EUROPEAN COAL & STEEL COMMUNITY

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HIGH AUTHORITY

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Economic Division
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THE ATOM AND EUROPE'S ENERGY GAP

One of the top-priority problems of our time is how to ensure a regular and economic supply of energy. There are four main reasons for this.

First, there is a fairly close relation between national income - which is to say the standard of living in a country - and the energy consumption of that country. Naturally, this does not necessarily mean that countries with abundant energy resources <u>ipso facto</u> have a high standard of living. But it does mean that a high standard of living for a growing population can only be kept high, and raised higher still, provided more energy is made available.

Secondly, energy requirements are rising rapidly: between 1870 and 1955 world consumption of commercial crude energy increased more than fifteenfold - which works out at over three per cent per annum. And we have no reason to suppose that the rate of increase will fall off at all in the future.

Again, there is the fact that requirements are coming to be concentrated more and more on secondary energy - that is, on forms of energy which, being more convenient to use and more readily adaptable to different purposes and different consumption peaks, are more valuable than crude energy. The more technical and mechanical the various industrial-production processes become, and the more the human element insists on shorter working hours without loss of earnings, the faster consumption of secondary energy will increase - and so, consequently, will consumption of crude energy.

Finally, world energy supplies have up to now been derived to a very great extent from exhaustible sources - reserves of coal, oil, natural gas, peat and so forth. Estimates vary as to the length of time this natural capital may be expected to last, and it is, indeed, difficult to make any definite forecast. An American expert not long ago reckoned, that if requirements of fossil fuels continue to increase at the same rate as hitherto, 3½% per annum, the world's economically-workable reserves of these fuels will be exhausted by about the year 2030. I do not suppose he is very far out in his calculation, but to my mind what we need to know - we Europeans in particular - is how long <u>we</u> can count on maintaining the flow of energy supplies <u>at approximately the costs and prices of today</u>.

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To Europe the problem of future energy supplies is exceptionally important - more so than a hundred years ago, or even than fifty years ago, and more so, too, than for the other broad subdivisions of the world. The economic advance of this continent and its economic position in the world rested during the nineteenth and early twentieth centuries on its abundant supply of cheap coal. This advantage is now steadily shrinking. Coal is still our most important source of supply, but not to all intents and purposes the only one, as it used to be. Others, such as oil and natural gas, for which Europe is comparatively poorly off, are challenging its supremacy.

But an even more important factor are the soaring costs of extracting the coal from our deep-lying deposits. New pits are two or three times as expensive to sink in Western Europe as they are in the United States, for instance. Geological conditions in the Western European coalfields make the use of power-driven machines much more difficult, so that it is not possible to increase outpour per man/shift at anything like the same rate as in the American coalmining industry. The proportion of human labour in the European mines is comparatively high, and it is becoming harder and harder to guarantee the miner the privileges he is entitled to over other occupations as regards pay and working hours, in view of the arduousness of his job.

For these various reasons, coal - in fact energy generally - has become scarce, and consequently expensive. Studies carried out quite independently by O.E.E.C. and the European Coal and Steel Community arrive at the conclusion that European energy requirements will rise a good deal more steeply than indigenous crude-energy production. The six Coal and Steel Community countries are at present importing something like a hundred million tons of hard-coal equivalent net every year - barely one-quarter of total requirements. It is estimated that in ten years' time net imports will have doubled and will be covering one-third of total consumption, and that from 1975 they will come to some three hundred million tons - three times as much as today - which will even so represent barely 40% of consumption. The only thing that can relieve the situation is the emergence of new sources of supply. There is certainly a chance to diminish energy requirements by better techniques and greater savings in energy utilization. These possibilities are not small although they often have been overestimated. Furthermore people mostly forget that a higher utilization rate of energy means also capital investment.

From a purely economic point of view, there is nothing particularly undesirable about dependence on outside sources for the supply of energy, provided the volume of exports and/or income from services is sufficient to ensure a satisfactory balance-of-payments position. But in actual practice it involves very considerable risks. For one thing, it means that the flow of supplies is particularly exposed for interruption, take the first few years after the war, the Korean boom or the Suez crisis. Again, increasing energy requirements, which have to be met by increasing imports, seriously complicate the balance-of-payments position, especially where in addition it is necessary to import large tonnages of other industrial raw materials. The cost of transporting crude energy is very high, and what is more, very erratic. Bigger and bigger imports of coal and oil mean bigger and bigger investments in harbour, transhipment and transport facilities. They also make it essential to step up exports, and that means, in the first place, large-scale investments in the export industries. And moreover, in view of the pattern of European exports, which consist principally of finished products, it is hardly reasonable to expect export prices to remain unaffected. The probability is that import and export prices will rise in proportion.

The sum up: fuels today account for some 15% of the total imports of the Community. If energy imports double over ten years and total imports go up 50% (I am quoting this figure on the basis of an optimistic estimate of exports and imports together), then one-fifth of total imports will be in the energy sector. And that will be a pretty serious matter for the Community countries' balances-of-payments. Even today the energy position in, for instance, France or Belgium is a bottleneck for economic progress generally.

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Reliable and regular supplies on as economic terms as possible must be the supreme object of energy policy everywhere. But for highly-developed, industrialized countries like those of Western Europe it is going to be harder than it used to be to achieve a balance between the two aspects, the reliable and the economic.

Imports of crude energy will be a permanent - in fact an increasingly predominant - feature of the supply situation in future. It remains to decide just how predominant that feature is to be allowed to become, which in turn will determine how far the governments' policy for energy is to be one of complete freedom or of control according to circumstances, of unrestricted competition or of compensation schemes and so on.

Whatever decisions will be met by the six countries, all of them have to envisage methods how to harmonise imports of energy with the global development of their foreign exchanges. This is not a problem of self sufficiency or autarcy but how to find an equilibrium between energy needs, energy supply from indigenous sources and energy imports.

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So much for the background. My subject is how nuclear energy can help to ease Europe's energy supply situation. So I do not propose to talk about our present biggest source of supply, coal, or its newer competitor, oil, or the position as regards conventional energy generally: it is much too wide a field to deal with in a single talk. Nor have I time to go into the details of the processes by which nuclear energy is actually released; you will in any case no doubt be familiar with them to some extent. I shall, therefore, go straight on to deal with some of the outstanding technical and economic problems which arise in the development of an entirely new type of production.

First, commercial reactor construction: would it be true to say that there are already in existence purely commercial, <u>i.e.</u> non-military, reactors? If we put the question thus categorically, the answer is, No. But that would not be a complete answer, as matters stand at present.

At your Calder Hall station two reactors have been in operation since October 1956, producing both plutonium for military purposes and electric current for lighting, heating and industry. The results have been so good that a number of purely commercial plants of the same type, but with an even greater capacity, are either already building or planned. The first of these will come into operation some time towards the end of 1961. In the United States two plants, in Shippingport, Pennsylvania, and in Los Alamos, California, are about to be taken into operation; several more, which will be producing from 1960 onwards, are in process of construction or in the blueprint stage. France is building one which is to come into operation next year. Canada expects to start producing nuclear electricity at about the same time. That is how matters stand at present in regard to reactor construction in the various countries concerned (leaving out the Soviet Union). The main thing from our point of view is that two or three types have now been so far developed as to be suitable for installation in our countries - the British type and an American model which exist in two slightly different forms. Our reasons for confining ourselves <u>for the time being</u> to these types are that they have already been tried out, can be operated with existing technical facilities and personnel (an important point for us), and are technically suitable for adaptation to European conditions, and moreover that, to begin with, Europe would be well advised to choose reactors running on natural or only slightly enriched uranium.

Next, how big is the nuclear-energy programme to be, and how soon can it be carried through? The so-called Three Wise Men, in their well-known report, "A Target for Euratom", suggested a capacity of fifteen thousand megawatts, to be installed by the end of 1967. Although this was intended as a target and not as a programme, it was widely criticized as over-ambitious. So I feel I should run over the considerations on which the Three Wise Men based themselves.

We can pretty safely assume that total electricity requirements, and total electricity production, will approximately double over the next 10 or 12 years. Additional power-station capacity will have to be installed at a more or less corresponding rate, even assuming a certain increase in the number of load-hours per annum. And even if we further assume that the maximum use will be made of available water power, brown coal and blast-furnace gas to meet the demand for electricity, it still follows that the regular coal and oil-fired power-stations will have to install more than twice the amount of new capacity. It is here that nuclear energy can and must come to the rescue. To give you only one set of figures as an illustration, the installed capacity of the thermal power-stations in the six countries at the end of 1955 amounted to 26,250 MW, and by the end of 1967 it would have to be brought up to 60,450 MW - an increase, by extension and new installation, of more than 34,000 MW. Part of this additional capacity is to take the form of colliery power-stations using low-grade hard coal, which will by 1967 be contributing a maximum of seven to eight thousand megawatts. That leaves 26-27,000 MW, also to be met by building new capacity, which - a point of vital importance nowadays - will have to be run on imported coal or imported oil.

This brings me to another consideration. The rate at which atomic power-stations can be built depends on the building period for the first few stations (at least four years), the subsequent year-by-year increase in capacity requirements, and last but not least the general aims and objects to be worked for in the energy field. What is our nuclear-energy programme intended to achieve? Well, obviously, to keep energy imports within bounds! If we set to right away on getting the 15,000 MW installed, it should be possible to stabilize energy imports more or less at the level they will have reached by about 1964 - 1965. If we succeed in reaching the target within the period suggested, the six countries ought by the end of 1965 to be importing 23,000,000 tons less of hard coal equivalent than they would be without nuclear energy, and by the end of 1967 43,000,000 tons less. That would represent a currency savings of something like 850,000,000, and would, as I say, be sufficient to keep energy imports steady at approximately the 1964-65 level.

Thirdly, there is the question of making nuclear energy competitive. In general, the principle I stated earlier on holds good: the aim must not be simply to ensure regular supplies of energy regardless of cost, but to see that, as far as possible, these regular supplies pay their way. Before we can answer this much-disputed question as to the economic soundness of nuclear energy, we have to get it absolutely clear what we are comparing and by what criteria we are comparing them.

It takes four to five years' planning and building before a big atomic power-station of, say, 100-150,000 kW finally comes into operation, after which it can be expected to continue producing for anything from twenty to thirty years. The operating costs of such a power-station will certainly be higher in the early stages than later on, as technical improvements will be made during its lifetime; new production methods normally do work out relatively expensive to begin with, but very soon become steadily cheaper and cheaper. In the case of atomic power-stations, improvements in the production of fuel elements and in the radiation cycle will reduce the costs even for a reactor which is already completed. In addition, the actual capital costs will probably diminish. It follows that if we are to compare atomic power-stations to be completed in 1965 with conventional power-stations at the same period, the best method is to compare their average costs over their whole life-time.

Future cost elements and cost structure in respect of thermal and atomic power-stations are not easy to determine, since we have to work on certain hypotheses as to prices, rates of interest, depreciation and so forth.

To take coal-fired or oil-fired power-stations which are to come into operation in the middle sixties, we know that, with the exception of the pithead stations, they have mostly to be run on imported crude energy. This costs today anything from $18 to 20 a ton - that is, approximately from six pounds fifteen to eight pounds five - and there is no real expectation that it will become cheaper as time goes on. The average investment costs are known. If we assume that the long-term rate of interest on capital will remain more or less what it is now and that the write-off period will be about 15 years, and if we further assume that the capacity installed will operate a high number of load-hours per annum, we can reckon that the cost of producing electricity in thermal power-stations will be at least about one penny per kilowatt-hour, even allowing for a progressive improvement in thermal efficiency. One important point is that of the total costs (less maintenance and operating costs) about 20-35% goes on service of capital, and 65-80% on fuel costs.

As regards the competitive position of atomic power-stations, we have to base ourselves on British and American tenders and on British operating experience.

The big obstacle to the use of nuclear fuel in power-stations is the high investment costs - something like 2½ times as high as for a conventional thermal power-station at the moment, and likely even in the near future at any rate to remain twice as high. However, from the beginning of the sixties they are expected to fall fairly quickly, since with experience it will probably be possible to simplify many cost elements as we learn which items of expenditure on safety are really necessary and which safeguards today regarded as indispensable are in fact exaggerated, and also as we come to know more about the behaviour of reactor materials. Economically, the additional expenditure on investment for a given nuclear programme represents only a small percentage of the whole: the Three Wise Men put it at $2,850,000 for the installation of 15,000 MW inclusive of fuel stocks, which would amount to about 1.5% of the gross yearly investment of the six countries. But for an individual power-station the problem is rather more difficult, particularly if we bear in mind the already considerable difficulty of raising capital even for conventional power-stations. There is, of course, also water power: investment costs for hydro-electric stations, however, vary from $100 to $800 per kilowatt, and are on the average higher than those for atomic power-stations. But as most of the economically-workable water-power resources in Europe - with the exception of Norway, France, Yugoslavia and possibly Austria - are already harnessed, very careful consideration will be necessary in deciding which type of investment is to be given priority. The hypotheses on which we have based our estimates for water-power development are highly optimistic, and if they prove erroneous the proportion of total electricity supplies which will have to be furnished by the thermal power-stations will be even greater than we have supposed.

A number of conclusions can be drawn from this.

First, as investment costs per kW of installed capacity are lower for large plants than for small, it will be necessary to plan right from the start for atomic power-stations of a given size. 150 eMW for a commercial reactor is probably about as low as we can reasonably go: incidentally, in Britain you are at present working for units of 300 eMW, and expect to go on later even to 500. It is particularly necessary to have big units when the fuel used is natural uranium, by reason of various considerations connected with the service of the capital.

Secondly, the cost per unit produced by any one reactor goes down as the number of kilowatt-hours supplied goes up. To be economic, therefore, atomic power-stations must operate at a high rate of utilization, not less than 6,000 load-hours per annum, but better 7,000 hours. To ensure that this high load factor is maintained, it will be necessary to institute various special measures, such as building storage pumping stations, extending the transmission network among the various countries, setting up big joint power-stations financed by and serving several countries, and so on. I cannot go into these problems in detail today: they are among the matters which Euratom will be taking up in the near future.

Thirdly, initial operations in the atomic field will definitely need Government assistance, at any rate so long as it remains impossible to calculate accurately the element of risk involved. On what scale and in what way the State will be required to help out remains to be seen.

Fourthly, Europe will have to depend to begin with on the experience and help of the more advanced countries, such as Britain, the United States and Canada. Here too there are various possibilities: in any event, these countries are prepared to sell us reactors and otherwise assist us. The mere fact of having their experience and technicians placed at our disposal would in itself save us a great deal of the time, trouble and expense it would cost us to acquire the "know-how".

All in all, financing atomic power-stations, particularly in the early stages, involves quite a number of tasks and problems, but none of them constitutes an insurmountable obstacle.

The second cost element is fuel costs. What makes nuclear energy so desirable for us in Europe in this respect is that the cost of the nuclear fuels per kilowatt-hour produced is even today only half or less than half that of coal or oil. As I mentioned in my introductory remarks, we must expect the cost of conventional crude energy to increase in future: how much the fuel costs of the power-stations will be affected depends on the rate of improvement in thermal efficiency. The cost of nuclear fuels, on the other hand, is expected to go down - how fast and how far will depend on various factors, chief among which is the socalled burn-up. Once you arrive at a burn-up of about 5,000 megawatt-days - for natural uranium, that is: for enriched uranium the figures will be correspondingly higher - fuel costs become a minor consideration. The fact that nuclear fuels cost so little, and should later on cost even less, in comparison with conventional fuels also explains why it is expected - in fact, definitely known - that nuclear energy will be of practical value to Europe before it is to the United States, inasmuch as the United States has cheap coal and cheap oil in plenty for a long time to come.

I am disregarding various incidentals, including maintenance and operating costs, because they will probably be much the same for nuclear as for conventional power-stations. On the other hand, we should do well to allow a certain amount for unforeseen contingencies: the Three Wise Men suggest 25%.

Taking in conjunction all these various considerations as to the economic remunerativeness of nuclear energy, we can reckon, on the basis of our present knowledge, that by the middle sixties electricity generated in the big base-load stations running at 7,000 load-hours per annum will cost perhaps between a penny and a penny-farthing per kilowatt-hour. That is an average for the six countries, based on the rates of interest and accepted write-off periods prevailing in Europe, and compares with the figure of just under to just over a penny, which I mentioned just now for thermal power. One very important factor in this calculation is, as I say, the 7,000 load-hours per annum. We should probably also be correct in assuming a certain dispersion of costs; the extent of this dispersion depends on the technical scope for the development of individual reactor types, on the fuel elements, and so on. In the initial stages the costs of nuclear electricity will be higher than later on, although the margin of uncertainty is undoubtedly not as much as 100%, as is sometimes suggested. We have reason to expect not only that the level of costs will fall, but also that the dispersion will diminish.

All things considered, we can pretty safely predict that 10 years or so from now nuclear energy will be in a position to compete with coal and oil. For myself, I should not be surprised if it had by then been so for some time. But I must repeat that all calculations so far are only estimates, not recorded results: they depend in particular to a great extent on the life of the reactor parts and fuel elements, which has yet to be found out by practical experience. It would be premature to try to draw conclusions as to production costs in general. Moreover, there are the electricity distribution and transmission costs to be taken into account. Since transport costs for nuclear fuels are low in comparison to conventional fuels, atomic power-stations have the great advantage of not being tied to a particular location. And this advantage has another side. Where a conventional power-station has to be so sited as to incur considerable transmission costs on deliveries of electricity to the consumer area, any comparison must be between straight production costs for an atomic power-station built close at hand and production plus transmission costs for the conventional station. The competitive capacity of the atomic station would in such a case be determined by the difference between the two totals.

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Well, Gentlemen, I dare say some of you may be beginning to wonder whether I have perhaps lost the thread of what I meant to say. So I will go back to my original point, which was, What help will nuclear energy be in meeting European energy requirements? In general, we can say that nuclear fuels will help to extend the range of resources available for this purpose, which, particularly in Europe, are now running so short. They are especially well qualified to do so inasmuch as, after a running-in period involving various as yet unknown hazards, bottle-necks and even hold-ups, electricity produced from atomic energy will by the mid-1960's be in a position to compete with electricity produced from imported crude energy. At some time after that, production costs will fall below those of conventional thermal power-stations. When and how quickly this process will take place depends on a number of factors which I shall now touch on in conclusion.

First, the initial process. As I have mentioned, there is as yet no purely commercial atomic power-station in operation, but a considerable number are building. My present information is that atomic power-stations with an installed electrical capacity of some 620 MW are under construction in the United States, and should come into operation between now and the end of 1960. Additional capacity totalling 410 MW is planned, and should come into operation between the end of 1960 and the end of 1962. These figures do not include the various experimental reactors. Your own C.E.G.B. have up to now placed orders for five atomic power-stations, with a total capacity of 1590 MW_{el}, to come into operation by the end of 1962. In the Community, so far as I am at present in a position to calculate, capacity of from 80 to 100 MW_{el} is partly building, partly in the planning stage, on which about 60 MW is in France and 15 MW in Germany. Belgium has built a small commercial reactor of 10-15 MW_{el} to supply light for the Brussels International Exhibition. Leaving the European experimental reactors also on one side, I can only say that plans for the construction of atomic power-stations are at different stages of completion in the different countries. To the best of my knowledge, they provide for a total capacity of up to 3,000 MW_{el}, to come into operation by the end of 1965 or 1967. That is admittedly not very much, and certainly a long way off the target of 15,000 MW. But the process is expected to speed up from the beginning of the sixties onwards.

Whatever the reasons for our six countries' slowness in starting on their nuclear programmes - some of them undoubtedly are very cogent ones - the fact remains that the time and means of our entry into the atomic age will vitally affect all subsequent developments. To begin with, up to 1961 or so, nuclear energy will not make any contribution at all to Europe's energy supply. So we shall have to go on meeting increasing energy requirements by increasing imports of coal and oil, which will probably rise disproportionately in the next two or three years, because we shall have to reckon with a gradual shortening of the working week in the coalmining industry, and hence with a levelling-off in coal production. (It is of course impossible to forecast any variations in general economic activity during this period as a result of market fluctuations.) As, in addition, it is estimated that the European countries will have in the early stages to buy half of their atomic equipment abroad, the result will be a double strain on our balances of payments. The sooner we build up our own atomic-equipment industry, the better.

It is often contended that we should do better to wait until other countries have assembled a larger and more readily assessible fund of experience than they have at present: in particular, that would reduce the risk of premature obsolescence of our atomic power-stations later on. I do not think there is much in this argument. Premature obsolescence is already unlikely, particularly if we learn to use production techniques in which the reactor core can be exchanged after a certain length of time.

Since, moreover, fuel costs for atomic power-stations are low, it will in any event be worth while to run them for comparatively long periods of years with a high base-load factor, and at the same time hold the old-type thermal power-stations in reserve to cover peak requirements.

One of the first things to be done in instituting a programme for building atomic power-stations in Western Europe is to set an approximate capacity for the production units. This must be the 100 to 150 MW_{el} per unit now usual even for conventional stations, and should go above it as soon and as far as technical knowledge and possibilities permit. British experience has shown that investment costs per kW installed in the latest large 500 MW units are ten to twenty per cent lower than in the case of 150-200 MW units. That is a very important point for the atomic power-stations as regards service of capital. It is, in fact, an instance of what has been well termed "technical foreshortening".

Finally, just one last word as to the problem of our lack of "know-how", and even more important, our lack of technical personnel. Technical know-how you can only get by actually handling the plant and equipment you are proposing to use - in this case commercial reactors. To start with we shall have to depend on British and American experience and help, particularly as we shall need to import our reactors. But we hope, that as time goes on we shall be able to stand on our own feet, and perhaps make our own contribution to the advance of nuclear science for peaceful uses. In the meantime I need hardly say how greatly we appreciate the most generous cooperation we are being shown.

To sum up briefly: Nuclear energy has come on the scene at a time when our energy supplies - particularly ours in Europe - have fallen critically low. It will relieve the situation technically and economically, but we must not forget that even in the future it will only be <u>one</u> contribution to the energy economy as a whole - although the fact of its existence means that we shall need to rethink, and where necessary reorganize, the whole energy-supply system.

However that may be, we realize that the march of technical progress demands a mastery of nuclear technique. The prospects it opens up are immense - so are the difficulties still to be disposed of. But it is all part of the everlasting challenge to the human race symbolized thousands of years ago by the Bible's account of how God created Man and told him to "subdue the earth". Subdue the earth - make all you can of the limitless resources of Nature, so that you and your children and the generations to follow may lead a richer and fuller life.

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