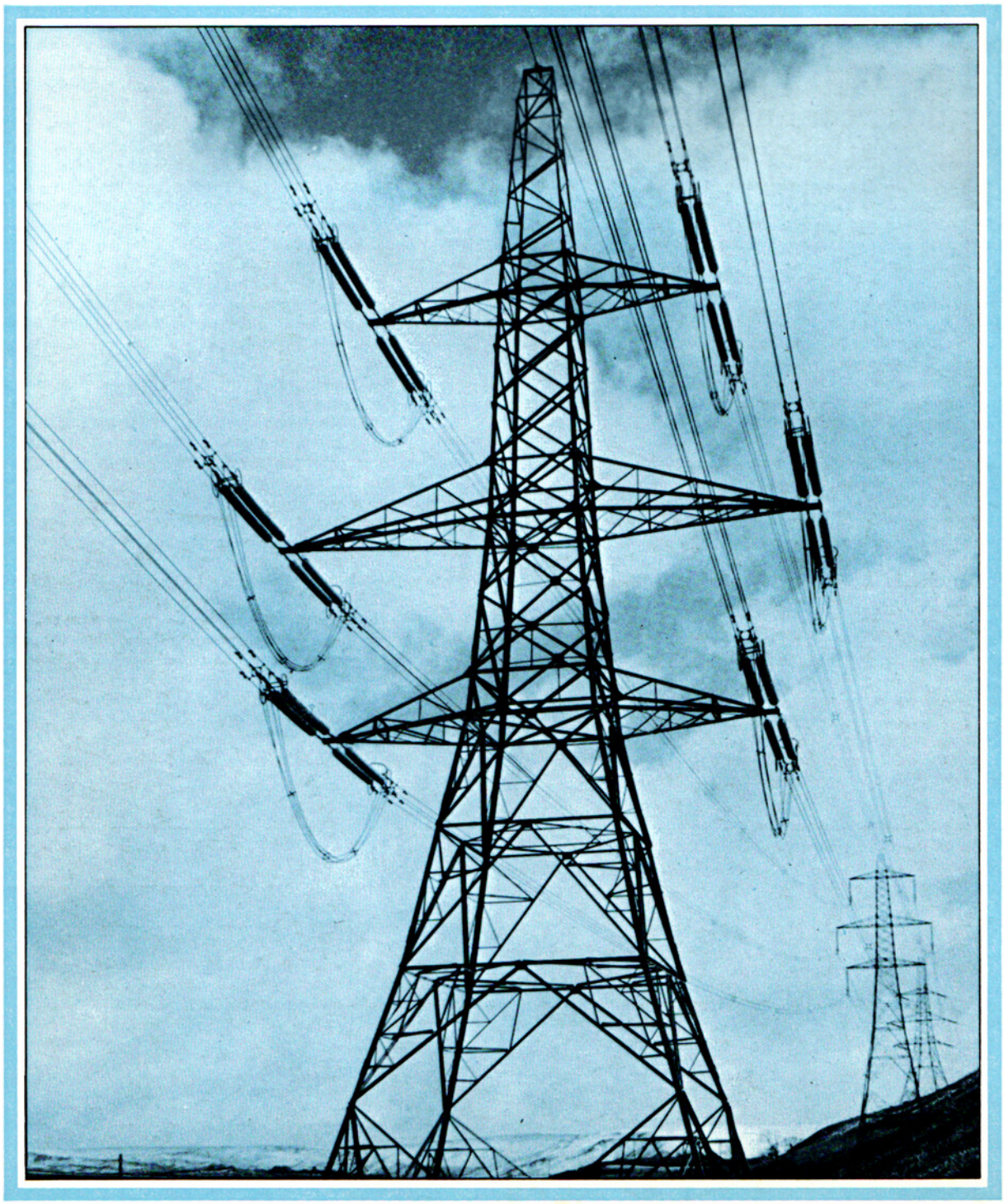
Costs of producing electricity

from nuclear, coal-fired and oil-fired power stations



Central Electricity Generating Board
July 1980

The text below is a reprint of Appendix 3 of the Annual Report for 1979-80 of the Central Electricity Generating Board (CEGB).

1 The Board publishes generation costs per kW h incurred at recently commissioned power stations so that the costs and performance of nuclear and conventional stations of roughly the same date of construction can be compared. The term "conventional power station" is used to describe coal-fired and oil-fired steam power stations. Comparative costs for 1978-79 were published in "CEGB Statistical Yearbook 1978-79", Table 11, and summarized in the 1978-79 Annual Report, Table 8.

2 The Board has now decided:
(A) to supplement the past method of calculating costs at main stations commissioned between 1965 and 1977 by giving the associated figures for interest during construction, for research, and for training;
(B) to give similar figures for the contemporary stations Hinkley Point B and the first half of Drax,
(C) to provide estimates of generating costs of stations under construction;
(D) to set out explicitly the relationship of this method of calculation to that employed in taking investment decisions on future stations. In this way the figures for stations in commission and under construction are arrived at more in line with the general principles of evaluating investment proposals.

(A) Stations commissioned between 1965 and 1977

3 Table 1 sets out for 1978-79 and 1979-80 the comparative generating costs incurred at existing stations commissioned between 1965 and 1977. It incorporates the figures previously published for 1978-79 and specifies in addition the costs for interest during construction, research and training. It is based on the assumptions set out in Paragraph 4.

4 Table 1 is based as follows:
(a) The stations under the different heads are:
Nuclear (Magnox): Dungeness A, Sizewell, Hinkley Point A, Oldbury, Trawsfynydd, Wylfa;
Coal: Tilbury B, Ferrybridge C, Aberthaw B, Fiddler's Ferry, Drakelow C, Ironbridge B, Rugeley B, Cottam, Ratcliffe, West Burton, Drax first half, Eggborough, Didcot;
Oil: Fawley, Pembroke.
(b) The actual outputs in kW h for each year were divided into the costs for that year.
(c) *"Capital charges"* are based on the sum of the annuities calculated in the original capital expenditure in each year at each station calculated at the National Loans Fund rate obtaining in that year. A life of 20 years is applied to the nuclear stations and of 25 years to conventional stations. As explained in the 1978-79 Annual Report (Paragraph 31), the calculations use annuities instead of the straight-line depreciation plus interest on the outstanding balance; the reason for preferring annuities is that they remain constant over time whereas the straight-line method of depreciation used in the accounts shows a fall in capital charges over time.
(d) *"Decommissioning costs"* are the annual sums estimated to be required to cover the ultimate decommissioning, demolition and dismantlement of stations, net of scrap value.
(e) *"Interest during construction"*: the Board does not capitalize interest during construction but for the purpose of the calculation it is assumed that it did so at the National Loans Fund rate prevailing in the year of expenditure.
(f) *"Inclusive fuel costs"* cover:
(1) for nuclear stations, the cost of the complete fuel cycle, i.e. the purchase and conversion of uranium concentrates, fabrication into fuel elements, subsequent reprocessing and ultimate disposal of residual waste. They include the cost of initial as well as replacement fuel. Although the cost of extracting plutonium from the irradiated fuel is included, no value is assigned to the plutonium in it;
(2) for conventional stations, the delivered cost of fossil fuel and the cost of fuel handling and ash disposal.
(g) *"Other costs of operation"* covers salaries and other costs of operating, repairing and maintaining the plant incurred in the year.
(h) *"Research"*: expenditure by the Board in the year has been broadly identified with the different types of station and divided by the kW h generated by each type. It does not cover past expenditure by UKAEA on generic work on reactors.
(i) *"Training"*: expenditure in the year other than on nuclear has been spread in proportion to manpower. Nuclear stations carry their share of this non-nuclear component and also the expenditure directly attributable to nuclear. The differences do not show to the second decimal point.

5 A considerable part of the above costs, especially for nuclear stations, is fixed, and so when expressed per kW h is sensitive to the station output. For comparative purposes it is possible to express output in terms of load factor, i.e. the proportion of output

Table 1: Comparative generation costs for power stations commissioned between 1965 and 1977 and load factors and availability for 1979-80

	1979-80			*1978-79*		
	Nuclear (Magnox) p/kW h	Coal-fired p/kW h	Oil-fired p/kW h	*Nuclear (Magnox) p/kW h*	*Coal-fired p/kW h*	*Oil-fired p/kW h*
(1) Capital charges and provision for decommissioning	0·34	0·09	0·14	*0·34*	*0·09*	*0·10*
(2) Interest during construction	0·06	0·02	0·02	*0·06*	*0·02*	*0·01*
(3) Inclusive fuel costs	0·60	1·29	1·61	*0·48*	*1·08*	*1·13*
(4) Other costs of operation	0·26	0·14	0·14	*0·20*	*0·12*	*0·09*
(5) Research	0·03	0·01	0·01	*0·03*	*0·01*	*0·01*
(6) Training	0·01	0·01	0·01	*0·01*	*0·01*	*0·01*
(7) **Total**	**1·30**	**1·56**	**1·93**	***1·12***	***1·33***	***1·35***
(8) 1978-79 Report basis (lines 1, 3 and 4 above)				*1·02*	*1·29*	*1·32*
	per cent	per cent	per cent			
(9) Load factor on design output	56	61	41			
(10) Load factor on declared net capability	70	64	43			
(11) Availability on declared net capability	70	69	77			

to what would have been produced if the station had operated throughout the year at full power. In the Board's normal statistics for load factor, full power is measured in terms of declared net capability (DNC) which is the highest number of kW which the plant can send out indefinitely without damage to the plant. This is frequently lower for various reasons than the design output of the station. In the case of the Magnox stations a major cause for this difference was the steps to combat steel oxidation (Annual Report 1971-72, Paragraph 52), but a variety of factors apply to all stations including conventional stations.

6 The load factor thus reflects the use of the station. Because nuclear stations have significantly lower running costs than conventional stations they are run to the limit of availability. In the early years of their life new conventional stations also normally have lower running costs than the stations already on the system, and so too run to the limit of availability, but in time they are superseded by newer plant and in the case of oil stations today may not run on continuous load even in the years immediately following commissioning.

7 Table 1 shows for 1979-80 the station load factors expressed in terms of design output as well as their present DNC. It also shows their availability, measured in terms of average capability available for generation over the year divided by DNC.

(B) Hinkley Point B and Drax (first half)

8 The stations in Table 1 are roughly contemporary. As regards Hinkley Point B, the Board's first operational AGR nuclear power station, the comparable station in timing is the first half of Drax coal-fired station. Table 2 compares the two stations in 1979-80.

9 In calculating the figures in Table 2 the same conventions have been used as set out in Paragraph 4 except that the life of Hinkley Point B has been taken as 25 years and of Drax as 30 years. These are the lives which will be used under current cost accounting when adopted for 1980-81. Similar book lives will then be used for the stations in Table 1 in the accounts but for comparison between years it is proposed to retain the lives of 20 and 25 years for them in the Statistical Yearbook.

10 In comparing the figures in Tables 1 and 2 it is necessary to bear in mind that the capital charges and interest during construction for Hinkley Point B and Drax first half reflect the inflation that has taken place between the time of building the Magnox and contemporary fossil-fuelled stations and the time at which Hinkley Point B and Drax first half were built. It is for this reason that the Board sets out comparisons between stations constructed over broadly the same years.

Table 2: Comparative generation costs in 1979-80 for Hinkley Point B and Drax first half

	Hinkley Point B p/kW h	Drax first half p/kW h
Capital charges and provision for decommissioning	0·37	0·12
Interest during construction	0·18	0·04
Inclusive fuel costs	0·55	1·25
Other costs of operation	0·16	0·09
Research	0·07	0·01
Training	0·02	0·01
Total	**1·35**	**1·52**
	per cent	per cent
Load factor on design output	43	73
Load factor on declared net capability	55	73
Availability on declared net capability	55	74

(C) Stations under construction

11 For stations still under construction it is necessary to combine historic expenditures with forecast costs and performance, and to relate the amalgam to the average forecast output. Table 3 does this process of averaging on the assumptions set out in Paragraph 12. Dinorwic pumped storage power station and the main gas-turbine power stations are excluded from Table 3 as special cases.

12 The following assumptions have been made in compiling Table 3:

(a) For capital charges, the capital expenditure incurred in each year has been converted into a lifetime annuity and summed. For expenditure before 1980 the annuities have been calculated at the National Loans Fund rate obtaining in the year. Since future expenditures are calculated at constant (March 1980) price levels they have been converted to lifetime annuities at the real rate of return of 5 per cent. A 25-year life is assumed for AGR stations and a 30-year life for conventional stations.

(b) Interest during construction has been calculated by compounding/discounting the expenditures in each year in

Table 3: Comparative generation costs of nuclear and conventional power stations under construction

	Nuclear			Coal-fired	Oil-fired	
	Dungeness B	Hartlepool	Heysham I	Drax second half	Littlebrook D	Ince B
	p/kW h	p/kW h	p/kW h	p/kW h	p/kW h	p/kW h
Capital charges and provision for decommissioning	0·97	0·85	0·87	0·68	1·92	2·16
Interest during construction	0·79	0·57	0·58	0·45	1·15	1·42
Inclusive fuel costs	0·61	0·61	0·61	2·30	3·40	3·40
Other costs of operation	0·16	0·16	0·16	0·14	0·14	0·14
Research	0·08	0·08	0·08	0·01	0·01	0·01
Training	0·01	0·01	0·01	0·01	0·01	0·01
Total	**2·62**	**2·28**	**2·31**	**3·59**	**6·63**	**7·14**

(a) to the date of commissioning at the rate of interest used in (a) and then converting the interest component into lifetime annuities.

(c) The components of the inclusive fuel costs are as given in Paragraph 4 above. For nuclear it has been assumed that fuel cycle costs increase by nearly 2 per cent a year in real terms. For fossil fuel prices it is assumed that the real cost of coal rises at an average rate of 3 per cent a year from now to the end of the century and that of oil by $3\frac{1}{2}$ per cent a year.

(d) The remaining components are calculated as in Paragraph 4.

(e) It is assumed that the average lifetime output per design kW will be, in kW h per annum: AGR, 4300; coal, 4900; and oil, 1500.

13 The figures in Table 3 are substantially higher than for the corresponding stations in Tables 1 and 2. This is partly because of the later commissioning dates, so that the capital charges reflect higher inflation and higher interest rates. Drax second half is significantly later in start on site than any of the other stations in these tables. However, there is a further point: Table 3 incorporates into the fuel cost at Drax the present value of future real increases in the price of fuel. At the actual fuel price of 1979-80 the fuel cost would have been 1·25 p/kW h and the total 2·54 p/kW h. For Littlebrook D the figures are 1·61 p/kW h and 4·84 p/kW h respectively, and for Ince B 1·61 p/kW h and 5·35 p/kW h.

(D) Investment decisions

14 For the future the Board can choose between stations with relatively high capital but low running costs and those with low capital cost but high running costs. Once a station is built it will be used only by reference to its running costs: the station with the lower running costs will be used more than the station with higher running costs even if both have the same availability. In order to compare the costs of stations operating under such different regimes (and possibly over different effective lives) the Board calculates for each type of station its 'net effective cost' (NEC) per kW per annum. This is calculated by:

(a) setting out for each year the effect that one kW of a new station has on the cash flow of the Board from the start of construction to its final decommissioning. In the period of construction the cash flows are adverse but thereafter the station produces what are called 'net system fuel savings', and these normally exceed the day-to-day cost of manning and maintaining the station. Net system fuel savings arise because the new plant will normally have lower fuel costs than some existing plant on the system. Hence, except when all plant is required to meet the load, the new plant displaces the older plant and gives savings equal to the difference between its own fuel costs and the costs at the capacity displaced;

(b) discounting these cash flows to the date of commissioning at 5 per cent (the required rate of return laid down by the Government). This gives a present value at date of commissioning for each type of station. It may be positive or negative depending on the magnitude of the net system fuel savings. A negative NEC implies that it is economic to install the plant for energy cost savings alone;

(c) converting this present value into an annuity over the operating life of the station (25 years for nuclear and 30 years for conventional), calculated at the required rate of return of 5 per cent.

The NEC are normally expressed in terms of £/kW per annum, but Table 4 gives the figures at March 1980 price levels for a new nuclear and a new coal-fired station (oil is no longer an option) both on a £/kW per annum basis and in terms of p/kW h. It has to be emphasized that for investment the object is to choose the lowest cost in terms of £/kW per annum since the object is to minimize the cost to the system of providing new capacity.

15 In comparing the figures for generation costs in Table 4 with those for stations in Tables 1 and 3 it is necessary to bear in mind that:

(a) All the capital charges in Table 4 are at March 1980 price levels whereas those in Table 1 are all based on historic price levels and those in Table 3 partly so. The Board has considered converting the historic figures to current price levels by the use of price indexes but has not adopted that practice on the grounds that it distorts the record of past decisions and costs incurred.

(b) The figures assume real increases in the price of coal at an average rate of 2 per cent per annum from the date of commissioning to the end of the century.

Table 4: Net effective cost (NEC) of future stations at March 1980 price levels

	Nuclear		Coal-fired	
	£/kW p.a.	p/kW h	£/kW p.a.	p/kW h
Capital charges at station and provision for decommissioning*	77	1·39	36	0·76
Interest during construction*				
Inclusive fuel costs§	34	0·61	113	2·38
Other costs of operation	12	0·22	10	0·21
Research	..	..	..	..
Training	..	..	..	..
Generation costs	123	2·22	159	3·35
Less fuel saving from displacing less efficient plant	148	2·68	143	3·02
NEC*	−25	−0·46	+16	+0·33
Load factor, per cent		63		54

*Excluding transmission, which in each case amounts to £5/kW p.a. for capital charges and interest during construction together.

..Not significant to the decimal place given, assuming substantial programmes of similarly designed stations.

§The inclusive fuel costs for nuclear reduces by £3/kW p.a. (0·05 p/kW h) and NEC is adjusted correspondingly if refuelling on full load is adopted.

(c) The costs of building new stations have tended to increase faster than the rate of inflation.

16 The figures used for investment choice always involve a number of judgements about the relative cost and performance of the alternatives. In comparing nuclear stations with conventional stations, the most important judgements are those of the capital cost of the nuclear stations (and their relative cost compared with conventional stations) and the future increase in the real price of fossil fuel. On the capital costs, the Board has no recent experience of ordering nuclear plant and has had to rely on theoretical assessments and on interpreting the data obtained from contracts placed so far for Heysham II and, on conventional plant, for the second half of Drax. The assumption used on the price of fossil fuels is given in Paragraph 12(c) above. In view of the uncertainties, the Board tests the sensitivity of its central case for reasonable changes in the assumptions to ensure that the conclusions are robust (see CEGB Memorandum M17 to the Select Committee on Energy – Minutes of Evidence 6 February 1980, Paragraphs 15–26).

Location of power stations mentioned in this leaflet

(The CEGB has a total of 132 power stations and a further 11 under construction)

The CEGB

The Central Electricity Generating Board (CEGB) is part of the publicly owned electricity supply industry of England and Wales. The industry consists of the Electricity Council – the central co-ordinating body – the CEGB and the twelve Area Electricity Boards.

The CEGB owns and operates 132 power stations and the main transmission system, which consists of a network of overhead lines and cables together with switching and transforming stations. The CEGB supplies electricity in bulk to the Area Boards and a small number of direct consumers, and the Area Boards distribute electricity to meet the needs of 49 million people.

A small amount of electricity – less than 0.2 per cent – is generated by hydro-electric power stations, gas-turbine power stations and diesel engines. However, the bulk of electricity supplies is produced by main steam power stations which burn coal or oil or derive their heat from nuclear fuel. Coal is at present the dominant fuel and about three-quarters of the CEGB's electricity is produced by coal-fired power stations.

The CEGB's nuclear power stations first began producing electricity in 1962, and they now generate 11 per cent of electricity supplies. There are nine nuclear power stations in operation in England and Wales and a further three under construction.

Further information

The CEGB produces a wide range of booklets and leaflets on energy and related topics. Details are given in "CEGB Publications List", available without charge from the addresses below.

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