CABINET

NUCLEAR POWER PROGRAMME

MEMORANDUM BY THE MINISTER OF POWER

I seek the authority of my colleagues for a statement on the revision of the nuclear power programme. I attach (Appendix A) a draft of the statement that I would like to make in the House of Lords concurrently with a similar statement by the Paymaster-General in the House of Commons.

2. Since the publication of the White Paper of February 1955 (Cmd. 9389), it has become a matter of common knowledge that technical progress during the two years that have passed has rendered out of date the estimates which it contained and that the way is open for a considerable acceleration of the programme. An official Working Party which included representatives of the Atomic Energy Authority and the English and Scottish Electricity Authorities have now concluded their examination of the problems involved in such an acceleration. Their report is attached to this memorandum. I have discussed its contents with Lord Citrine and his colleagues on the Central Electricity Authority and with Sir Edwin Plowden, the Chairman of the Atomic Energy Authority, and secured their agreement to the policy outlined in my draft statement. I have also had discussions with the Chancellor of the Exchequer.

3. The 1955 White Paper envisaged that work might begin on the first two civil nuclear stations about mid-1957; that these stations might each have a net output capacity of between 100 and 200 MW.; and that by the end of 1965 we might hope to have some 1,500-2,000 MW. of civil nuclear capacity in operation.

4. Progress in fact has been considerably more rapid. Before Christmas the Central Electricity Authority had been able to place contracts for their first two stations (Bradwell in Essex and Berkeley in Gloucestershire) each with an output capacity of about 300 MW. or 50 per cent. greater than the maximum capacity originally estimated for the earlier stations. By the end of the present year work should have started on two further stations of similar capacity, one in the south of England and one in the south of Scotland (the provisional sites chosen for these stations are Hankley Point in Somererset and Hunterston in Ayrshire but both are still subject to planning procedure). Moreover the Atomic Energy Authority’s station at Calder Hall for the production of fissile material for military purposes has now been in operation for four months and gives us reason to hope that the first civil nuclear stations which are fundamentally similar in design will prove thoroughly efficient in operation.

5. The earlier nuclear stations are very costly to construct. Bradwell and Berkeley (if the cost of their initial fuel charges is taken into account) will cost three and a half times as much as a conventional coal-burning station of similar capacity. Technical progress is expected to bring about a rapid decrease in these capital costs. Meanwhile running costs (excluding capital charges) are under half the costs of conventional power stations.
6. I am advised by the Atomic Energy Authority that, in the light of the technical progress that has been achieved since February 1955, it would now be reasonable to plan for a nuclear capacity of 6,000 MW. instead of the 1,500-2,000 MW. mentioned in the White Paper.

7. The Electricity Authorities are planning for a total electricity output capacity of 51,000 MW. by 1970 as against the present capacity of nearly 22,000 MW. By 1970, it would be hoped that of the total capacity 12,000 MW. would be nuclear power.

8. The inclusion of the first instalment of 6,000 MW. of nuclear power by 1965 would involve the Authority in an extra cost of £770 millions in addition to £2,580 millions which would have been the cost had the whole installation to this date been conventional oil or coal-burning plant.

9. 6,000 MW. of nuclear power would involve the commissioning of nineteen nuclear stations on sixteen different sites before the end of 1965. It would save the equivalent of 18 million tons of coal in a full year's operation.

10. The main arguments in favour of such a programme are:

(i) The increasing gravity of our energy situation. Estimates agreed by my Ministry and the Treasury suggest that whatever measures we may take in the meantime, we are likely to require nearly twice as much imported oil in 1970 as we are consuming to-day. The net cost of importing energy is likely to grow from £250 millions in 1955 to £450 millions in 1970. It is imperative that we should do everything possible to slow down the rate at which this energy gap is widening, and to start to reduce it at the earliest possible moment by the use of nuclear energy.

(ii) The increased security which a nuclear programme offers to the economy when compared to dependence on the availability of growing quantities of oil or coal from abroad.

(iii) The need to maintain the impetus of our own nuclear programme if we are to take full advantage of our opportunities in the export market.

11. I am, however, impressed by the possibility of slippages in the execution of the programme and by the danger that the capital costs of the nuclear stations will not fall quite as rapidly as we may hope. Moreover, a programme of this scale will involve a heavily increased investment load in the early 1960s and will at that time pose formidable physical and financial problems. I propose therefore that we should take advantage of the fact that a final decision on the amount of nuclear capacity to be commissioned by the end of 1965 need not be taken for perhaps 18 months or two years, and announce our present decision to adopt a range of 5,000-6,000 MW. by that date as our target for planning purposes. This would mean making all our immediate plans, e.g., for the supply of uranium and other material required, for the acquisition of sites, and for the planning of the transmission network, on a scale sufficient to accommodate a 6,000 MW. programme. On the other hand, if experience showed the need for the lower programme, we should not be committed publicly and would be retaining freedom of action.

12. I also seek the agreement of my colleagues to introducing into the current Electricity Bill a number of clauses amending the existing procedure in regard to securing planning consent for electric power stations and overhead lines. The reasons for this request are set out in paras. 27-31 of the Working Party's report and a note on the proposed amendments is attached as Appendix B to this memorandum. I realise that legislation designed to eliminate some of the existing opportunities for delaying action in planning procedure will not be popular. But even with conventional generating stations the delays caused by the existing procedure are beginning to represent serious handicaps to progress and these risks will be greatly increased with a nuclear programme. I believe that some amendment to the existing law would in any case become inevitable within the next few years and that the announcement of an important nuclear programme offers us the best opportunity of securing it with the assent of public opinion.

M.

Ministry of Power, S.W.1.
22nd February, 1957.
APPENDIX A

DRAFT GOVERNMENT STATEMENT ON THE NUCLEAR POWER PROGRAMME

The Government, in conjunction with the English and Scottish Electricity Authorities and the Atomic Energy Authority, have now completed their re-examination of the programme outlined in the White Paper of February 1955, which set a target of some 1,500–2,000 MW. of nuclear capacity in operation in the country by the end of 1965. Since we already spend some £250 million net per annum on importing fuel and this burden on our balance of payments will grow inevitably during the next decade, the importance of our need to develop nuclear power as a source of energy cannot be in doubt. Our task has therefore been to consider the extent to which the 1955 programme can be accelerated in the light of technical advances within the last two years.

2. It is the considered opinion of our expert advisers that in the light of present knowledge the English and Scottish Electricity Authorities can reasonably aim at having at least 5,000 MW. of nuclear capacity in operation by the end of 1965, and that if technological development continues to be favourable and the necessary physical and financial resources can be made available, a figure of 6,000 MW. could be achieved by that date.

3. The Government have decided, with the full agreement of the Electricity Authorities and the Atomic Energy Authority, to adopt as the basis for present planning a range of 5,000–6,000 MW. of nuclear capacity in operation by the end of 1965. This means that the supply of raw materials for nuclear generation, the acquisition of sites and the planning of the transmission network will be on a scale sufficient to bring 6,000 MW. of nuclear capacity into operation by the end of 1965. The actual amount of nuclear capacity to be installed by that date will be subject to technical experience and development as planning progresses, including the trend of capital costs, and to the availability of physical and financial resources.

4. I am authorised to say that the Government of Northern Ireland are to-day announcing that the Electricity Board for Northern Ireland intend, with the approval of the Government, to bring into commission a 150 MW nuclear station in 1963 or 1964.

5. We must not assume that the nuclear programme represents an easy or painless solution to our energy problems. It holds out the brightest prospects for the future: a full year's operation of 6,000 MW. generation capacity would save some 18 million tons of coal. But its execution would mean that the annual investment programme of the Electricity Authorities would rise during the early 60's by some two-thirds above its present level. This would mean a very heavy burden on the nation's capital resources during a period when those resources are likely in any event to be seriously strained.

6. The programme will moreover involve the erection of new power stations and of overhead transmission lines in parts of the country which have not hitherto felt the impact of the nation's requirements for electricity. This is unfortunately inevitable because nuclear stations raise special siting problems. Her Majesty's Government and the Electricity Authorities are determined to carry through the programme with the least possible interference with the amenities of our country-side or with the rights of individuals. But these rights can be fully safeguarded while at the same time allowing for that acceleration of the present procedure which is essential if the programme is not to be seriously delayed. My Right Hon. Friend, the Paymaster General, will accordingly be tabling a number of minor amendments to existing legislation for inclusion in the Electricity Bill which is at present before the House of Commons.

7. I would only add that nothing said about the prospects of the nuclear power programme in any way affects the importance of the coal industry. However rapidly we develop nuclear energy, coal will remain the basis of our economy and the need to exploit to the full our national coal resources remains as urgent as ever.

22nd February, 1957.
PROPOSALS FOR AMENDING LEGISLATION

1. Procedure on Applications for Consent to Establish Generating Stations
   
   (a) Repeal of Electric Lighting Act, 1909, Section 2.
   
   (b) Amendment of Electricity (Supply) Act, 1919, Section 11, by omitting the words “other than the Central Authority or the North of Scotland Board.”

   This would have the effect of extinguishing the present statutory right of the local authority and of owners and lessees of land within 300 yards of the site of a proposed generating station to receive notice of the proposal and to state objections direct to the Minister. Instead (by virtue of the administrative arrangements agreed between the Ministry of Housing and Local Government and the Ministry of Power, and operating in cases of deemed planning procedure) the local authority and such owners and lessees would in practice be no worse off than they are in relation to any other industrial development.

   The reason for these proposals is to obviate the delays which are imposed on the programme by the present procedure. This entails inviting individual objections (for which reasonable time is in practice provided) as laid down by Section 2 of the Act of 1909 and, by agreed administrative practice, scrutiny and consent by the local planning authority. The procedure of the Town and Country Planning Acts appears to suffice for other forms of industrial development, and there is no reason to continue the procedure of the Act of 1909 which was, of course, instituted at a time when “planning Acts” were unknown.

2. Procedure for Stopping up and Diverting Highways

   Amendment to the Sixth Schedule of the Town and Country Planning Act, 1947, to reduce the period for objections from three months to thirty days.

   Present procedure for making orders (by the Minister of Transport and Civil Aviation) provides for advertisement and for display of the draft order and map over a period of three months, during which objection may be made. The procedure cannot be put into force until planning permission for the development has been given—in the case of generating stations that is not until the Minister of Power has given his consent and deemed planning permission. But entry on the land and work on the station site is by then urgent, and rights of way are now quite frequently obstructed with tacit agreement of the local authority concerned. Compliance with the law imposes at least a three months’ delay on the start of the work and if objections lead to a local enquiry the delay can be much longer. Any individual objector could bring about such a delay in starting work, and this delay could of course be prolonged if final approval was followed by a period of bad weather. It is proposed that this new procedure should be confined to electricity development.

3. Rights of Entry on Land to Assess its Potentialities or the Nature and Cost of Works

   Provision is needed to give Electricity Boards a right of entry on land for the purposes of survey and making trial bores. At present there is no right of entry, except by consent, in relation to proposed electricity works in England and Wales so that an Electricity Board may not be able to satisfy themselves completely that a site which appears suitable from maps is in fact suitable and economic for a generating station. In the case of routes for overhead lines for the same reasons it may well be impossible for a Board, in advance of the Minister’s consent to the route, to make any survey of the tree felling which might be necessary or to choose
the best footing for poles or pylons: as a result a hearing or enquiry into an application for a compulsory wayleave often cannot be combined with a hearing into the question of tree cutting and compensation therefor. This prolongs the whole procedure by many weeks and is often inconvenient to owners.

The principle of rights of entry for survey purposes has already been conceded in Section 3 of the Hydro-Electric Development (Scotland) Act, 1943, which gives power to the North of Scotland Board to enter on land to—

"make such surveys and collect such information as they may consider necessary to ascertain the water power resources in the North of Scotland District or in any part thereof . . ."

subject to giving not less than seven days' notice and subject to payment of reasonable compensation for any damage caused.
REVISION OF THE
NUCLEAR POWER
PROGRAMME

Report by the
Nuclear Power Working Party

FEBRUARY 1957
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REVISION OF THE NUCLEAR POWER PROGRAMME

I.—INTRODUCTION

1. The task of the Working Party has been to examine the implications for the electricity supply industry of an acceleration of the Programme of Nuclear Power set out in the White Paper of February 1955 (Cmd. 9389).

2. The Working Party consisted of representatives of the Central Electricity Authority (C.E.A.), the South of Scotland Electricity Board (S.S.E.B.), the Atomic Energy Authority (A.E.A.), and of the following Government Departments: Treasury, Atomic Energy Office, Scottish Home Department and the Ministry of Power. The Board of Trade, the Ministry of Housing and Local Government, the Ministry of Labour and National Service and the North of Scotland Hydro-Electric Board have been consulted on various points.

3. This Report deals throughout with the electricity requirements of England and Wales and of the area covered by the South of Scotland Electricity Board. While the North of Scotland Hydro-Electric Board and the Electricity Board for Northern Ireland will probably wish to install nuclear generating capacity during the period under review, their requirements are unlikely to be large enough to affect significantly the general conclusions.

II.—HISTORICAL SUMMARY

4. The White Paper of February 1955 gave a provisional nuclear programme covering the period 1955–65. This envisaged twelve nuclear power stations in commission by the end of 1965 with a total capacity of 1,500–2,000 MW and hazarded a guess that at the end of the period nuclear generating capacity might be coming into commission at the rate of some 500 MW per annum. It added that “if all went well” it might be practicable by the early 1970’s to expand the rate of construction of nuclear power stations to match total requirements of new generating capacity which by this time might amount to about 3,000 MW a year.

5. In the two years since the White Paper was issued, technical progress in the field of nuclear power has been sufficiently rapid to justify the C.E.A. in placing contracts for stations with an output capacity of 300 MW at Bradwell and 275 MW at Berkeley compared with the maximum of 200 MW per station assumed in the 1955 White Paper. An order for a 300 MW station has also been placed provisionally by the South of Scotland Electricity Board.

6. The public has been kept aware of the rapid advances in nuclear technology and pressure has been mounting both inside and outside Parliament for a substantial upwards revision of the 1955 White Paper. The Minister of Fuel and Power (Mr. Aubrey Jones) refused to commit the Government until the Bradwell and Berkeley tenders had been thoroughly examined by the C.E.A. and this process could not be completed until December. The award of the contracts for the two stations was announced by the C.E.A. on 13th December, 1956, and on 17th December, Mr. Aubrey Jones stated in the House of Commons that he hoped the Government would be in a position to make an announcement on the revision of the Nuclear Programme after Parliament reassembled.

III.—BACKGROUND

7. There are a number of general considerations that Ministers will wish to bear in mind in considering the amount of effort that the nation should devote to the nuclear programme during the next decade. Any attempt to estimate the situation 10 or 15 years hence is bound to involve a considerable measure of judgment and a decision on a programme covering this length of time cannot be entirely dependent upon a detailed examination of figures. Some of the general considerations can be summarised very briefly as follows:

(a) There has been a continuing shortage of primary fuels since the middle of the last war and imports of oil and coal have had to be increased until they now meet a quarter of the United Kingdom’s total energy demand. To satisfy the requirements of the national economy, supplies will, on a
conservative assumption, have to be increased each year by about 5 million tons of coal equivalent. Supplies of indigenous fuels cannot be increased sufficiently to meet these growing requirements which will therefore involve rapidly increasing dependence on imports. This dependence would be accentuated if supplies were limited to the conventional fuels.

(b) Nuclear power can eventually make a very appreciable contribution towards improving the balance of payments. It is true that so long as we have to import nuclear fuel there will always be some element of foreign exchange expenditure in nuclear power, but the total costs of nuclear fuel represent a very much lower expenditure of foreign exchange than the cost of an equivalent amount of energy in the form of imported oil or coal.

(c) In the shorter term, however, a substantial nuclear power programme would impose burdens on the balance of payments: directly because each nuclear station requires an initial fuel charge which involves a substantial tonnage of uranium when it is commissioned; and indirectly through the effects on our imports and exports of the increased investment load arising from the fact that nuclear stations, especially the earlier types, will require much more capital resources than stations of the conventional type. The question that now faces the country is the extent to which such additional investment should be undertaken in the initial period of the programme (a period whose length will be determined largely by the speed with which the capital cost of a nuclear station can be reduced) in order to secure the benefits of nuclear generation in later years.

(d) The main producers of uranium are such countries as South Africa, Canada and the United States, which can be expected to remain friendly to the United Kingdom and to enjoy settled Governments (the great bulk of United Kingdom supplies are expected to come from Canada and South Africa). The tonnage that is needed of these raw materials is insignificant in volume and the generation of nuclear electricity could proceed without fear of such interference with shipping routes and pipelines as has caused the present oil shortage. The impact of United Kingdom uranium requirements on the shipping position generally would be insignificant compared with the import of an equivalent amount of energy in the form of fossil fuels.

(e) In any examination of the domestic nuclear programme, account must be taken of the political and material advantages that should accrue to the United Kingdom so long as it retains its lead in nuclear developments.

IV.—THREE POSSIBLE PROGRAMMES

8. It would be unrealistic to consider a programme of nuclear development over any finite period without reference to the requirements (both financial and physical) for subsequent years. The curve of demand for electricity is likely to continue to rise for many years to come and the task of meeting it is a continuous process, involving planning for a period of five (or more) years ahead. Thus, at any given point in time, the electricity authorities have in hand work on stations to be completed in the current year and work relating to stations in the various intermediate stages of construction and due for completion over the next five years or so. Moreover, as is pointed out in paragraph 18 below, the healthy development of the new nuclear power industry requires that so far as possible the manufacturers who are going to have to switch their capacity to the production of nuclear plant should be given a reasonable prospect of continuity of demand for nuclear equipment—a condition that requires a review of the programme up to 1965 to take some account of the rate of nuclear commissioning after 1965. On the other hand it would be difficult at this point of time to make any very useful estimates about the place of nuclear power in the electricity industry after about 1970. With these considerations in mind forecasts have been taken up to the year 1970 but not beyond.

9. As a basis for the Working Party discussions, the C.E.A. in consultation with the S.S.E.B. have prepared three illustrative plans for generating plant which
provide for a total nuclear output capacity of 12,000 MW by 1970* (out of a
total estimated output capacity including nuclear and conventional plant of
51,000 MW) representing the maximum nuclear capacity which the C.E.A.
consider to be prudent as a basis for planning in the light of the present knowledge
of costs and technical considerations. The plans have been prepared to provide
for three different levels of commissioning of nuclear plant by 1965 within the
assumed overall nuclear output capacity of 12,000 MW by 1970, and have been
worked out in as much detail as regards siting of new stations, construction of
transmission systems, and availability of conventional fuel, as has been possible in
the very limited time available.

10. The plans assume an annual overall plant commissioning level of
2,250 MW output in 1961, 2,500 MW from 1962 to 1965, and 2,600 MW from
1966 to 1970, and the nuclear programmes contained therein may be summarised
as follows: —

Programme A provides for commissioning up to 3,425 MW output of
nuclear plant by 1965, and this would be installed in 11 stations on 10 sites.
The rate of commissioning would reach 800 MW by 1965, but thereafter
would be stepped up to 1,600 MW for each of the next five years to reach
the overall figure of 12,000 MW by 1970. This programme differs from the
original White Paper proposals of 1955 in that it takes advantage of the
technical progress which has enabled the output capacity of reactors to be
almost doubled. A further difference is that eleven stations are now envisaged
in place of the original twelve.

Programme B provides for commissioning up to 4,575 MW output of
nuclear plant by 1965, which would be installed in 15 stations on 13 sites.
The rate of commissioning would reach 1,350 MW by 1965, and thereafter
would be at the annual rate of 1,400 MW again to build up to a total of
12,000 MW by 1970.

Programme C provides for commissioning up to 5,975 MW output of
nuclear plant by 1965, which would be installed in 19 stations on 16 sites.
This is the maximum level of nuclear plant regarded by any member of the
Working Party as a prudent target for 1965, and would involve a
commissioning rate of 1,850 MW in that year. If the capacity of nuclear
plant in operation in 1970 were to be limited to 12,000 MW, this would require
the annual rate of commissioning to be cut back to 1,200 MW after 1965.

V.—CONSIDERATIONS RELEVANT TO THE CHOICE OF PROGRAMME

6) The Load Factor

11. Nuclear plant involves heavy capital cost—mainly for engineering reasons
but partly also because the initial fuel charge is included in the first cost of the
station—but the running costs (including fuel replacement) during the life of the
reactor should be low. The capital cost per kilowatt of capacity of the earlier
nuclear stations will be very much higher than that of conventional stations. The
first batch of stations are some three times more expensive than contemporary
conventional stations and 3½ times when the initial fuel charge is taken into
account. The figure (including initial fuel charge) for the advanced types of nuclear
stations which should be coming into commission around 1965 will probably be
at least two and a half times as much as that for contemporary conventional
stations. On the other hand, once a nuclear station has been built, its running
costs (excluding capital charges) should be less than half the running costs of a
conventional station of the same capacity. The development of nuclear technique
is expected to result in a progressive reduction in capital cost of plant and buildings
per unit produced and in progressive increases in the efficiency in the use of fuel.
If more expensive enriched fuels are used, the increased cost per ton of such fuels
should be more than offset by their greater efficiency. It can, therefore, be expected
that the unit costs of electricity from nuclear stations will decrease progressively.

12. The earliest types of nuclear plant will, because of their heavy annual
capital charges, be economic only when they are used on base load, that is with

* Alternatives have also been prepared for each plan which would restrict the nuclear output
capacity to 8,000 MW by 1970 on the assumption that all available coal supplies would be utilised
in conventional plant together with the minimum consumption of oil. These are not considered
further in the present document.
a plant load factor of not less than 75 per cent. The estimated base load available for nuclear generation in 1970 will be about 8,500 MW* and the extent to which nuclear capacity in that year can be economically justified in excess of the base load will depend on the success of the efforts to render nuclear plant capable of showing an economic return at lower load factors.

13. The bearing of this consideration on the nuclear programme in the years preceding 1970 is obvious. It raises, however, a particularly difficult problem because there is so little concrete experience upon which to base a judgment. There are two main factors involved:

(i) whether nuclear stations will be sufficiently flexible in operation to meet effectively as part of a public supply system the varying levels of demand upon their capacity;

(ii) whether the reduction in total capital costs and the resulting decrease in annual capital charges will be sufficient to enable the stations to be competitive at a low load factor.

It is believed that both these problems will be solved. Indeed, A.E.A. for their part believe that (i) raises no serious difficulty, and that, so far as (ii) is concerned, nuclear stations having the necessary low capital costs can be evolved within the period under review. The real question is one of timing as regards (ii).

14. The answer to this question must depend on an estimate of the rate of technical progress over the next few years. Including initial fuel charges, the capital cost of the two first stations at Bradwell and Berkeley will be about £174 per kilowatt of output capacity. It is on this basis that it is estimated that a nuclear station must work at about 75 per cent. load factor to pay its way. The C.E.A. in drawing up their illustrative plans have assumed that by 1970 progress will have been sufficient to enable one-third of the nuclear capacity in commission to operate economically at less than base load so that, allowing for 8,500 MW of nuclear plant working at base load, 12,000 MW would be about the maximum economic nuclear output capacity to commission by 1970. C.E.A. believe that it would be imprudent in the present state of knowledge to base planning on the assumption that this figure could be exceeded and have related each of their three illustrative nuclear programmes to this "economic ceiling."

15. The A.E.A. representatives on the Working Party have expressed the view that this figure of 12,000 MW in 1970 should not be regarded as a firm figure for planning purposes. They believe that:

(a) The early nuclear stations are likely to be very flexible technically.

(b) It is to be expected that with a new industry on which a great deal of development effort is being expended, the rate of advance will be rapid and the costs of generating nuclear power will fall rapidly during the period under review. In particular, it can be expected that the capital cost per kilowatt will come down. It would not be unreasonable to expect that the capital cost per kilowatt of nuclear stations coming into commission in the late sixties might have been reduced to, say, 60 per cent. of the cost per kilowatt of the first C.E.A. nuclear stations.

On such grounds A.E.A. believe that the "economic ceiling" in 1970 might be 3,000-4,000 MW higher than the figure used in the C.E.A.'s calculations (i.e., 15,000-16,000 MW instead of 12,000 MW).

16. The Working Party as a whole is not qualified to express an opinion on this essentially technical question. The economics of electricity generation in the later sixties will moreover depend as at present on a large number of other factors such as the movement of interest rates, of coal and oil prices, the level of construction costs and the load factor itself. It would be highly dangerous to attempt now to make any precise assumptions on these matters.

17. We have set out in paragraphs 8-16 above some of the major considerations which must influence the Government's decisions on the size of the
new ten-year programme. We have not regarded it as our duty to assess these considerations in the form of a recommendation in favour of any particular programme, and in subsequent paragraphs of this Report we refer to several other considerations which also have a bearing on the decision to be taken. At this stage, therefore, we comment only that a ten-year programme consistent with a nuclear capacity of 12,000 MW in 1970 reduces some of the risks we have mentioned. Such a programme still represents a considerable acceleration of the present programme, and leaves room for the Government to indicate their willingness to increase it still further if and when it seems expedient to do so. Such an approach would, of course, require that the production and planning of critical supplies, such as uranium and steel plate, should proceed on a higher level.

(ii) The Effect on the Electricity Supply and Manufacturing Industries

18. Experience with the plant programmes since the war points to the desirability of giving manufacturing industry a programme which is free from any violent fluctuations. This experience is particularly relevant to a nuclear plant programme which involves a major transfer of industrial capacity and effort from conventional to nuclear plant and some consideration should be given to avoiding a position in which there might arise a need to switch a substantial part of capacity back from nuclear to conventional plant. If the C.E.A. are right in thinking that the maximum nuclear output capacity that would be economic in 1970 is 12,000 MW, then a programme to achieve 6,000 MW output by 1965 would imply some reduction in the rate of nuclear commissioning after 1965 and a temporary reversal of the downward trend in the annual rate of commissioning of conventional plant. This might cause some unbalance in the general programme of construction and plant erection, with some effect on manufacturers’ programmes, although the potential embarrassment to the manufacturers would be mitigated to the extent to which advance warning could be given to them about changes in the rate of commissioning. There is also the possibility of developing the export of nuclear equipment.

19. It is hoped that the United Kingdom will be able to develop a considerable export trade in nuclear reactors. Initially these will consist of reactors similar to those being built for the C.E.A., i.e., large stations of the Calder Hall type. They will be required chiefly in industrial countries and it is, therefore, to be expected that some of the equipment will be provided by the countries themselves. Exports are likely to be limited to the reactor itself and specialised equipment associated therewith; the turbo alternators and conventional electrical plant might well not be exported. There is, however, also the possibility of scaling down the size of the Calder Hall type of reactor to provide an output of 30 to 50 MW. In this case complete power stations might be exported to less industrialised countries. In either case the power stations exported are not likely to be commissioned before about 1963 but there might be a sharp rise in the exports from 1965. Although we cannot pretend to quantify the effect, the manufacturing load caused by these exports may well offset to some extent any slackening in the rate of installation in the home nuclear power programme; and there are, of course, obvious advantages in manufacturers establishing themselves in the export markets as quickly as possible.

20. In the review of the factors to be taken into account two important matters have been considered but remain as unknown “risks” in any programme. The first is the “life” assumed for the reactor in all the calculations. This is assessed at 20 years, on the expert advice of the A.E.A. A change in this figure would, of course, affect the economics of the nuclear power stations favourably or otherwise. The second is the reliability of the plants. On scientific grounds there is every reason to believe them reliable, but there is as yet no experience of running a nuclear station for a long period under the conditions necessary in a public electricity supply system. No special margin has been included in any of the illustrative programmes to cover these problematical risks. The electricity authorities’ plans for total plant commissioning up to 1965 are estimated to be sufficient to meet new demands, and to overtake the present deficit of plant in an average spell of cold weather, but the C.E.A. consider that the larger the nuclear programme the stronger the case for allowing some margin of capacity to cover these unknowns.
21. The demands of the nuclear programme upon capital resources are quantified in the following table, which shows the estimated capital cost of the stations which will need to come into commission during the years 1961-65. The figures include (besides the capital cost of the power stations) the cost of the transmission network and working capital relating to nuclear fuel, but exclude other working capital and expenditure on distribution since these last two items are broadly common to conventional and nuclear programmes. Current price levels have been used throughout, and the expected reduction in later years in the capital cost of nuclear and conventional plant has been taken into account. For the sake of comparison, a hypothetical programme X based on all-conventional plant has been added: this is hypothetical because it ignores the nuclear stations on which work has already started; it assumes that fossil fuels would be made available, but takes no account of the capital cost involved in producing and transporting them.

<table>
<thead>
<tr>
<th>Programme</th>
<th>£ million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programme X (hypothetical: all conventional)</td>
<td>810</td>
</tr>
<tr>
<td>Programme A</td>
<td>1,190</td>
</tr>
<tr>
<td>Programme B</td>
<td>1,310</td>
</tr>
<tr>
<td>Programme C</td>
<td>1,460</td>
</tr>
</tbody>
</table>

22. In order to show the full effect of the burden on capital investment resources, it is also necessary to show broadly how the capital expenditure will be phased year by year. For this purpose (again taking the same assumptions about price levels) an attempt has been made to estimate the phasing of expenditure in each financial year. The figures are based on the C.E.A.'s assumption that, by the end of 1970, 12,000 MW of nuclear plant will be in commission. Expenditure on plants due to come into commission before 1961 and after 1965 has been added and so have the items (distribution and other working capital) which are excluded from the table in paragraph 21. The resultant figures are thus broadly comparable with the electricity industry's current total capital investment programme.

<table>
<thead>
<tr>
<th>Programme</th>
<th>£ million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programme</td>
<td>X</td>
</tr>
<tr>
<td>Financial years</td>
<td>£ million</td>
</tr>
<tr>
<td>programme</td>
<td></td>
</tr>
<tr>
<td>Year 1956-57</td>
<td>230</td>
</tr>
<tr>
<td>Average of 4 years (1957-58 to 1960-61)</td>
<td>250</td>
</tr>
<tr>
<td>Average of 3 years (1961-62 to 1962-63)</td>
<td>270</td>
</tr>
<tr>
<td>Total over 10 years (1956-57 to 1965-66)</td>
<td>2,560</td>
</tr>
</tbody>
</table>

23. Although under hypothetical programme X capital expenditure shows a small but steady rise from year to year, it will be seen that the increase under the three nuclear programmes is greater. Of the capital expenditure required under these programmes over the next ten years, nearly two-thirds falls into the five-year period 1961-62 to 1965-66, and it is only in this period that costs begin to differ noticeably as between the three. Indeed, if it is assumed that the total nuclear capacity in 1970 is 12,000 MW, the difference between the illustrative programmes from the investment point of view is mainly one of timing; programme C, for example, means more stations of the early and, therefore, expensive type in the early sixties.

24. None of the three programmes considered by itself (we are not concerned with the military programme) presents an insuperable problem in respect of the supply of nuclear materials. In broad terms the amount of steel required for Programme B is about the same as the requirement in 1956. Programme A would need slightly less and Programme C slightly more. From now until 1963, however, there will be very severe competition for tubing and more particularly for the thick steel plate which the Nuclear Programme will need in comparatively large
quantities. Special steps may be needed to ensure adequate supplies of these products. Certain special engineering and instrumentation requirements will also need particular attention, as will the supply of certain special materials such as beryllium, zirconium and new steel alloys.

(v) Supply of Labour

25. The Ministry of Labour and National Service have advised that there is already difficulty in meeting the demand for skilled manpower in the turbo-generator industry—a difficulty which would be increased by any of the three programmes. There will also be a serious shortage of skilled welders for fabrication on the site, as the programmes would be in competition with the shipbuilding industry. Special steps may therefore be needed in the case of these groups.

26. A considerable increase will be needed in the labour force on sites:

<table>
<thead>
<tr>
<th>Programme</th>
<th>Labour Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>22,000</td>
</tr>
<tr>
<td>Programme A</td>
<td>33,000</td>
</tr>
<tr>
<td>Programme B</td>
<td>44,000 Maximum up to 1965</td>
</tr>
<tr>
<td>Programme C</td>
<td>55,000</td>
</tr>
</tbody>
</table>

but the Ministry of Labour do not in general expect any serious difficulties to arise provided that Irish labour is acceptable. Carpenters and steel erectors will, as now, be difficult.

(vi) Procedure Relating to Power Station Siting and Overhead Lines

27. The siting and building of generating stations and the routing of electricity lines are matters which may concern several Government departments and must concern the local planning authority and statutory bodies such as River Boards. The time spent in consultations and on public enquiries has been growing of late years as the procedures have become more complex and the number of relatively unobjectionable sites and routes diminishes; these difficulties will be accentuated by the introduction of nuclear power stations. Certain administrative action can be taken to minimise delays at some points but there is no doubt that a major programme of the sort envisaged could still, because of its novelty and special technical needs, and the greater number of sites involved, be seriously delayed if present procedures have to be continued without amendment. It must be emphasised that the time that has to be spent on these matters is the time of senior and specialist officers whose whole energies are required for the tasks of technical planning and construction.

28. Any programme of nuclear power will involve an increased interference with public amenities and private interests. Indeed, the only means of making absolutely certain that procedural matters will not prevent any of the three illustrative programmes being completed on time would be to free the electricity authorities from statutory planning procedures to an extent that could not be contemplated in peacetime. There is, therefore, no guarantee that there will not be major delays in completing the programmes and the larger the programme the greater will be the danger.

29. This danger will be very serious indeed unless the electricity authorities are relieved from certain of their existing obligations. The amendments to legislation which this would involve would be comparatively few in number, although they might well prove controversial. For instance, generating station projects are subject to more exacting control than any other industrial development. Not only do the requirements of the Town and Country Planning Acts apply but also, under the Electric Lighting Act, 1909, prior notice, by advertisement or otherwise, must be given to owners and lessees of land within 300 yards of the site, who must be given time and opportunity to state objections. The result has been that consents for conventional power stations have been increasingly delayed during the past ten years by the need to deal with such objectors, who would have no such special locus if it were a case of any other industrial development, even if there were an enquiry under the Town and Country Planning Acts. If the requirements of the 1909 Act were abolished, generating station projects would be on an equality with other industrial development and might be subject to less delay than at present. This change would, however, have to be accompanied by a rather stiffer attitude toward local planning authorities.
30. More adequate powers of survey are also needed by the C.E.A. and some minor amendments of existing statutes would be needed to enable certain action to be taken concurrently which must now be taken in sequence.

31. The Electricity Bill now before Parliament provides an opportunity for any amending legislation Ministers may decide to introduce.

(vii) Coal Savings

32. From the early sixties onwards, as the new stations come into commission, the benefits from them will accrue in the form of rapidly increasing coal savings. The capacity installed at the end of 1965 would be sufficient in a full year's operation to save 11, 14 or 18 million tons according to whether the A, B or C programme was adopted. It is estimated that these savings will be equivalent to 3·3, 4·2 and 5·4 per cent. respectively of the total energy demand in the middle sixties. If, for the sake of illustration, 12,000 MW were installed at the end of 1970, a full year's operation of this capacity would save 32 million tons—which represents about 9 per cent. of the expected total energy demand at that time.

33. The following table shows the impact of the assumptions made in the preceding paragraph on the power station demand for coal:

<table>
<thead>
<tr>
<th>FUEL REQUIREMENTS FOR PUBLIC ELECTRICITY SUPPLY IN GREAT BRITAIN, EXCLUDING NORTH OF SCOTLAND AND A.E.A.</th>
<th>Million tons of coal equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fuel required</td>
<td>28</td>
</tr>
<tr>
<td>Oil, assuming present contracts</td>
<td></td>
</tr>
<tr>
<td>continued</td>
<td></td>
</tr>
<tr>
<td>Nuclear A†</td>
<td></td>
</tr>
<tr>
<td>Nuclear B†</td>
<td></td>
</tr>
<tr>
<td>Nuclear C†</td>
<td></td>
</tr>
<tr>
<td>Solid fuel</td>
<td>28</td>
</tr>
</tbody>
</table>

* The decline between 1965 and 1970 reflects a reduction in load factor of the oil-burning stations.
† These figures refer to savings in the years 1965 and 1970 and not to the savings given in paragraph 32 which relate to a full year's operation of the capacity installed at the end of those years.

34. The C.E.A. are committed by contracts with the oil companies to increase their total use of oil to about 8 million tons a year of coal equivalent, and because of the expected continuing shortage of coal in the years immediately ahead they have no alternative but to complete the programme for oil-fired stations on which they are already engaged. This should be done by the early sixties. Thereafter, while it would be possible for the oil contracts to be terminated and oil consumption reduced to a very low level, it is likely to be economically attractive to the C.E.A. to continue using the stations for oil burning instead of converting them back to coal at considerable capital cost. In that case, the power station demand for solid fuel, which is expected to be about 47 million tons in 1957, would be only 46 to 51 million tons in 1965 and only 49 million tons in 1970.

35. The savings that will be secured by the nuclear power programme will, however, consist of the smaller sizes and inferior qualities of coal normally used in power stations. As the supply of these types of coal is already comparatively easy and is likely to become progressively easier during the next few years, special measures will be needed if the United Kingdom energy situation is going to benefit to the full extent rendered possible by the nuclear programme. We cannot assume that by the middle sixties export markets will be able to absorb the whole of this coal, while British consumers, if left to themselves, would neither wish to consume more of it nor be equipped to do so. To avert the danger of growing surpluses of unsaleable coal it will be necessary to modify the screening and washing facilities at the collieries, to alter consumers' appliances and to bring pressure to bear upon them to use the smaller sized coal instead of oil or large coal that has to be imported. It will also be necessary to press on with research and development directed to the conversion of small coal into oil. In view of the growing gap, between our indigenous resources of fuel and the requirements of the economy, it is believed that Ministers will want to put these measures in hand and that the potential surplus of small coal should not, therefore, deter the Government from undertaking an ambitious nuclear programme.
VI.—CONCLUSIONS

1. There are economic, strategic, and political advantages to be derived from a substantial nuclear programme; and, as far as the balance of payments is concerned, the burden imposed by such a programme would be outweighed by the eventual benefits. (para. 7)

2. The three illustrative programmes examined in this Report provide for the following nuclear stations coming into commission by the end of 1965:

<table>
<thead>
<tr>
<th>Programme</th>
<th>No. of stations</th>
<th>Number of sites</th>
<th>Capacity (MW)</th>
<th>From full load (In 1965)</th>
<th>In 1965</th>
<th>From full year's operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11</td>
<td>10</td>
<td>3,425</td>
<td></td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>B</td>
<td>15</td>
<td>13</td>
<td>4,575</td>
<td></td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>C</td>
<td>19</td>
<td>16</td>
<td>5,975</td>
<td></td>
<td>14</td>
<td>18</td>
</tr>
</tbody>
</table>

1955 White Paper (Cmd. 9389) (for comparison) 12 — 1,500— 2,000 — — 5–6

(paras. 4, 9, 10, 32 and 33)

3. The implications of these programmes cannot be properly assessed without looking forward another five years beyond 1965, because planning and construction work must be continuous. The target for 1965 is therefore dependent to some extent on the probable position in 1970. (para. 8)

4. Present day nuclear plant involves heavier capital costs and lower running costs than conventional plant of the same capacity. Thus, early types of nuclear plant can only be economic when operated on base load (i.e., at a load factor of not less than 75 per cent.). The estimated base load available for nuclear plant in 1970 will be about 8,500 MW output capacity, and how far nuclear plant can be economically justified in excess of that capacity by that year depends on how far its cost (and particularly its capital cost) can be reduced below present levels. (paras. 11–13)

5. C.E.A. have assumed that sufficient progress will have been made to justify a nuclear capacity of some 12,000 MW by 1970 out of an estimated total capacity of 51,000 MW. On this basis, the rate of installation of new capacity in the period 1965–70 would rise steeply under programme A, remain steady under programme B, and fall under programme C. A.E.A. consider that, while it is not possible to make a precise estimate, the capital cost of nuclear stations is likely to fall sufficiently rapidly to justify a somewhat higher figure (perhaps 15,000–16,000 MW) for 1970, and that, on this assumption, none of the programmes would involve any decrease in the rate of commissioning of nuclear stations after 1965. We express no opinion on this question, which is essentially a matter of technical judgment, and in any event can hardly be resolved in isolation from a number of other factors about which precise assumptions cannot at present be made; but a programme based on the lower figure would reduce some of the risks while leaving the way open for further acceleration later, provided that timely action were also taken to obtain supplies of critical materials for a higher programme. (paras. 9, 10, 14–17)

6.—(i) It is desirable to give manufacturing industry a programme free from violent fluctuations. Such fluctuations would arise on programme C unless the 1970 capacity proves to be materially higher than 12,000 MW, or the export market smooths them out at the right time. (paras. 18–19)

6.—(ii) In the absence of operating experience under the conditions necessary in a public electricity supply system, there are at present two unknowns of fundamental importance to the economics of nuclear generation—the life of the reactor (which has been assumed to be 20 years) and its reliability. The C.E.A. feel that the larger the nuclear programme the stronger the case for allowing some margin of capacity (not at present allowed for in the illustrative programmes) to cover these unknowns. (para. 20)
7. Even the lowest of the three programmes would greatly increase the cost of the electricity industry’s capital investment programmes, particularly during the years 1961 to 1966. (paras. 21–23)

8. Nuclear material supplies should be sufficient provided early decisions are taken, but there will be particular problems in ensuring adequate supplies of certain other materials, especially tubing and thick steel plate. Labour supply may present difficulties and special measures may be needed to overcome these. (paras. 24–26)

9. The problem of finding power station sites is becoming progressively more difficult and, because of the more exacting siting requirements of nuclear stations, any of the three programmes will involve increased interference with public amenities and private interests, if delays are to be avoided. The C.E.A. believe that the risk of serious delays in completing any of the programmes on time will be greatly increased unless the electricity authorities can be relieved of certain of their present obligations. To make absolutely certain that the programmes could be completed on time would involve major legislation of a sort that could not be contemplated in peacetime; and unless the electricity authorities are afforded some relief, the danger of delays would be very serious indeed. Such relief could be secured by some amendments to existing legislation. These would not be very numerous but might prove controversial. (paras. 27–31)

10. The coal saved in 1965 would be 9 million tons under Programme A, 11 million under Programme B, and 14 million under Programme C. If there were a nuclear capacity of 12,000 MW by end 1970, the coal saving from that capacity in a full year would be 32 million tons, representing about 9 per cent. of total energy demand at that time. (paras. 32–34)

11. This saving, however, would be in small coal, and vigorous measures will be called for to ensure that full advantage can be taken of savings materialising in this form. This need not be regarded as a discouragement, nor as a significant factor in determining the choice between the various programmes, but rather as a challenge to be faced in securing the full potential benefits from an ambitious nuclear programme. (para. 35)

Ministry of Power, S.W. 1,
February, 1957.