consultations had taken place between the Hong Kong Government and the People's Republic of China concerning the proposed nuclear power plant at Shumchun;
- whether consultations had taken place between the British Government and the People's Republic of China concerning the proposed building of nuclear reactors and power plants in Hong Kong;
- whether a nuclear waste disposal plant would be built if the proposed nuclear power plant was built at Shumchun, Hong Kong;
- whether the British Government were consulted by the Hong Kong Government about the proposed nuclear power plant at Shumchun;
- what system of civil defence existed in Hong Kong in the event of a nuclear emergency;
- what contingency plans existed in Hong Kong in the event of a nuclear emergency;
- what representations the Hong Kong Government had received objecting to the proposed nuclear plant at Shumchun;
- whether a feasibility study had been carried out on the proposed nuclear plant at Shumchun, and whether any study would be made public;
- whether he was satisfied with the contingency plans for the evacuation of Hong Kong in the event of a nuclear disaster;

• and what qualifications in nuclear safety were held by the consultants employed by the China Light and Power Company in Hong Kong.

Mr Blaker: The China Light and Power Company, which is a Hong Kong company, is undertaking a joint feasibility study with the Guandong electricity authorities into the possible siting and construction of a nuclear power plant in Guandong Province in the People's Republic of China. No decisions have yet been made, nor are they expected in the near future.

The company is making use of the technical advice and expertise of the UKAEA and the feasibility study, which will be made available to the Hong Kong Government, will of course take into account the need for the highest standards of safety. The Hong Kong Government and the UK Government are in touch over the study. There have so far been no consultations between either Government and the Government of the People's Republic of China.

The Hong Kong Government have machinery to deal with emergencies of all kinds. No specific plans exist in connection with a nuclear power plant but if the Chinese authorities were to decide to build one in the vicinity of Hong Kong, such plans would of course be made.

IEA meeting

3 June 1980

Mr Maxwell-Hyslop asked the Secretary of State for Energy if he would make a statement about the meeting of the governing board of the International Energy Agency at Ministerial level on 22 May.

Mr David Howell: The governing board of the IEA met at Ministerial level on 22 May under the chairmanship of the Fed. German Minister for Economic Affairs, Count Lambsdorff. I represented the UK.

Ministers concentrated on the medium and long-term measures needed to reduce the dependence of IEA countries on imported oil and on short-term instruments to limit the damaging economic effects of large short-term movements in the oil market. They noted a secretariat analysis of areas where energy policies could be strengthened in individual IEA countries and agreed that each Minister would give weight to this analysis in forming national energy policy. Particular emphasis was given to the role of proper energy pricing policies and the need to develop coal and nuclear power. Ministers agreed that results actually achieved by IEA countries as a group for net oil imports should substantially under-shoot the existing 1985 group objectives (26.2 mbd as oil imports including bunkers). The secretariat estimates the potential under-shoot at around 4 mbd. Efforts to reduce oil imports will be continued beyond 1985. It is expected that, as a result, the ratio between the rate of increase of energy consumption and the rate of economic growth for IEA countries as a group over the coming decade should be reduced to about 0.6 and the share of oil in total energy demand to about 40 per cent by 1990.

Ministers agreed that if at any time tight market conditions appear imminent they will meet at short notice and that IEA countries would take effective short-term action to restrain demand. In such a situation Ministers will take a decision on the use of individual oil import ceilings as a means of self-imposed restraint. I made it clear that that decision could only be taken in the light of the circumstances at the time. Ministers also agreed on a system for consultation on oil stock policies.

The political importance of energy research, development and demonstration was recognised. The meeting endorsed the report of the international energy technology group set up following the Tokyo summit and agreed to use the R, D&D strategy which has been developed by the IEA as a guide for settling national priorities.

The IEA countries reaffirmed their willingness to discuss common problems with the oil-producing countries and they accepted the need for further action by the international community to help developing countries develop their indigenous energy resources.

H.M. Government believe that effective implementation of the conclusions of the IEA meeting, particularly those relating to pricing policy, is essential to restrain growing demand for oil to a level which can be met from the supplies likely to be available. Implementation will require courageous and sometimes unpopular action from all member Governments. H.M. Government will approach the IEA conclusions in this spirit and hope that all other member Governments will do the same. [See also p. 216, this issue.]

Namibia

5 June 1980

Mr David Steel asked the Lord Privy Seal what was the Government's policy toward Resolution 301 of the United Nations Security Council as it related to existing contracts for the supply of uranium from Namibia.

Mr Luce: The UK abstained in the vote on Security Council Resolution 301. In accordance with the reply I gave to Mr Lyon on 31 March, H.M. Government do not regard that Resolution as requiring member States to interfere with existing contracts for the supply of uranium from Namibia.

AGR royalties

9 June 1980

Mr Gordon Wilson asked the Secretary of State for Energy what decisions had been reached on the payment of royalties for the advanced gas-cooled reactor technology by the electricity boards to the UKAEA.

Mr Lamont: My Department is keeping this under review as our nuclear programme develops.

Renewable energy sources

9 June 1980

Mr Frank Allaun asked the Secretary of State for Energy if he would take steps to increase the amount spent on renewable forms of energy to make it more comparable with that spent on nuclear energy.

Mr John Moore: My Department's expenditure on research and development into renewable sources of energy is being increased substantially this financial year. In 1979-80 expenditure by my Department on renewable source programmes approached £7 million. Expenditure in this financial year is expected to be about £11 million.

Plutonium nitrate transport

10 June 1980

Mr Donald Stewart asked the Secretary of State for Energy on what date it was proposed to commence carrying nuclear waste by sea through the Minches.

Mr Lamont: The Government know of no plans to carry nuclear waste by sea through the Minches. However, as part of the programme for the operation of the prototype fast reactor (PFR), the UKAEA proposes later this year to commence the movement of plutonium nitrate recovered from PFR fuel from Dounreay to Windscale by road and sea, through the Minches.

Safety documentation

16 June 1980

Mr Frank Allaun asked the Secretary of State for Energy if he would take steps, following the request of the Health and Safety Executive, to ensure that all reactor safety documents are published.

Mr Lamont: It is the policy of the Government, and all the organisations concerned, to make as much information available on nuclear safety as is reasonably possible. In particular, the appropriate safety documentation supporting the initial licensing of nuclear power stations in the UK, including the first PWR, will from now on be prepared with a view to being made available to the public.

Birthday honours

The Authority are pleased to record that Mr T.H. Davies, of the Personnel and Administration Directorate, Northern Division, Risley, was awarded the MBE in the 1980 Birthday Honours. □