

Ireland's Future In The World Demand On Energy Resources

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The experience of two world wars has led the more advanced nations to examine the growing demand on their energy resources. In the English speaking countries, with which the economy of this country is particularly involved, several studies have been published both on general and on specific aspects of the question (1) (2) (3) (4), and the trend of much research and development work at present in progress indicates the importance that is attached to it at governmental level. The purpose of this paper is to examine some of this published material and to present in a non-technical way such data as may have a bearing on the future position of Ireland.

Energy has been defined as the ability of a system to do work. To a large extent the term *power* has acquired a similar meaning, as for example in *water power*, although more strictly it is a measure of the rate of performing work as in the unit *horsepower*. There are many forms in which energy exists and these forms are interchangeable. Thus electrical energy transmitted from a power station, where it may be produced by heat energy from the combustion of oil, peat, or coal, can be converted back into heat energy and simultaneously into light energy in the ordinary tungsten filament lamp. While it is a fundamental law of physics that, despite any changes in its form, the total amount of energy in a system remains unchanged when measured in terms of any one form (the principle of the conservation of energy), this is a matter merely of theoretical significance from the social point of view. The consumer is concerned with the amount of useful work which can be performed in the conversion of the energy, that is with the so-called *efficiency* of conversion. For example if he is using electrical energy for the production of light, he is concerned with the amount of light which he obtains from a given amount of electrical energy reaching his dwelling, the cost of which is related to the amount of fuel used in its production in the power station. He is not concerned with the total amount of energy which is available as heat energy from that amount of fuel, most of which incidentally is dissipated in the cooling towers of the power station, nor is he concerned with the large part of the electrical energy which is lost as heat from the light bulb, even though this may serve a useful purpose in assisting to heat and dry his house.

These concepts may be translated into more homely terms in relation to that very complex system the human machine. A man is described as being "full of energy" as an indication of his ability to do work. He derives his energy from the fuel which he consumes in the form of food. Neither the national economy, nor in particular his employer, is concerned with the amount of energy he possesses,

but rather with the amount of useful work he does, that is the portion of his energy which appears as production. Here again it is the amount of useful work which is performed by the worker that is a measure of his efficiency, though it is not measurable in exact figures as in the conversion of energy by mechanical means. An improvement in the efficiency of the human machine as a part of industrial operations is the aim of modern operational research.

The term *industrial productivity*, or output per worker, has acquired great prominence as a yardstick in the economic discussions of the post-war period. It is related to the amount of work performed by the worker together with that performed by the mechanical energy sources at his command. Table 1 gives data to indicate the relative values for this energy output per worker in different countries; parallel with these are data to show the relative productivity per worker.

TABLE 1.

	Relative Energy Output per worker	Relative productivity per worker in 1950
	(a)	(b)
United States	100	100
Canada	66	78
Sweden	—	49
Britain	60	45
Denmark	—	37
Netherlands	23	34
Belgium	53	34
Germany... ..	40	32
France	27	30
Italy	9	20
Spain	—	15
Russia	8	—
India	4	—
China	3	—

(a) Based on figures by T. T. Read published by Chase, S., "Men and Machines," The Macmillan Co., New York (1933).

(b) Data taken from an article "A Comparative Analysis of Labour Productivity," in Stanford Research Institute Bulletin, (November, 1953).

The figures are not strictly comparable since they refer to periods separated by a twenty year interval, but they are sufficient to indicate that productivity is related to the total energy available to the worker. Additional data which support this conclusion are available for the 50 year period 1900-1950 in the U.S.A. In that time the labour force increased 119%, the energy supply increased 345%, while production increased 372% (1a); production increased nearly five-fold although the amount of labour was only slightly more than doubled, and was more nearly related to the increase in the energy supply.

The available supply of energy is probably the largest single factor in determining national productivity. There are other factors which are significant; the type of business management, whether technical or purely managerial; policies directed towards high prices and an output, sometimes deliberately restricted, other times limited

by small markets ; restrictive labour practices ; the absence of scientific knowledge aimed at improving efficiency ; lack of standardisation and simplification ; these all contribute to keep down productivity. A plentiful energy supply appears to be fundamental to raising it.

Apart from the energy consumed in industrial production, an important portion of national consumption is devoted to the everyday life of the community :—in domestic life for cooking, heating and lighting ; in agriculture for food production ; for public and private transport ; for public lighting. The extent to which these uses are growing is very remarkable. The mechanisation of agriculture, the development of the automobile in private transport, the spread of rural electrification, and the growth of air transport are outstanding examples in the Irish economy. What are the energy sources on which this growth is dependent ?

The principal sources of energy in nature include the fuel sources : coal, peat, timber, oil shales, petroleum and natural gas ; the gravitational sources : water power and tidal power ; windpower ; solar energy ; and the most recently discovered—atomic or nuclear energy. The combustible fuels, together with water power (hydro-energy), constitute the main sources at present being exploited ; the remainder are in the experimental or development phase. For convenience in comparing these different energy sources their energy content may be expressed in terms of their bituminous coal equivalent.

The Paley report estimates (1b) that the total energy requirement of Western Europe in 1950 was equivalent to 630 million metric tons of bituminous coal, and that it was derived 75% from solid fuels, 14% from petroleum and 11% from hydro-electric power. It further states that although there are still large coal reserves in Western Europe, their development has not been rapid enough to meet the increase in the demand for energy, and imports of both coal and oil are considerable. It is estimated that despite the growing demand, coal consumption will not increase substantially, presumably because the cost will rise owing to increasing difficulty of mining, and increasing wage costs. It is expected that increasing imports of oil from the Middle East will be utilised to meet the demand.

This picture of increasing dependence on petroleum is supported by experience in the U.S.A. during the past 25 years where the consumption of coal measured as a percentage of the total energy demand has steadily declined, although the actual volume of coal used has been growing. It is expected, however, that some time after 1975, as the domestic oil and natural gas position in the U.S.A. alters, coal will contribute in greater proportion to the energy demand. Existing *known* reserves of oil and natural gas in that country are not expected to suffice for the next 25 years (1c) while coal reserves are adequate to meet requirements for over 200 years.

The Ridley report (2a) sets out the picture for Britain and foresees that planned coal output will meet in full the demand in 1962. Large increases above the planned output, however, would mean steeply rising costs. Within the same period it is expected that consumption of fuel oil will double. Already surplus fuel oil from the greatly increased oil refining capacity in Britain is seeking an outlet (5). Both the Ridley report and the Simon report (3a) stress the importance

of improving the efficiency of use of coal in view of its importance as the main indigenous source of energy in Britain.

The prospect for Western Europe is not encouraging. As a possible method of increasing the supply of energy to this highly industrialised sector of the world, a proposal to pipe natural gas from the oil fields of the Middle East has received serious consideration (6). Technically the project is feasible although the political difficulties are very great. Dependence on this source, as indeed present dependence on liquid petroleum products from the Middle East, constitutes a source of great weakness in time of war.

The necessity for Western Europe to import a proportion of its fuel requirements is tantalising in view of the fact that much of the fuel at present produced is lost in the course of its conversion and use. The concept of efficiency of conversion of energy from one form to another has already been stated. Thus the domestic open coal fire as widely used in this country and in Britain for domestic heating has an efficiency for this purpose estimated at less than 20%. The remaining 80% of heat energy is lost to the outside atmosphere as hot flue gas, unburned carbonaceous material and unburnt combustible gases. Against this, a domestic central heating plant such as is used in Sweden or the U.S.A. has an efficiency between 40 and 50% (3b). These figures reflect the loss of energy in burning coal for heating purposes; less than half the amount of coal burned in the open grate would have provided equivalent heating capacity in the central heating installation.

When coal is burned to produce electrical energy in a generating plant lower efficiencies may be obtained. An average present day figure for the efficiency of conversion from fuel in a steam station to electrical energy is 20%, and there is a further loss of energy in the transmission of the electrical energy from the power station to the point of use. Thus electric heating, measured in terms of fuel consumed for a given heat output, may be even less efficient than the open coal or turf fire. Despite the fact that conversion from fuel to electricity is so wasteful of energy, it is in widespread use because of the flexibility and convenience of electrical energy. For short-period use, as in an electric fire, it may even show an overall saving of energy when allowance is made say for the time in bringing up to temperature with other forms of heating.

Similar sacrifice of efficiency to flexibility and convenience of use is shown in the automobile engine in which the thermal efficiency may be approximately 30% but the actual efficiency is lower when measured in terms of useful work performed in relation to the load transported.

These instances indicate how energy is lost and therefore wasted in the process of conversion. In actual fact much of the progress of modern times has been achieved at the expense of a prodigal wastage of energy resources. While modern science has improved the efficiency of some processes it has created many others even more wasteful. It has been stated that more coal, oil and natural gas have been burned in the past 50 years than in all previous history (1d). In 1950 consumption of energy per capita in the U.S.A. was equivalent to 8 tons of bituminous coal, in Western Europe it was 2 tons, and in South and East Asia it was as little as one-tenth of a ton.

An important saving would result if the efficiency of conversion could be improved, and much research has been directed to that end. The results are reflected in some of the improvements which have been effected. In electricity generation for example, data for the U.S.A. indicate that 7 lb. of coal were required in 1900 to generate 1 kilowatt-hour of electrical energy; by plant improvements, this was reduced to 1.34 lb. in 1945, to 1.25 lb. in 1950 and the most modern U.S. plants consume only 0.75 lb. (1e). Similar developments have led to improved efficiency in the generation and utilisation of steam in industry.

In the case of the internal combustion engine improvements have been made through the development of fuels suitable for operation with higher compression ratios. A compression ratio of 4:1 corresponds to an efficiency of 28%; when the ratio is raised to 7:1 the efficiency is increased to 38%. The modern trend is towards higher compression ratios, but the ultimate gain in efficiency is doubtful. The conversion of the raw petroleum into the more refined fuel suitable for use in the higher compression engine may involve a greater loss of energy than is gained in the engine.

Much effort has been devoted to improving the efficiency of domestic fuel burning appliances and many cooking and hot-water appliances developed since the war can claim very marked improvements in thermal efficiency. In this case improved efficiency may be reflected in a greater margin of comfort in the household rather than in an overall saving of fuel, but it is a field in which very important savings can be effected.

Improvements such as these, important though they may be in themselves, do not make any great contribution to the problem of meeting a growing demand for energy from sources which are definitely limited. The indications point to a steadily developing strain on its indigenous resources, which if peacetime conditions prevail, would involve Western Europe in another quarter of a century in meeting one-third of its energy requirements from petroleum, the bulk of it imported (1f). What are the prospects of developing alternative sources to meet these requirements?

The natural sources of energy were listed earlier and may be grouped into:

- (a) those which are stored in the earth's crust: coal, peat, petroleum, natural gas and radio-active minerals—the last named constitute the present source material of nuclear energy.
- (b) those which are derived from sources outside the earth's solid crust: hydro-energy, tidal-energy, solar energy including heat and light energy, windpower.

The first group represent capital reserves accumulated during millions of years, mostly from light energy. The world is at present living largely on these capital reserves and they are becoming seriously depleted in parts of the earth. The second group represent current income, an income which can not be expended any more rapidly than it is received. To some extent this income can be accumulated in current account. For example, rain may be stored behind dams and light energy can be accumulated in photo-synthetic products such as timber.

Of the first group the only known reserve materials which have not so far been developed are the radio-active minerals, of which the element uranium is the only member at present under serious investigation as a source of power. This element is present in considerable amount, 4 parts per million, in the earth's crust. Smith (7) nearly ten years ago stated that the nuclear energy in known deposits of uranium would be adequate to serve the total power needs of the U.S.A. for 200 years. Since the date of that statement there have been reports of further reserves of the element but most of the information concerning it is now regarded as of strategic importance. Benedict states that authorities on the world's total reserves of coal and uranium are in agreement that if breeder-reactors prove economically feasible the total energy reserves in uranium and thorium will exceed those in coal (8). If breeders are not economic, uranium will be a relatively minor energy resource. Most well-informed estimates indicate that nuclear energy will be available for industry in some 15 to 20 years, and will almost certainly be produced as electrical energy obtained from the heat energy released by nuclear fission. The problems holding back development are largely problems of economics, the finding of easier and cheaper methods for the costly extraction and conversion processes involved. The solution of these problems will place those nations, to which uranium deposits are accessible and which have the industrial resources capable of developing them, in a very favourable position.

In the second group of energy sources, that is those which, though limited in the amount currently available, are inexhaustible through their recurrence, water-power is familiar. It is the only member of this group to have been directly exploited on a large scale. Allied to it is tidal-power, the use of which has been widely suggested, but apart possibly from some specially favoured geographic locations, it involves engineering problems of extraordinary magnitude.

Solar energy, the heat and light energy from the sun, is indirectly utilised in everyday existence. It is essential to all plant and animal growth, and it is the accumulation and breakdown of these plant and animal products in the earth that has furnished the coal, peat, petroleum and natural gas which are now being so extravagantly exploited. It has been estimated that the amount of solar energy reaching level ground in the lower middle latitudes is equivalent to approximately 1,000 tons of coal per acre per year, or 2.75 tons per day (1g). The conversion of this energy, by photo-synthesis in plant-life, has been estimated to have an efficiency of as little as 0.1% over the year. If even a small fraction of solar energy could be tapped directly it would make a significant contribution. At present it is utilised in industry for the solar evaporation of natural brines, principally seawater, in those countries where climatic conditions permit. Solar energy is also indirectly utilised by the heat pump, a device similar in principle to a refrigeration unit, which abstracts solar heat energy stored in water or in the ground and makes it available within a dwelling or factory. Unfortunately the economics of this machine are not attractive for domestic use unless conditions call for its use as a cooling device in summer.

It has been estimated that about one-third of the energy requirements of the U.S.A. is devoted to comfort-heating in factories and dwellings

(1h). Much thought and experiment has been devoted to meeting some part of this large requirement by direct utilisation of solar energy. While it is relatively easy to capture this energy, the problem of storing it for controlled use has yet to be solved. For comfort-heating, evaporation and similar industrial processes, it shows promise in certain latitudes but its use for industrial power does not appear to be practicable.

The winds directly result from the heat of the sun, and the utilisation of windpower is indirectly an exploitation of solar energy. Windpower has of course been used in past centuries but lost favour when cheaper and more reliable sources of energy became utilisable. To be economically attractive under U.S. conditions, wind velocities averaging 28 m.p.h. or more are required (1i). With increasing knowledge of the principles of aerodynamics a wide-spread interest in the use of windpower has developed in the past quarter century and much experimental work has been undertaken in different countries. It is very probable that practical proposals will emerge from this work and that the development of electrical energy on a large scale for feeding into an electrical network will become feasible.

So far an outline has been given of what the world at large is doing and hopes to do in regard to its energy resources, where does Ireland stand in relation to this ?

TABLE 2.

Imports of Coal and Petroleum Products into the Twenty-Six Counties.

	1937	1951	1952	1953
Coal (tons)	2,563,000	2,036,000	1,697,000	1,639,000
Petroleum products ... (gallons)	70,655,165	206,718,000	206,096,000	201,561,000
Total Coal Equivalent (tons)	2,911,000	3,054,000	2,712,000	2,632,000

TABLE 3.

Energy Output from Native Sources in the Twenty-Six Counties.

	1937	1951	1952	1953
Coal (tons)	126,000	176,000	185,000	175,000
Handwon turf (tons)	—	Estimated 3.5 million tons per annum		
Machine turf (tons) ...	10,000	239,000	482,000	648,000
Hydro-energy (kw. hr.)	247,451,000	465,900,000	456,472,000	361,032,000
Total Coal Equivalent (tons)	—	2,357,000	2,482,000	2,492,000
		1951	1952	1953
Total Energy requirements as Coal Equivalent in tons		5,411,000	5,194,000	5,124,000

Data for Machine Turf taken from Annual Reports of Bord na Mona.
 Data for Hydro-Energy taken from Annual Reports of Electricity Supply Board.
 Data for Coal and Petroleum imports and for Coal production supplied by
 Central Statistics Office. Conversion into coal equivalents based on
 average thermal equivalent for petroleum and turf, and on the assumption
 that 1.5 lbs. of coal are required to generate 1 kW hr. of electrical energy.

In Tables 2 and 3 statistical data have been compiled to show the energy requirements of the 26 County area of Ireland for the past three years and also for one pre-war year. They reveal that present overall imports are fairly stationary compared with pre-war requirements, and that the post-war trend towards reduced coal imports has been offset by increased petroleum imports (the figures for 1951 presumably include stocks assembled for emergency storage and would be above normal).

The data in Table 3, which show energy output from native sources, indicate a rising trend, due mainly to increased machine turf production of which a large portion is being converted to electrical energy for distribution by the Electricity Supply Board. This rising trend is not reflected in the figures for the total requirements of the 26 Counties which are given below Table 3, although a strict comparison is not possible owing to stock piling in 1951.

An average of the total figures for the three years indicates an annual per capita energy requirement equivalent to 1.8 tons of coal. This compares with figures for 1950 cited earlier in this paper: 7.1 tons per capita in the U.S.A. (equivalent to 8 short tons) and 1.8 tons in Western Europe (2 short tons).

While the present energy requirements of this country are equivalent to the average for Western Europe, it is not certain that the demand for energy is actually growing, as it is in Europe generally. Figures for the sale of electrical energy indicate that the demand for electricity is doubling itself every $5\frac{1}{2}$ years. This compares favourably with a doubling period of 10 years in the U.S.A., but in that country coal gas and natural gas are strongly competing for part of the load. The major part of the present consumption in Ireland appears to be devoted to domestic and other non-industrial use, and the present increase in demand for electricity may be due to the extension of electrical services to new domestic users in combination with a growing tendency for manufacturers to draw power requirements from the national supply and to scrap their own power plants. An increase in the demand for electrical energy from these sources would tend to be offset by a reduced demand for petroleum products and other imported fuels, and that position appears to be reflected in the import figures.

The overall figures for the energy requirements of this country during the past three years do not suggest a growth therefore, but rather a re-distribution of the demand against different sources of energy supply. It is probable that a closer analysis of figures over a longer period would determine to what extent there may be an actual growing demand for energy.

It is common knowledge that a large increase is planned in the supply of electrical energy from peat resources in the years to come. As a contribution to self-sufficiency, particularly in time of war, this is most desirable and is to be welcomed. On the other hand, the section of the peat resources around which this development is planned

has an estimated life of say 25 to 50 years and will be spent at a time when, as has already been suggested, a serious fuel problem may have developed in Western Europe. Assuming that no alternative native sources have been developed, Ireland would share in the difficulties of that time, or at best would be dependent to a much greater extent than now on imported energy materials. It may, however, prove to have been a disguised blessing that geological prospecting has been limited during the past century. Further workable deposits of coal may be found—the present contribution from native sources is not insignificant. On the other hand, oil shale, of which there are some indications, may exist in quantity. Petroleum may be found—in France for example post-war finds have led to hopes that the country may become self-sufficient in oil.

Presuming the absence of these recognised sources, is there hope that sources at present utilisable only in an experimental way, may be tapped? Solar energy might not be the first to come to mind—nonetheless the data for Dublin city for the twelve months of 1953 show that there was sunshine for 30% of daylight hours with the major part in the five summer months (9). That holds some hope for domestic heating—the solar house, in which the sun's heat is captured and stored, may prove to be more than a scientist's dream.

The main hope must rest, however, on windpower, since that is directly convertible into electrical energy to provide power for industry and cooking facilities for the home. The prospects for windpower development in Ireland have been examined by Munro (10) and he reports that the strong ocean winds reaching the west coast have an average annual velocity as high as 26 m.p.h. on many hill tops, that the velocities are high compared with most other parts of Europe and that the contour of many of the hills is well suited for windpower development. In a discussion of Munro's paper, Golding (10) has ventured an opinion that 3,000—4,000 million kWhr. is a possible annual production from windpower in this country. That figure compares with a present overall annual production of 1,160 million kWhr. of electrical energy in the 26 Counties. There are several experimental wind-power installations in other countries and the outlook for successful development from these experimental projects is not unpromising.

There is one domestic source which can continue to make a definite contribution in lessening the difficulties of the days when exploitable peat deposits and procurable coal imports have become a part of history: water-power. In the past year, water-power contributed 360 million units of the 1,160 million cited above and further developments already planned will raise this contribution to more than 600 million units. A conservative estimate of the total supply which could profitably be developed from hydro-electric sources is 800 million units. This would not be equivalent, however, to much more than 0.5 million tons of coal consumed in electricity generation. By adding the most optimistic figure of Golding for windpower, an equivalent of say 2.5 million tons of coal, the total, equivalent to 3 million tons, is considerably less than the present total energy requirements of the country.

The writer has endeavoured to make a superficial survey of the energy position as it may affect the Ireland of the future and hopes

that he has developed enough of the possible picture to suggest to some painstaking research worker the need for a more exact analysis of the present energy requirements of the country. It is inevitable that, like the rest of the world, this country must concern itself primarily with the problems of the present and the immediate future. It would be rash to plan now for a distant period which may be moulded by events still unguessed at. It suffices to suggest that the history of the next fifty years, as it affects Ireland, will be largely dependent on the disposition of the energy resources of Western Europe in relation to the population position as it develops during that time.

DISCUSSION

Mr. R. F. Browne said: This is a thought-provoking paper and draws attention to the serious waste in the utilisation of fuel. Coal has been relied upon as the main fuel for the purpose of the production of electricity, and it is clear that the rate of winning coal cannot keep pace with the increase in the demand for electricity.

The second important factor is very low mechanical efficiency. In the common grate it is doubtful, with coal, whether the efficiency is as high as 14 per cent. Even for electricity it is normally only about 20 per cent; in certain instances a figure as high as 29 per cent. has been reached. It is quite clear that, in the future, efficiency must be improved markedly because we are facing a universal shortage of fuel.

In this country the rate of increase of consumption of electricity has been remarkable. It has doubled in relatively short periods. The problem of how the demand can be met in, say, fifteen or twenty years is, however, one common almost to the whole world. There is no doubt that means will be found to meet what is required.

Productivity is tied closely to the rate of the usage of energy. This was shown clearly by the various teams which went to the United States to study productivity and output per man hour.

Energy as an item in the cost of production has, except in the case of a few industries, been very low and for this reason was not used as economically as otherwise it might have been.

It is a pity that the development of intelligence has not kept pace with the inventions and discoveries of engineers and scientists. At most the intelligence has not been developed higher than 10 per cent. This we can see quite clearly from the manner in which our thoughts are, for the greater part, quite uncontrolled. This absence of development of the intelligence must lead to catastrophies like wars.

The present position is such that, apart from the possibilities of atomic energy, substitutes must be found for the ordinary fuels. It would seem probable that substitutes will be found in solar sources.

Mr. Arnold Marsh said he was not worried, and he did not think the lecturer was, about the possibility of the world's energy resources being exhausted. People would discover new ones as old ones gave out, and he agreed with *Mr. Browne* that the only danger was their

misuse. But he felt alarmed sometimes at the extraordinary differences in the calculations of experts. Recently Sir John Cockcroft in the *Times Electricity Supplement* had estimated the life of the world's fuel resources at less than 200 years, and in the same issue Dr. A. Parker, Director of the British Department of Industrial and Scientific Research, had estimated the life of the reserves of coal alone at 2,000 years. This kind of thing shook one's faith.

With regard to wind, he looked on this as the only important source of energy we in Ireland possessed, and with new methods of power storage it should become much more valuable. There was however too much of a tendency to call any development "uneconomic" if it did not pay 5%, and our resources were supposed to expand and contract in inverse ratio to our interest rates. He thought the soundness of paying interest on capital outlays that were repeated year after year should be reconsidered carefully. It was hampering, and increasing the costs of, developments that would be of permanent value. If we borrowed £1,000,000 a year for fifty years, we should, after twenty years, be paying a £1,000,000 a year in interest in any case, and after forty years we should be paying £2,000,000, and still of course borrowing another. Our repayments of fifty years of such borrowings would amount to £175,000,000 instead of the £50,000,000 that we had invested. We should seriously consider either providing capital out of revenue or of providing it at such low interest rates as would make large scale development "economic" in the sense understood by the "uneconomists." Otherwise many nationally valuable enterprises might be held up.

Mr. Crampton in thanking *Mr. Flood* for his address referred to the apparatus he saw demonstrated at Olympia Building Exhibition last November. The device consisted of a refrigerator. The heat withdrawn from this refrigerator was passed into the hot water cylinder. It is intended to install this apparatus in ordinary houses. It is claimed that by transferring the heat from the refrigerator into the hot water a saving of 50% of electric energy is thereby saved.

Referring to the economy of central heating, *Mr. Crampton* quoted the case of two similar semi-detached houses which were built in Mount Merrion about 20 years ago. One house was supplied with a complete hot water central heating system and was offered for sale at the same price as the next door house with the usual fireplaces. It took three months longer to sell the house with central heating. The re-action of the public today, however, is not so "anti-central heating."

Dr. Geary said : I share some scepticism about the figures of relative productivity per worker in 1950 in different countries, given in Column (b) in *Mr. Flood's* Table I. I think, however, that they can be accepted as of the right order of magnitude for comparative purposes which is all that the lecturer requires. It is possible to draw a distinction between the comparative national productivity and what may be termed individual productivity, a distinction which is well recognised in the literature. National productivity depends simply on the total output of the nation, and depends on both the nature of the economic activities as well as relative productivity of each economic group.

For instance, a nation like Ireland will tend to have a lower national productivity than a highly industrialised country, simply because Ireland is largely agricultural and the productivity in agriculture in nearly all countries is lower than the productivity in non-agricultural activities. Individual productivity, on the other hand, can only be assessed by comparing the figures, industry by industry, and weighting the results according to a common industrial pattern.

Mr. Flood should have no difficulty in completing his Table 3 for Ireland. Total production of hand-won turf (in tons) was 3,586,000 in 1937; 3,687,000 in 1951; 3,316,000 in 1952 and 3,104,000 in 1953. I should also point out that from our Census of Production we can give details of fuel used in Irish industry in recent years. I will have a table giving the global particulars prepared which might be included in the summary of these remarks printed in the Journal. The following is the table :—

USE OF FUEL IN IRISH INDUSTRY, 1951 AND 1938. (The 1938 figures are estimated)

Type of Fuel	Unit of Quantity	Industries producing Transportable Goods		Service-type Industries		Total All Industries		
		Quantity	Coal Equivalent	Quantity	Coal Equivalent	Quantity	Coal Equivalent	
		Year 1951						
			tons		tons		tons	
Coal	ton	351,199	351,199	309,757	309,757	660,956	660,956	
Coke	"	45,267	48,972	2,152	2,328	47,419	51,300	
Turf	"	62,885	33,741	228,360	123,510	290,745	157,251	
Wood	"	15,927	7,176	3,902	1,758	19,829	8,934	
Electricity ...	1,000 k.w.h.	248,020	165,347	14,937	9,958	262,957	175,305	
Gas	1,000 cu. ft.	402,682	13,197	33,001	1,082	435,683	14,279	
Fuel Oil	gallon	32,365,852	260,083	8,158,484	65,559	40,524,336	325,642	
TOTAL 1951 ...			879,715	—	513,952	—	1,393,667	
			Year 1938 (estimated)					
Coal	ton	474,000	474,000	160,000	16,000	634,000	634,000	
Coke	"	48,000	51,928	5,000	5,409	53,000	57,337	
Turf	"	6,700	3,624	1,500	811	8,200	4,435	
Wood	"	—	—	—	—	—	—	
Electricity ...	1,000 k.w.h.	70,700	47,133	5,400	3,600	76,100	50,733	
Gas	1,000 cu. ft.	264,000	8,652	32,000	1,049	296,000	9,701	
Fuel Oil	gallon	4,384,000	35,229	873,000	7,015	5,257,000	42,244	
TOTAL 1938 ...		—	620,566	—	177,884	—	798,450	

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- (1) *Resources for Freedom*—A Report to the President by the President's Materials Policy Commission, 3 volumes, I—V, U.S. Government Printing Office, Washington, U.S.A. (1952).
 - (1a) *ibid.* I, p. 105; (1b) *ibid.* III, p. 29; (1c) *ibid.* I, p. 104;
 - (1d) *ibid.* I, p. 104; (1e) *ibid.* IV, p. 5; (1f) *ibid.* III, p. 29;
 - (1g) *ibid.* IV, p. 213; (1h) *ibid.* IV, p. 217; (1i) *ibid.* IV, p. 218.
- (2) *Report of the Committee on National Policy for the Use of Fuel and Power Resources.* H.M.S.O., London (1952).
 - (2a) *ibid.* p. 13.
 - (3) "Domestic Fuel Policy," *Report by the Fuel and Power Advisory Council.* H.M.S.O., London (1946).
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