THE
ECONOMIC RESEARCH INSTITUTE

Fuel and Power in Ireland: Part II

Electricity and Turf

by

J. L. BOOTH

August, 1966 Paper No. 34

73 LOWER BAGGOT STREET, DUBLIN 2

Copies of this paper may be obtained from The Economic Research Institute, 73 Lower Baggot Street, Dublin 2, price 5/- a copy.

Fuel and Power in Ireland: Part II

Electricity and Turf

Contents

General Introduction

The use of fuel and power, or energy, in Ireland is the subject of these papers. Energy is needed to provide heat, light, and motive power to run our factories and homes, and to transport ourselves and the goods we consume from one place to another. In some instances we buy these services direct (as when we travel by public transport) and in others we own appliances with which to produce them from commercially available forms of energy (as, when we travel in our own cars, we use petrol). Ultimately we are in all cases buying services, or satisfactions of one sort or another, and here we are particularly interested in the energy involved in the provision of these services.

Each of the various commercially available forms of energy has its special physical and economic characteristics that make it more suitable for providing some particular services: petrol is primarily a transport fuel, and electricity is particularly well suited for lighting, for example. Yet, in principle, any of the basic forms of energy can be adapted to providing any of the services associated with the use of energy; a car *could* be made that would run on turf, but it would not be a very efficient device either technically or economically.

The supply of and demand for different forms of energy are subject to forces similar to those which bear upon the supply and demand for other groups of closely related commodities, like food or housing for instance. Indifferent substitution of one commodity within the group for another is not generally the case, but the extent of possible substitution is sufficiently large to justify the collection of the commodities concerned into a group, and to warrant study of the behaviour of the group as a whole. This, then, is the justification for considering as a group the different forms of energy, of fuel and power, that are used in Ireland.

The bulk of the work described in these papers is analytical in an historical sense. Its object has been to identify over a period from 1950 to 1963 how much energy was consumed in Ireland, in what form that energy was supplied, and for what purpose it was used. The combined emphasis upon the historical and statistical aspects proved necessary because the study of fuel and power has received relatively little attention in Ireland and both statistical data and descriptive information was lacking. It is hoped that this paper will do something to correct that deficiency.

However, the first and most important of the four papers that make up the series deals with the future and with projecting Ireland's energy needs forward to 1970. The remaining three papers may be regarded as supporting evidence and explanatory background material.

The four papers are, or will be:

Part I Energy Consumption in 1970.

Part II Electricity and Turf.

Part III International and Temporal Aspects of Energy and of Electricity Consumption.

Part IV Sources and Uses of Energy.

The author is an employee of the Royal Dutch/Shell Group of companies whose services were made available to The Economic Research Institute for the year from April 1964, to April 1965, to undertake the study which has resulted in the publication of these papers. He is responsible for their contents including any views expressed therein.

The author is grateful to a number of organisations for help in gathering together such statistical material on fuel and power consumption in Ireland as is available, and particularly to the following:—

Department of Transport and Power
Central Statistics Office
Electricity Supply Board
Bord na Móna (Turf Board)
Esso Petroleum Company (Ireland) Ltd.
Irish Shell and BP Ltd.

He is also indebted in a personal way to a number of people in these and other organisations who read and commented on the earlier drafts of this series of papers. They bear no responsibility for any errors or omissions.

Fuel and Power in Ireland: Part II

Electricity and Turf

BY J. L. BOOTH

INTRODUCTION TO PART II (ELECTRICITY AND TURF)

The supply of these two very different forms of energy are discussed together in Part II of this series of papers because they are both, in Ireland, controlled and run by State Corporations. As a consequence of its much greater importance, more space is devoted to electricity than to turf.

Four separate sections are devoted to electricity, and this part of the paper is introduced in considerable detail in the first section which deals in the main with the historical background. The second section covers the physical features of electricity supply in its Irish context and an understanding of these is essential to any consideration of the complicated economics of the industry. The finances of the industry are described in the third section. Finally the economics of electricity supply are dealt with in their particular relation to the problem of pricing, but including in a theoretical sense the interdependent problem of the level of investment.

Turf supply is dealt with in three shorter sections. The first sketches the historical background and the second outlines the finances of the industry in a similar way to that used for the finances of the electricity industry. The third section discusses the problem of the use of turf for generating electricity.

Part IIA Electricity Supply in Ireland

SECTION 1: THE HISTORICAL BACKGROUND

The supply of electricity in Ireland is in the hands of the Electricity Supply Board. A useful description of the activities of the Board is given in the Autumn, 1957, issue of *Administration*, the journal of the Institute of Public Administration, Dublin. That specially enlarged issue was devoted entirely to the Electricity Supply Board. Because such a wealth of detail has already been published in that issue and elsewhere it is not necessary here to give more than a summary description of the Board's status and activities.

Of particular interest in that issue of *Administration* for tracing the history of the Board is the article by P. J. Dempsey, then Secretary to the Board. It tells how the decision to make a national approach to electricity supply was inspired by the need "to retrieve what had been so far neglected", in the words of the Minister for Industry and Commerce referring to the possibility of water-power from the Shannon in the debates on the Shannon Electricity Act, 1925. In 1927 the Electricity (Supply) Act set up a business board to organise and regulate the generation, transmission, distribution and supply of electricity throughout the State and in particular to generate electricity from the Shannon scheme. The Board was given wide powers of control over the operations of existing authorised supply undertakings and the authority to acquire those undertakings if it thought fit. In the event the Board decided not merely to supply electricity in bulk but to take over existing undertakings and, eventually establish itself as a national supply industry in every sense.

Thus the Electricity Supply Board is the Statutory Corporation envisaged in the Electricity (Supply) Act of 1927, which lays down its powers, duties, functions and financial structure. It derives its existence and authority directly from that statute and is not incorporated under the Companies Act. There have been numerous amendments to the original

Act, notably that of 1954 enabling the Board to raise capital by direct flotation of loans and the Acts of 1945, 1955, 1958 dealing with the provision of electricity in rural areas, but even now the powers and responsibilities of the Board remain largely as they were defined in the original Act. It is required to furnish an annual report of its proceedings to the responsible Minister, now the Minister for Transport and Power, with annual accounts in the form prescribed by that Minister in consultation with the Minister for Finance.

The Board engages in all aspects of electricity supply from the construction of its own power stations at one extreme to the sale of electrical appliances at the other. Included between the two extremes are its principal activities of generation, transmission, distribution and sale of electricity. It has also acquired the fishery interests affected by its hydro-electric schemes and is now responsible for their management and preservation. In its capital assets and its annual turnover the Board is the largest industrial undertaking in Ireland. It is also the largest of all the state-sponsored bodies; its total assets being comparable with those of the Central Bank of Ireland. At the 31st March 1964 the Board employed a staff which numbered over 9,000 of which 6,000 were described as regular staff. Thus, its activities provide an important source of industrial employment, although being a highly capital–intensive undertaking the Board's financial rôle as a consumer of capital is relatively more important than its rôle as a provider of employment.

In the financial year ended 31st March 1964, the Board generated 2,900 million units of electricity, of which nearly 2,400 million were sold to its 680 thousand customers of all classes, industry, commerce and households. In the year ended 31st March 1930, 43 million units were sold, roughly 2% of current sales. More recently, over the ten-year period since the year ended 31st March 1954, sales have increased by 126% representing an average annual compound increase of 8½%.

The installed capacity of the Board's generating stations at 31st March 1964 totalled almost 850 thousand kilowatts, of which just over a quarter was hydro plant, nearly two-fifths was plant equipped to burn turf fuel in one form or another, and the remaining one-third was steam plant for either coal or oil. Of this last group, one small station is specifically designed and located to consume Irish coal. The largest steam generating set had a rated capacity of 40 thousand kilowatts, although sets of 60 thousand kilowatt capacity are at present being installed.[1] The largest hydro set had a rated capacity of 25 thousand kilowatts.

[1]By the beginning of 1965 the first of these sets was in operation.

The Electricity (Supply) (Amendment) Act of 1941 clarified the Board's position in regard to its powers to generate electricity with turf as a fuel. It envisaged the use of turf by the Board but without laying down the Board's specific responsibilities in that respect. Thus, the spirit of the original Act in regard to water-power was extended in a general sense to the use of turf, the other potential indigenous source of power. The original Act included few clauses dealing with the choice of new generating stations since at that time it was expected that the Shannon scheme would mean the closing down of existing generating plant, and the great upsurge in demand requiring the construction of much new plant was not foreseen. Nevertheless, Section 27 of the Act gave the Board responsibility for advising the Government on the exploiting of Ireland's natural resources. Government policy with regard to the use of turf became clear in 1946 with the publication of a White Paper which established among other things that new thermal plant should, where possible, be built to burn turf.

Thus, the Board has been required to give special preference to indigenous fuels, and in particular to the use of turf. Quite clearly this requirement has, at times if not always, conflicted with its own interests —interpreted in a narrowly commercial sense. Generating stations have had to be located at the source of fuel and further from the load centres on the coast than stations burning imported fuels need have been. Transmission losses have thus been increased. Stations to burn turf tend to cost more than equivalent coal/oil stations, both because turf is a bulky fuel requiring more expensive handling equipment and because the Board has had itself to play a large part in the development of the stations. Finally, in its day-to-day supply operations the Board must give preference to a fuel which at current import prices costs them more than coal or oil, and which is in short supply at times, sometimes most inconveniently.

Water-power, the other main indigenous source of electricity, does not suffer from the fuel price disadvantage of turf. The greater expense of the construction of water-works is compensated by an almost negligible operating cost. The disadvantage of this form of power, however, is its inherent variability because of its dependence on rainfall. The annual power output from the Shannon works, for example, has varied in a ratio of more than 3 : 1 from a very wet year to the very dry year of 1933. This variability could be avoided by installing less generating capacity but it would mean water being wasted in a wet year. The seasonal variation in water flow could also be avoided, by building large water storage facilities. The relative economics of the various possibilities are too complicated to describe here, but usually the most economic solution involves accepting considerable fluctuation in output, both seasonally and from year to year, and installing additional steam plant so as to be prepared for abnormally dry periods. There remains, inevitably, some small residual degree of risk but the cost of eliminating entirely all risk of short supply would be too great to contemplate; rather it is a case of choosing an acceptable minimum risk and paying the cost of the additional facilities thus required. The same principle is applied to the risk of bad weather curtailing the supply of turf and, indeed, to the risk that any station or part of the transmission system may break down.

A scheme for supplying electricity to rural areas was begun in 1946 after a report, prepared by the Electricity Supply Board, had been published in 1944. The report estimated that supply could be offered at standard rural rates to the majority of rural dwellings in Ireland if half the capital cost of connections were provided by subsidy. By the end of March 1964 only in seven out of the 792 areas scheduled for connection under the original scheme did work remain to be completed and supplementary schemes were already under way. At the end of 1964 the limit to expenditure on rural electrification was £37 million; nearly £34 million had been spent on assets already in commission in March 1964. The government has recently authorised the payment of a larger share by way of subsidy towards the connection of some rural dwellings not included in the original scheme. The subsidy (in the form of non-repayable capital contributions) paid by the government up to March 1964 had, however, fallen short of the half originally envisaged, by approximately £9 million.

In the financial year 1963/64 sales of electricity brought in over £20 million, more than forty times as much as in 1929/30. In that year the average selling price of electricity per unit was a little more than 2½d.; the average selling price in 1963/64 was just over 2d. Thus, even in current prices there has been a fall in price. Taking into account the declining purchasing power of the pound, the drop has been substantial. It has been the result of a combination of factors, not least among them the economies of scale possible in this industry and the rapid technical advances that have been achieved during the last 30 years. The fall in price in real terms is the result of the efforts made by the Board to adapt itself to changing conditions and to absorb, and take advantage of, technical advance; it provides a broad measure of the Board's success.

The 1927 Act established the basis on which electricity prices were to be fixed. In P. J. Dempsey's words: "It was a simple one with the objective: no profit, no loss". Explicitly, the Act stated that:—

"All charges made by the Board . . . shall be fixed at such rates and on such scales that the revenue derived in any year by the Board from such sales and services together with its revenue (if any) in such year from other sources will be sufficient and only sufficient (as nearly as may be) to pay all salaries, working expenses and other outgoings of the Board properly chargeable to income in that year (including the payments falling to be made in such year by the Board to the Minister for Finance in respect of interest and sinking fund payments on advances out of the Central Fund) and such sums as the Board may think proper to set aside in that year for reserve fund, extensions, renewals, depreciation, loans, and other like purposes".

While it may be objected that such a permissive approach to what is properly chargeable to income before a profit balance is struck (or rather before a profit balance is avoided) hardly constitutes a satisfactory definition, by implication, of the term profit, there is no doubting that Dempsey's interpretation of its spirit is acceptable, namely that the Board's financial operations shall neither be a drain on the Exchequer nor a source of revenue for it. It fulfils its task as a legislative instrument without using the statute book for propounding economic theory. Specifically, the Act does no more than establish the mechanism for determining what the year's revenue shall be in relation to out-goings as shown on the balance sheet; it requires them to be equal (the balance sheet, it will be recalled, is subject to approval by the responsible Minister after consultation with the Minister for Finance). The Board's financial operations have undoubtedly proved satisfactory according to the terms of the Act and the general pattern has been to show a relatively small surplus described simply as a residue or surplus per net revenue account. In the year ended March 31st, 1964, for example, the declared surplus amounted to £370,000, less than 2% of receipts from sales.

The 1927 Act does not concern itself with how individual rates of charge shall be set but only, and again by implication, with the average level of such rates. While in 1963/64 the average revenue for each unit of electricity sold was just over 2d., the marginal rate per unit (the price of an extra unit) varied by a factor of more than ten. Cheapest were units sold at high tension on the industrial maximum demand tariff during the last two months of 1963, when some units were sold at seven-tenths of a penny per unit—excluding both fixed charges and charges for each kilowatt of maximum demand. Most expensive were units sold for lighting industrial premises outside the Dublin tariff area; the first 500 units of consumption were sold at eightpence per unit with no fixed charges to pay. A similar rate applied to the first 240 units of electricity for lighting in registered hotels outside the Dublin area. It is the business of the Board to set these rates subject only to the overall requirement that its revenue shall equal its outgoings over the year. The principles involved in rate-fixing are discussed in a later section of this paper.

The brief description given in the above paragraphs hardly does justice to the task facing the Electricity Supply Board in controlling an undertaking that is in size and function almost a major sector of the economy in itself. It gives little inkling of the technical complications of generating and supplying an essential but dangerous form of energy to nearly every home in the country. It must do so 24 hours of the day every day of the year, when water and fuel supplies run low and when freezing conditions (like those of early 1963) prevail just as on a warm spring day when water and fuel are plentiful. The problem is to fit the load, the conductors, and the generators into a supply network that is as cheap as possible to build, maintain, and run while at the same time giving adequate safety and reliability of supply to consumers.

The economic problems are no less severe. In the first place, the overall national interest may dictate policies that override the normal commercial interest of the Board. Such policies are necessary because the electricity supply industry requires large amounts of capital, because its decisions about plant and fuel can substantially affect not only other branches of domestic industry but also the country's foreign exchange balance, and finally because electricity is a commodity essential for industrial and economic growth. The interpretation of what is in the national interest is the task of government and the electricity supply industry may at times be subject to direct and indirect controls exercised by government. In the second place, the Board must plan its operations and investments within these constraints in order to deliver electricity to the consumer at the lowest possible cost. A power station can take five years or more to build, which points to the calibre of the judgements that must be made by the Board and by its planning staff if, in the event, the industry is to find itself equipped to meet the demand that arises. Under-investment and over-investment are likely to be strongly criticised, should either ensue.

The consumer of electricity is more than a mere purchaser. He is also, at several removes, the owner of the supply undertaking. This dual rôle may arouse some conflict of interest, for the public will naturally react more vocally to a price increase which affects each of its members individually than to a failure to raise price even though such a measure were in the collective interest. Too low a price would mean that the community would have to pay for the electricity consumed through taxes and, less directly, through other benefits foregone. In setting prices, then, the reactions of the consumer cannot be neglected but the interests of society as a whole must be safeguarded.

The present survey of the operation of the electricity supply industry in Ireland has been undertaken as part of a review of the overall fuel and power requirements of Ireland. It was not begun with the primary intention of analysing the activities of the Electricity Supply Board and it is not intended to be a thorough-going analysis of the Board's activities. It does nevertheless deal exclusively with the Board and with its activities. The survey is divided into four sections of which this, which gives some of the historical background, is the first.

The second section describes and analyses the physical aspects of the Board's operations. Physically, the Board's task is to turn energy from a variety of sources into electricity and to distribute electricity produced. Any application of economics to the study of that task would lack empirical content and utility were it to neglect first to examine the basic physical and technical characteristics of electricity supply and demand. Electricity is sufficiently distinct in its characteristics from other manufactured goods and from other services to justify the fairly extensive examination that has been undertaken.

Attention is given to the pattern of generation and to the pattern of use of electricity. Various trends are identified and quantities attached to them; these trends are of well-known types, the increasing proportional use of thermal sources for generating electricity, for example, and the decreasing specific consumption of fuel per unit of electricity produced. Statistics of fuel consumption, electricity generation and electricity consumption are presented on a calendar year basis. The author was given access to the Board's internal reports in order to prepare these statistics and he received much generous assistance from officials of the Board in this and other matters.

The third section reviews the Board's financial operations in some detail for the financial year 1963/64 and in summary form for the ten preceding years. In its annual reports to the Minister the Board presents its financial results in eleven separate accounts. Considerable effort is called for in assessing developments over a period of years because of the abundance of data and the complicated form of the presentation. It is hoped that the summary of eleven years' accounts on one table will give a useful perspective to the Board's operations. Some liberties have been taken in preparing these accounts in order to focus attention on the financial flows involved.

The fourth section deals with the pricing of electricity. It shows that the statutory injunction that the Board be solvent in its financial operations does not, in itself, determine the detailed structure of electricity tariffs. Possible criteria on which tariffs could be based are considered, as are the advantages and disadvantages of the different types of tariff commonly used. The argument is tentative rather than conclusive. Its main concern is to demonstrate the importance of pricing policy, of establishing a price mechanism that will if possible have a determinate and justifiable relation to defined ends.

That the rate of consumption of electricity has peaks and valleys is well-known and that the expected rate of consumption at the peak determines the amount of supply capacity needed, if black-outs are to be avoided. This is traditional ground for those economists to till that are searching for ideal pricing systems. The answers produced are generally derived from a more or less sophisticated application of marginal cost-pricing which in turn depends on difficult and controversial theorems of welfare economics. Marginal cost-pricing of electricity requires that the price of electricity vary with the time of day and the season of year, which in turn means the installation of expensive metering facilities. Only in France are marginal principles applied to electricity rates to any great extent; elsewhere they have been rejected on grounds of impracticability and of cost. One great advantage of time-related charges needs little theoretical justification: they enable consumers at the time of the peak to be charged a price for electricity that reflects its cost. This problem is, of course, of great importance in meeting the nation's need for energy—for fuel and power of all kinds—in a way which reflects both consumer preference and the real cost to the nation.

In an appendix an attempt is made to determine the costs of supplying electricity in Ireland as if marginal principles were being applied. With a considerable number of important reservations about the procedure adopted for calculating these costs, and using figures that should be regarded as merely to illustrate the nature of the calculations, a range of costs are determined. During winter peak hours the marginal unit cost is estimated at 8·9 pence, almost 13 times as great as the marginal unit cost of 0·7 pence estimated for summer off-peak hours. At present the majority of consumers pay between one penny and twopence for extra units at peak hours. However, the remedy is easier to propose than to apply and some pains are taken to describe the practical difficulties of applying time-related charges. Apart from any question of advocating revolutionary changes in pricing policy, the calculating of cost is a useful exercise in itself. Economic programming as it is nowadays practised by government depends for its success on its accurate knowledge of the costs of alternative courses of action. The price the consumer pays for any good may or may not reflect its cost in any determinate sense, for price may be subject to considerations other than those of cost, but at least that cost should be known if the right decisions are to be taken.

SECTION 2: THE SUPPLY AND CONSUMPTION OF ELECTRICITY

This section is concerned with the physical aspects of electricity supply and consumption, how electricity is made and used in Ireland. It cannot hope in such a few pages to cover the subject exhaustively. It attempts, however, to give a broad impression of supply and demand and to study some interesting aspects in detail. Figures are used to illustrate the argument whenever possible.

The section divides naturally into two parts, the first dealing with consumption of electricity and its characteristic fluctuations and the second dealing with the supply of the electricity consumed.

In discussing this highly technical subject it is necessary to use a certain number of specialised terms. These have been avoided where possible. Where such terms remain they are sufficiently familiar not to need elaborate explanations: a term like "generating capacity" for example. However, there are two technical terms an understanding of which is essential to seeing clearly the problems of electricity supply. They are the terms "load" and "peak".

The "load" is the rate at which electricity is being consumed and, consequently, it is also the rate at which the supply system has to work in order to meet that consumption. It varies continuously, but for many practical purposes the load can be pictured as varying from hour-to-hour. It is measured in power units, watts in the case of electricity although it would be entirely possible to measure the load as so many horse-power.

The maximum load experienced during a given period is called the "peak" load and, quite obviously, the supply system has to be powerful enough to meet this load (the maximum power of the system is called its supply, or generating, capacity). More generally, the pattern of variation of load during the period is called the load curve, the highest point of which is the peak load.

An important property of the load curve is the "load factor". This measures average load as a percentage of peak load. A load factor can relate to a day, to a year, or to any prescribed period without any change of definition. The use of the term load factor need not be confined to the whole supply system; it can also describe the load characteristics of a single consumer, of a single appliance, and of groups of consumers and of appliances.

Exactly as the load factor describes an important characteristic of demand for electricity, a measure called the "plant factor" describes a corresponding characteristic of supply. It measures the average load met as a percentage of the output capacity of the supply system, or of any part of the system down to the individual generating set. As far as the system as a whole is concerned the difference between load factor and plant factor is due to whatever unused generating capacity there may be in the system at the time of peak load.

Finally, it is important to add that the individual peak loads of a number of consumers (or of appliances) do not in general add up to give the system peak load. This is because they do not all occur at the same time and is a property referred to as "diversity". It could happen that at the time of the system peak no individual consumer was using electricity at his individual peak rate of consumption.

The Consumption of Electricity

Electricity is a form of energy much in demand. It provides the most easily controlled means of producing mechanical energy and it can be very simply converted into heat. It is essential for many technically specialised applications like radio, television and telephone. No other form of energy has such a wide range of use.

In many of its uses, electricity has no substitute. But in its heating uses, from domestic heaters to industrial furnaces, it has to compete with most other forms of energy. It has certain advantages—of cleanliness and ease of regulation—but it tends to be relatively costly as heat because it is energy in high-grade form, that has gone through a process of manufacture or transformation. Its other advantages in heating uses are, first, that electricity is almost always at hand because it must be used for lighting, and second that electrical heating appliances are relatively cheap because of their simplicity. The availability of electricity and the cheapness of appliances that use it make up a lot for its comparatively high price as a form of heat.

Income, price and the other factors mentioned are the general determinants of consumption. Season, climate, and social and working habits have a more particular effect. According to the pattern of daily habits of cooking, washing, working and relaxing, so will the demand for electricity fluctuate during the day: for use in electric cookers and in water-heaters, for industrial purposes, and for comfort-heating, television, radio etc. Daily load curves will tend to follow roughly the same pattern on all working days of the week, but to follow different patterns on Saturdays, Sundays and holidays. In addition there is an annual cycle of seasonal variation.

These regularities of variation in the rate of consumption are clearly to be seen but they are not exact. No two load curves ever have exactly the same shape. On any day at any hour the rate of consumption will depend on the particular climatic and other conditions then prevailing. The more rapid the growth in consumption the more likely it is that patterns of consumption are changing over time.

Consuming appliances of a similar nature may be grouped together: water-heaters; cookers; radiant fires; storage heaters; industrial furnaces; street lamps etc. etc. Over the year each group of appliances of a similar type will have a characteristic pattern of use. Heating appliances will show a strong seasonal influence, and a daily variation that will depend on the type of appliance: radiant fires will be used morning and late evening, storage heaters at night. Cookers will show little seasonal influence but a strong and relatively stable variation from day-to-day (except on Fridays!). Electric furnaces will probably show no seasonal effect at all but have a daily variation in consumption depending on the shift system worked in the industry where they are used.

Just as each group of similar appliances will have its characteristic pattern of use, so each class of similar consumers will own a characteristic set of appliances. Householders will tend to own electric irons, refrigerators, washing-machines, heaters and radio sets and to consume electricity at certain times according to when they use these appliances. Thus, each class of consumer will have its respective pattern of consumption of electricity, depending on the sort of appliances it owns.

To sum up, total consumption over the year shows a daily, weekly and seasonal pattern of variation that can either be considered to be the sum of the use-patterns of different types of appliance or the sum of the use-patterns of different classes of customer.

The pattern of variation of the total is easy to identify because it is equivalent to the pattern of generation, which is known down to the last detail. Table 1 shows the variation in peak load and the variations in total consumption from quarter-to-quarter for selected years. Table 2 shows the variation by month, and Table 3 shows the variation during the day on representative summer and winter days.

The monthly consumptions in Table 2 are not

Table 1: QUARTERLY AND ANNUAL VARIATIONS IN CONSUMPTION OF ELECTRICITY; SELECTED YEARS

Year	Item	Unit	Quarter[1]				Year
			Jan/Feb/Mar	April/May/June	July/Aug/Sep	Oct/Nov/Dec	
1950	Peak load	th. kw	217	190	190	251	251
	Consumption[2]	m. kwh	238	195	191	277	901
	Load factor[3]	%	50·1	46·9	46·0	50·5	41·1
	Variation in consumption		125	102	=100	145	—
1955	Peak load	th. kw	348	294	285	362	362
	Consumption[2]	m. kwh	449	331	308	440	1,528
	Load factor[3]	%	59·0	51·5	49·4	55·6	48·3
	Variation in consumption		146	108	=100	143	—
1960	Peak load	th. kw	476	415	425	540	540
	Consumption[2]	m. kwh	644[4]	466	459	652	2,221
	Load factor[3]	%	61·9	51·4	49·4	55·3	47·1
	Variation in consumption		140	102	=100	142	—
1963	Peak load	th. kw	632	561	507	674	674
	Consumption[2]	m. kwh	864	618	571	798	2,851
	Load factor[3]	%	62·6	50·4	51·5	54·2	48·4
	Variation in consumption		151	108	=100	140	—

Notes: [1]Consumption data relate to 13-week periods.
[2]Total electricity generated before subtracting use by station auxiliaries and transmission losses etc.
[3]Calculated against quarterly or annual peaks respectively.
[4]This quarter comprised 14 weeks; total has been scaled down in the ratio 13:14.
Source: Data extracted from E.S.B. records.

exactly comparable because some months contain more weekends than others, but they serve to illustrate the degree of fluctuation. Consumption in August is always low and falls out of sequence because of the incidence of holidays. January 1963 was an especially cold month.

Table 2: MONTHLY CONSUMPTION OF ELECTRICITY; 1962 and 1963

Month	Million units consumed			
	1962	1963	Total	June=100
January	272	321	593	164
February	230	277	(507) 562	156
March	253	255	508	141
April	206	227	(433) 448	124
May	189	212	401	111
June	170	180	(350) 361	100
July	177	191	368	102
August	170	183	353	98
September	192	205	(397) 410	114
October	223	240	463	128
November	257	266	(523) 540	150
December	277	309	586	162

Source: ESB *Annual Reports.*
Note: Months with less than 31 days have received proportional increases as shown in the Total column.

If the pattern of variation of the total load applied to the system is known down to the last detail, the patterns of variation of the individual loads applied by consumers, by groups of consumers, and by different types of appliance are much more difficult to know. To obtain this information—and it is information that is basic to setting up tariff structures that discriminate between classes of consumer and between types of use—expensive and time-consuming surveys must be conducted, using sampling techniques.[2] The shape of the load curve of electricity supplied under a particular tariff could be determined only by continuously observing, or recording the readings of, the meters of a sample of the consumers supplied with electricity under this tariff over a period of time. Less difficult to determine, perhaps, are the load curves applied by different classes of consumer. For example, the power supplied to a suburban area, where electricity is used for household purposes only, would probably pass through a small number of sub-stations and the output from these stations could be traced with precision. Industrial consumers are fewer in number

Table 3: LOADS AT SELECTED HOURS ON REPRESENTATIVE SUMMER AND WINTER DAYS IN 1963

Hour	Approximate Load; '000 kw	
	Tuesday 2nd July 1963	Thursday 19th Dec. 1963
2.00 a.m.	150	300
5.00 a.m.	140	280
7.00 a.m.	190	350
9.00 a.m.	375	580
12.30 p.m.	440	630
2.00 p.m.	320	510
4.00 p.m.	330	530
5.30 p.m.	320	670
9.00 p.m.	250	550
11.00 p.m.	315	525

Source: Charts published in the ESB 1963/64 *Annual Reports.*

[2]The ESB do indeed carry out such surveys from time-to-time.

and their demands much greater; their patterns of load variation merit individual attention.

However, the general point, which must be emphasised, is that it is one thing to know the breakdown of total electricity consumption between consumers and appliances over an accounting period, but quite another to know the breakdown of the "instantaneous" load applied at any time. This point will be referred to later when tariff structures are discussed.

The analysis of total annual consumption by class of supply that has become a traditional part of the Board's reports does not distinguish clearly either between classes of consumer or between types of appliance (this is because the tariff structure does not permit a full analysis by type of appliance). However, the Board keep internal records of the sales of electricity to the main classes of consumer and the author has arranged these two-monthly sales figures to give quarterly and annual totals. Table 15 appended shows the annual totals for industrial, commercial, and domestic consumers for each year from 1950 to 1963. In Table 4 the proportions of total annual sales going to the principal classes of consumer (with a slightly more detailed breakdown than in Table 15) are shown for selected years.

TABLE 4: PERCENTAGE OF ELECTRICITY SALES BY CLASS OF CONSUMER; SELECTED YEARS

Percent

Consumer Class	1950	1955	1960	1963
Industry	33	31	33	32
Commerce	23	23	22	23
Public lighting	4	3	2	2
General domestic	37	33	31	31
Rural domestic	3	10	12	12
	100	100	100	100

Source: Data extracted from ESB records.

Changes during the last 13 years have not been startling, the remarkable feature being the increase in rural consumption. In England and Wales in 1962/63 a much higher proportion (43%) went to industrial consumers; households and farms together consumed nearly 34% of the total, and commercial consumers only 10%. Possible disparities in the classification of consumers do not permit more detailed comparisons.

Quarterly sales figures permit a slightly more useful breakdown of consumption, since they permit some analysis of the seasonal variations in consumption. For the quarters of 1962 and 1963 estimates of sales by class of consumer are given in Table 5.

It is immediately obvious that Industry provides a balanced seasonal pattern of demand, almost completely lacking fluctuation from quarter-to-quarter,

TABLE 5: QUARTERLY SALES OF ELECTRICITY BY CLASS OF CONSUMER; 1962 AND 1963

Million units

Consumer Class	Quarter: Jan./Feb./Mar.	April/May/June	July/Aug./Sep.	Oct./Nov./Dec.
Industry:				
1962	172	174	166	186
1963	186	182	180	197
Total	358	356	346	383
3rd quarter=100 ..	103	103	100	111
Commerce:[1]				
1962	167	106	80	147
1963	188	113	87	153
Total	355	219	167	300
3rd quarter=100 ..	213	147	100	202
General Domestic:				
1962	203	145	127	191
1963	242	156	137	205
Total	445	301	264	396
3rd quarter=100 ..	169	114	100	150
Rural Domestic:[2]				
1962	75	57	51	71
1963	91	63	56	78
Total	166	120	107	149
3rd quarter=100 ..	155	112	100	139

Notes: [1]Excludes public lighting.
[2]Includes all consumption on the rural two-part tariff, of which some is for agricultural uses.
Source: Data extracted from ESB records.

TABLE 6: TREND RATES OF GROWTH IN SALES OF ELECTRICITY; 1950 TO 1963

Class of Consumer[1]	Calendar years: % p.a.	R^2 [3]
Total Sales	9·0	·99
Industry	8·9	·99
Commerce (excl. public lighting) ..	8·8	·98
Domestic	9·6	·99
of which: general	7·4	·99
rural	20·4	·90
Class of Supply[2]	**Financial years: % p.a.**	**R^2 [3]**
Total Sales	8·9	·96
Domestic	8·9	·99
General lighting	7·0	·99
General heating, cooking and water-heating	8·0	·98
Night storage	11·0	·78
Motive power	9·0	·98

Sources of data: [1]ESB records.
[2]ESB *Annual Reports*.
[3]Measures closeness of fit of simple exponential trend lines.

but that Commerce has an extremely high seasonal variation in demand. This is not unexpected because the electricity used by Commerce must mostly be for heating shops and offices and for display lighting. General and rural domestic sales show an intermediate pattern of fluctuation, the heating load being balanced to some extent by the cooking, water-heating and other loads that continue throughout the year.

To examine the growth in sales of electricity over the years, simple time trends have been fitted to annual sales figures by the method of least squares. To each series of data a simple exponential trend has been fitted, which amounts to assuming that, but for random deviations, each series has grown with a constant compound rate of increase. Naturally this assumption suits some of the series better than others, and indeed its suitability for rural domestic sales (where the rate of increase in the number of new consumers is declining rapidly) and for night storage heating sales (where the rate of increase in sales has fallen considerably in recent years) is questionable. For simple comparisons of "average" rates of growth, however, the approach is acceptable. Table 6 shows, first, the breakdown of calendar year sales by class of consumer and, second, the breakdown of financial year sales by class of supply (as given in annual reports), giving in each case the "trend" rate of increase and the proportion of variance explained by the curve fitted. The differences between growth rates are seen to be small except in the case of rural domestic sales.

The Supply of Electricity

An electricity supply system consists of a network of generating stations connected to the centres of consumption and to each other by transmission lines, usually the familiar pylons stretching across the countryside. Power is carried in these transmission lines at high voltage to reduce losses, and is transformed to lower voltages for local distribution to factories, business premises and homes. In the home, connection is made via the meter to the usual electricity-consuming equipment.

The transmission grid of the Irish supply system consists in nearly 1,700 miles of 110 kilovolt lines and cables. These lines run around the perimeter and across the middle of the country to connect the major inland generating centres (on the bogs of the Central Plain) and the hydro generating centres (on the Shannon, Lee and Erne rivers) to the centres of demand at Dublin and Cork etc. 110 kv. is not a high voltage by world standards; a 735 kv line has been installed in Canada and research into the carrying of power at 1,000 kv is now proceeding in various countries. The need for high voltage is a function of the distance and of the power to be transmitted; the relatively short distances involved in Ireland make very high voltages unnecessary. However, a 220 kv super grid is under construction—to stretch across the country from Cork to Dublin via Limerick and via the milled peat station being built at Shannonbridge, Co. Offaly. Work began on this project during 1963.

Distribution takes place at 38 kv and lower voltages. There were over 2,500 miles of 38 kv lines and cables in existence at the end of March 1964 and well over 50,000 miles of lines and cables at 10 kv and 380/220 volts.

Generating Plant

In Ireland, electricity is generated either from water-power or from the burning of fuels, there being no nuclear power stations, no geothermal steam sources, and no generation from wind-power or tides. Generation from all native sources made up 62·5% of all electricity generated in 1963/64 and, of this, 38·9% was generated from native coal and turf. In 1953/54 the proportions were: all native sources 68%; hydro 41·2%; turf 26·8% (there was little or no native coal burnt).

Generating equipment on 31st March 1964, included nine hydro-electric stations with a total maximum output capacity of 219 thousand kilowatts in 16 separate generating sets. Fuel-fired steam generating stations were 15 in number with a total maximum output of 630·5 thousand kilowatts in 33 separate generating sets.

Seven of the steam stations were designed to burn sod turf (including four small stations) and these stations had a total output capacity of 117·5 thousand kilowatts. Three further stations burned turf in the form of milled peat, with a combined output capacity of 210 thousand kilowatts. A single station at Arigna, Co. Roscommon, used Irish coal as fuel; it had a capacity of 15 thousand kilowatts. The remaining four stations, of total capacity 288 thousand kilowatts, burned imported fuels, either coal or oil.

Table 7 gives the capacities of the generating stations in commission at 31st March, 1964, with the fuels they were designed to burn and the years in which they were brought into commission.

Technical details of these stations can be found in the appendices to the Board's annual report.

It will be noticed that, while much of the hydro plant—which in any case has a very long lifetime—is more than ten years old, the majority of the steam plant has been installed within the last ten years. The notable exceptions are the large stand-by station at Pigeon House, most of the equipment of which is over 30 years old, and the two largest stations burning machine-cut turf, at Portarlington (part) and Allenwood.

Table 7: GENERATING CAPACITY AT 31ST MARCH 1964

Station	Maximum Output Capacity (kw)	Fuel, or Water Source	Date of Commissioning
Ardnacrusha	85,000	Shannon	1929^{3}; 1934^{1}
Poulaphouca	30,000	Liffey	1944^{1}; 1947^{1}
Golden Falls	4,000	"	1943
Leixlip	4,000	"	1949
Cliff	20,000	Erne	1950^{1}; 1955^{1}
Cathaleen's Falls	45,000	"	1951^{1}; 1952^{1}
Carrigadrohid	8,000	Lee	1957
Inniscarra	19,000	"	1957
Clady	4,000	Clady	1959
Total hydro ..	219,000		
North Wall	48,000	Oil	1949^{1}; 1953^{2}; 1964^{1}
Marina (Cork)	60,000	Coal or Oil	1954
Ringsend	90,000	"	1955^{2}; 1956^{1}
Pigeon House	90,000	"	1929^{1}; 1935^{1}; 1936^{1}; 1938^{1}; 1940^{1}
Arigna	15,000	Irish coal	1958
Portarlington	37,500	Sod Turf	1950^{2}; 1962^{1}
Allenwood	40,000	"	1952
Lanesborough	20,000	"	1958
Four small stations	20,000	"	1957^{3}; 1958^{1}
Ferbane	90,000	Milled peat	1957^{3}; 1964^{1}
Rhode	80,000	"	1960^{2}; 1963^{1}
Bellacorick	40,000	"	1962^{1}; 1963^{1}
Total steam ..	630,500		
Total All Plant	849,500		

Source: ESB *Annual Report* 1963/64; commissioning dates supplied by ESB.
Note: The figures superscribed in the right hand column show the numbers of generating sets commissioned during the year to which they refer.

Only one generating station has been retired from service during the last ten or fifteen years, the steam station at Albert Road, Cork, in 1953–54. Next to be retired will be the old plant at Pigeon House at the southern lip of the entrance to Dublin Harbour, near to where Ringsend station already stands.

Operating the Supply System

Any given hourly demand up to the total supply capacity then available can be met in a number of ways by choosing which stations shall be used to generate electricity. Of course, if the load is equal to the capacity available there is no choice. If not, then the cheapest way of meeting the load is to use stations (or individual generating sets) with the lowest operating costs, or (more generally) with the lowest incremental/decremental generating costs. Provided that there are no long-period constraints, stations with the lowest operating costs will be used more over the year as a whole. Constraints arise through the withdrawal of plant for maintenance and repair, through the lack of sufficient storage or inflow of water at hydro stations, and through shortage of fuel at steam stations (this constraint applies particularly to stations that burn turf).

Hydro stations are not designed to run at maximum output capacity the whole year round. The inflow of water is so variable that to achieve continuous running would mean installing turbines of such low capacity that large volumes of water would be wasted during wet periods. To a limited extent water can be stored from hour-to-hour (if it is not overflowing its storage capacity) and can thus be saved to meet demand peaks. But storage capacity is not intended nor is it sufficient to permit seasonal balancing of supply. The available capacity at any instant and the output of electricity over any period depends on the rate at which water has accumulated and can be run off through the turbines without bringing the water-level below limits set in the interests of safety and amenity. Ultimately the amount of electricity available depends on the rainfall over the area drained by the rivers serving the hydro-electric works. More electricity can be generated in the wet than in the dry season and the total quantity of electricity produced over the year can vary quite widely depending on the year's rainfall. Table 8 shows the monthly and annual outputs of hydro-electric stations during the last five years.

On the experience of the five years shown in Table 8, June is the month with the least flow of water and December that with the greatest. Both the monthly and the annual figures show large variations; the variation by a factor of 18 between the months of September 1959 and September 1960 is specially to be remarked, as is that between the year 1959 and the year 1960. On the whole, more water is available in winter when more electricity is consumed, and thus hydro fits well into the supply system. However, shortages of water in the Spring

TABLE 8: GENERATION OF HYDRO-ELECTRICITY BY MONTH; 1959 TO 1963 MILLION kwh

Calendar Month	Year					Average Hydro Output	Average Total Output	% Hydro
	1959	1960	1961	1962	1963			
January	111	134	135	105	47	106	256	41
February	33	114	121	87	52	81	220	37
March	65	88	46	50	100	70	221	32
April	54	68	58	73	71	63	190	33
May	35	23	43	21	45	33	172	19
June	12	23	16	9	15	15	157	10
July	8	37	29	8	22	21	164	13
August	7	45	26	27	17	24	157	15
September	5	91	41	74	33	49	176	28
October	49	85	89	69	67	72	207	35
November	100	123	70	78	132	101	240	42
December	140	137	122	102	91	118	262	45
Total ..	619	968	796	703	682	753	2,422	31

Note: The monthly output figures shown here already include some smoothing out of the water inflow, through the accumulation and storage of water.
Source: ESB *Annual Report.*

and Autumn can be quite serious during sudden cold spells if a considerable amount of steam generating capacity is out of action for repair or maintenance. Indeed, the demand for electricity in a dry Autumn has been the deciding factor in determining how much generating capacity the supply system will require to meet demand throughout the year and not the need to meet *peak* demand during the coldest days of December and January. Water-power, for all its blessings of cheapness and of being self-renovating, can bring economic disadvantages if too much additional steam plant has to be installed merely in case very dry Autumns should occur. As the supply system grows, and hydro—which is already developed to its maximum extent under present economic conditions in Ireland—becomes a less significant part, so will its variability matter less. This may shortly be the case.

Steam plant, if more expensive to run, is not at the mercy of the elements in the same way as hydro plant. Steam plant can operate continuously at full power, except for periodic withdrawal for maintenance (that it is usually possible to programme to take place during the summer months of slack demand for electricity). It can meet any demands thrust upon it provided only that fuel is available and that sufficient warning is given to enable boilers and turbines to be warmed up ready to come into operation when required. This may take several hours, compared with a matter of minutes for a hydro station, and is an important consideration in being ready to meet sudden changes in demand. A hydro-electric station, and particularly one with storage for water (rather than one depending on run-of-the-river flow) is much better adapted to meeting unexpected surges in demand, supplying more power temporarily, perhaps, while a thermal station is being brought into operation. It is standard procedure to keep some plant on what is called spinning-reserve, ready to meet any added demand whether from consumers or arising through loss of capacity in some part of the system.

Electricity cannot be stored by conventional means and the switching-on of any appliance anywhere causes an immediate drain on the supply facilities then in operation and generating electricity. The number of appliances using electricity over the whole country, and their type, varies from instant to instant and the instantaneous load on the generating facilities fluctuates in quite erratic fashion. A sudden overload or a sudden fall in the load can be dealt with competently by the generator itself, within limits naturally, and provided that it does not last for more than a few minutes.

When more electricity is demanded than the system is designed to supply, the situation is quite serious. A small percentage over-demand can be met temporarily by overloading some generators and taking the chance of permanent damage being done by over-heating of parts of the plant. Further increases in demand can only be met by spreading the existing output more thinly, by lowering the frequency and voltage. The stability of supply is threatened if this goes too far, and then load must be shed. At that stage the decision has to be taken to cut off supplies to enough customers to bring the load on the system down to a size that can be met. This must be done by cutting off supplies to a whole area, for customers cannot (usually) be cut off individually. It is a highly undesirable expedient, for the power cut may cause unknown hardship or distress when it comes unexpectedly. There are times when it may not be avoidable for there is inevitably some residual element of risk.

Preference for Native Fuels

It was stated earlier that the cheapest stations to operate will always be called upon first to supply electricity to meet demand. Hydro power is always cheaper than thermal power and will generally be used whenever it is available. Nevertheless, the overall objective is to use hydro power in such a way that a minimum amount of thermal capacity is called upon. The thermal capacity which is required can then operate as continuously and therefore as cheaply as possible. In addition, those thermal stations with the lowest fuel costs can be used to the greatest possible extent.

However the ESB is required to give preference to stations using native sources of energy, which introduces a constraint upon its selection of thermal plant to meet the load. The order of preference is determined first by the preference for native fuel and only then is the cost of operation taken into account. Table 9 shows stations in order of fuel costs in 1963/64. It also gives the order in which they were in fact used in 1963/64, according to their plant factors (or percentage utilisations) over the year. Hydro stations are grouped together for convenience.

TABLE 9: STATIONS IN ORDER OF FUEL COST IN 1963/64

Station	Fuel	Fuel cost order	Plant factor %	Use order
Hydro	—	1	34	8
Ringsend ..	Oil	2	71	2
Marina ..	Oil	3	61	3
North Wall ..	Oil	4	31	10
Bellacorick ..	Milled peat	5	33	9
Rhode	Milled peat	6	26	11
Arigna ..	Coal	7	73	1
Ferbane ..	Milled peat	8	47	7
Pigeon House..	Coal/Oil	9	13	13
Lanesborough	Sod Turf	10	55	5
Allenwood ..	Sod Turf	11	59	4
Portarlington ..	Sod Turf	12	49	6
4×5 MW ..	Sod Turf	13	23	12

Source: ESB *Annual Report* 1963/64.

It will be noticed in Table 9 that not all the stations using indigenous sources of energy are elevated in the order of preference over (cheaper) stations using imported fuels. Hydro falls in the order for reasons of limited water supply already mentioned. The Irish coal station rises to the head of the list. It would be expected that the turf stations would follow, in order of their fuel costs, but this has not happened. All the sod turf stations rose in the list but two of the milled peat stations fell, and no turf station displaced Ringsend and Marina. It must be concluded that this was occasioned by limitations on the supply of turf, though the extent is difficult to gauge.[3] Output from turf stations was particularly low between July and October, in order to conserve turf for the winter. As a result, stations burning imported fuels were used more in the summer months than in the winter months, when demand for electricity was greatest.

Of the four small sod turf stations, the operations of the three at Cahirciveen, Milltown-Malbay and Screeb have been very much curtailed by shortages of turf. The problem here, however, is not due to the weather specifically but to the difficulty of obtaining a sufficient local supply of turf.

It has been pointed out earlier that 1963/64 was a poor year for the turf harvest. Thus the conclusion drawn above that turf is in insufficient supply (with respect to the installed capacity of turf-burning plant) may not be true under more normal conditions. The year 1960/61 was a year of good harvest for turf and in that year turf stations, except for the three small stations just mentioned and the station at Rhode which was only commissioned during the year, fell into their expected order. That is to say, they took preference over stations burning imported fuels in the order of relative annual use. However, 1960/61 was also an especially good year for water-power and the total output required from steam stations was correspondingly low. 1961/62 was a more normal year for hydro, as it was for the turf harvest, and the figures for that year show turf stations being given preference with the exception again of the three small stations and of Ferbane, which had a slightly lower load factor than Ringsend. In a normal year it seems that sufficient turf fuel is available.

Fuel Characteristics

The ESB use four main types of fuel. The native coal burnt at the Arigna power station is of the semi-bituminous variety, of a quality not really good enough for ordinary household purposes for example, and some 50,000 tons or so are consumed annually together with small quantities of oil for starting-up. The coal costs the Board about 86 shillings a ton. The imported coal used at other stations equipped to burn coal, namely Ringsend, Marina and Pigeon House, is of much the same inferior grade. It was mostly imported from England and cost at Ringsend about 68 shillings a ton. In fact, in the financial year ended March 31st, 1964, coal was burnt at Pigeon House alone of these three stations and then only to the extent of some 10,000 tons.

Characteristic calorific values of the fuels used by the ESB are shown in Table 10. In the case of the turf fuels these are related to standard moisture contents and are based on turf of anhydrous calorific value of 9,500 Btu/lb (gross) and hydrogen content of ·055 (see Note (4) to Table 10).

The right-hand column of Table 10 shows the comparative useful amounts of heat available from

[3]New plant was brought into commission at Rhode and Ferbane which makes it difficult to draw more than general conclusions. It may be noted that the harvests of sod turf and of milled peat are not necessarily similarly affected, nor to the same extent, by bad weather during the cutting season.

TABLE 10: CHARACTERISTIC CALORIFIC VALUES OF ESB FUEL

Fuel	Gross Calorific Value Btu/lb.	Net Calorific Value[1]		NCV with Coal =1·0
		Btu/lb.	m.Btu/ton	
Coal ..	10,300	10,000	22·4	1·0
Fuel Oil ..	18,300	17,400	39·0	1·74
Milled Peat[2]	4,250	3,450[4]	7·7	0·34
Sod Turf[3]	6,650	5,950[4]	13·3	0·59

Notes: [1]The net calorific value makes allowance for the heat lost as steam formed from the combustion of the hydrogen contained in the fuel.
[2]At 55 % moisture content.
[3]At 30 % moisture content.
[4]The formula NCV=GCV−1,055(MC+(1−MC) 9H), where MC is moisture content and H is hydrogen content, has been used; this formula is given by H. M. S. Miller in a paper read to the Institution of Civil Engineers in Ireland entitled "The Peat Industry of Today and Tomorrow", January, 1955.

equal weights of the four fuels. Over five times as much milled peat by weight would have to be burnt to provide the same useful heat as that from fuel oil.

Power Station Efficiencies

The economic merits of one fuel rather than another can only be measured very roughly by calculating prices per Btu of useful heat available from the different fuels, because some fuels can be and are used more efficiently than others. Table 11 shows as examples the operating efficiencies of the best and worst of stations burning fuel of each type in 1963/64 in terms of the useful heat input divided by the electricity sent out from the station. Also shown are fuel costs per unit sent-out.

The efficiency of energy transformation implied by the heat rate of 11,600 Btu/kwh at Ringsend is 29·4%. That is, 29·4% of the net heat content of the fuel is converted into electricity sent out from the station. For Lanesborough and Ferbane B the efficiencies are 24·5% and 27·3% respectively. These efficiencies take account of the different proportions of electricity generated that are consumed by the stations themselves: roughly 8% for milled peat, 5 to 6% for machine turf and 4 to 5% for coal/oil. For hydro, the proportional station use of the electricity generated is just over 1%.

TABLE 11: OPERATING EFFICIENCIES AND FUEL COSTS OF SELECTED STATIONS; 1963/64

Station	Fuel	Capacity MW	Plant Factor %[1]	Heat Rate Btu/kwh[2]	Fuel Cost pence/kwh[3]
Ringsend	Oil	90	71	11,600	·40
Pigeon House	Coal/Oil	90	14	20,900	·72
Arigna	Irish Coal	15	74	13,400	·63
Lanesborough ..	Sod Turf	20	55	13,900	·75
Portarlington	Sod Turf	37·5	49	15,900	·88
Ferbane B	Milled Peat	30	38	12,500	·55
Ferbane A	Milled Peat	60	48	15,600	·67

Notes : [1]100 % would indicate that the station worked continuously at full power.
[2]Fuel input (NCV times fuel consumption) divided by units sent-out from station ; to calculate percentage efficiency divide the heat rate into 3,412 (Btu/kwh).
[3]Per unit sent-out from station.
Source : Data made available by the ESB.

The Ringsend and Marina stations are so equipped that they can burn either coal or oil. This introduces considerable flexibility into the choice of fuel, for not only is it possible to operate one station rather than another but it also becomes possible to burn one fuel rather than another in either of these stations. Thus the ESB has been well placed to take advantage of movements in the relative prices of coal and oil.

A dual-fired station, equipped to burn either of two fuels is a hybrid device and something of a compromise. Such a station is generally less efficient burning either fuel than a station designed to burn one fuel alone. The size of furnace, the siting of boiler tubes and the arrangements of flue, chimney and heat economisers differ between coal and oil stations. A station burning either coal or oil, therefore, will not only cost more to build because of its duplicate burning facilities but it will also cost more to run because it is not as efficient as a single-fuel station.

At present prices, electricity from oil is cheaper than electricity from coal and there seems little prospect, even in the long-term, of the cost differential being reversed. The need for dual-fired stations becomes correspondingly much less important. This is reflected in the Board's present construction programme of stations to burn imported fuels, which is confined entirely to oil-fired stations. There is however the prospect of an additional dual-fired station early in the 1970's.

Development of the System from 1950 to 1963

A summary of the development of the ESB supply system is presented in Table 15 appended to this section. The table shows installed capacity, peak load, electricity output, sales of electricity, and fuel consumption year-by-year from 1950 to 1963 with some of the technical characteristics of the system.

Installed capacity has more than trebled over the fourteen years, while the amount of electricity generated has grown in very nearly the same proportion. Peak load has grown somewhat erratically but its general trend has been much in line with the growth in capacity and in output. The system as a whole, therefore, has been expanding in capacity and production at between 8 and 9% a year. The particular feature worthy of remark is the large excess of installed capacity over the peak load from 1955 until 1959. This was due to the fact that from 1956 demand did not grow as rapidly as expected because of unfavourable economic conditions.

The data in Table 15 relating to the features of the system just discussed refer to financial years, because figures for installed capacity are only available at 31st March, at the end of the financial year. Data relating to fuel consumption and to sales of electricity are referred to calendar years (in fact, each "year" had either 52 or 53 weeks, but the differences are slight) in order to achieve correspondence with fuel consumption data for other sectors of the economy. Output data are given with respect both to calendar years and to financial years for convenience in making comparisons.

In the 1963 calendar year, 2,851 million units of electricity were generated, of which 684 in hydro stations and 2,167 in steam stations. Of the total, some 137 million units (nearly 5% of the total) were used within the stations themselves and 2,714 million units were sent-out from the stations. Losses in 110 kv and 38 kv transmission lines and in transformation amounted to about 235 million units (or just over 8% of the total). Of the remaining 2,479 million units some 2,351 million were sold to consumers (this estimate of sales is derived from ESB's bi-monthly sales returns and is no more than a close approximation). The difference of 128 million units is due to the losses in distribution networks and to the inevitable metering discrepancies that arise; 500 million units, or nearly 18% were lost or consumed in the system in 1963. This showed some improvement over 1950 when nearly 20% of output was consumed within the system or unaccounted for. In England and Wales in 1962/63, 136,500 million units of electricity were generated and 115,500 sold, losses being 15·5% of output. It would be unrealistic to attempt to draw too much from the comparison, since most losses are due to technical factors peculiar to the system, and particularly to the distance of generating stations from load centres (turf and hydro stations are at a disadvantage in this respect).

To produce the 2,167 million units generated at steam stations in 1963, 69,000 tons of coal (mainly Irish coal), 333,000 tons of oil, 618,000 tons of sod turf and 927,000 tons of milled peat were consumed. The turf tonnage figures have not been adjusted for variations in moisture content. The total net calorific value of the fuel consumed was just over 29 billion Btu, of which coal supplied 5%, oil 45%, sod turf 25%, and milled peat 25%. The proportions which the various fuels supplied in other years are shown in Table 12.

If 29·14 billion Btu were used to generate 2,167 million units of electricity, the average number of Btu's required to produce one unit of electricity in 1963 was 13,450. This is equivalent to a heat rate of 14,200 Btu per unit sent-out from steam stations, the figure given in Table 15. Since a unit of electricity is equivalent to 3,412 Btu, the average efficiency of energy transformation (from heat input to sent-out electricity) was 24%. Comparable levels of average heat rate for earlier years are shown in Table 15. There have been significant improvements in efficiency: the heat input required to send out 100 units of electricity in 1950 would have enabled 129 units to be sent out in 1963. Almost the whole of this improvement was achieved by 1956; further improvement was restricted because turf-fired plant which came into commission (mainly) during succeeding years had efficiencies close to the system average of 1956.

There is one point of interest in the variations in heat rate since 1956. The greater the output of hydro-electricity the higher has tended to be the heat rate (and the lower the operating efficiency of thermal stations); see 1960 in particular. This was because when the required output from thermal stations was low a greater proportion could be generated in the less efficient turf stations rather than in coal/oil stations. There are of course a large number of other factors that affect the average heat rate of the thermal part of the system.

The percentages of each of the fuels consumed annually are shown in Table 12; these percentages are calculated from the heat input figures of Table 15. Also shown is a simple indicator of the quantity of each fuel consumed in relation to 1963=100. There are two outstanding features to be observed in Table 12. One is the very high degree of fluctuation in the relative shares of coal and oil; coal's share has generally fallen and oil's share has risen but there was a significant reversal of this trend in 1957 and the three following years (to be discussed below). Taken together, the shares of coal and oil have fallen and those of sod turf and milled peat have risen; this is the second outstanding feature of the changing pattern of fuel consumption. In 1960 the two forms of turf together supplied almost two-thirds of the total heat input to thermal power

TABLE 12: HEAT INPUT TO THERMAL STATION BY FUEL; PERCENTAGE SHARES AND GROWTH, 1950 TO 1963

Year	Coal		Oil		Sod Turf		Milled Peat		Total	
	%	1963=100	%	1963=100	%	1963=100	%	1963=100	%	1963=100
1950	78	414	10	7	12	13	0	0	100	28·3
1951	72	470	9	7	19	25	0	0	100	34·5
1952	57	456	6	5	37	61	0	0	100	42·3
1953	48	408	10	11	42	75	0	0	100	45·6
1954	23	150	30	23	47	66	0	0	100	35·2
1955	17	161	45	50	38	73	0	0	100	49·5
1956	6	58	59	65	35	66	0	0	100	49·1
1957	14	128	35	38	42	78	9	18	100	47·8
1958	26	223	24	25	28	51	22	42	100	46·3
1959	30	368	21	31	32	80	17	45	100	65·1
1960	28	330	8	12	38	93	26	66	100	62·9
1961	21	290	21	34	34	98	24	73	100	73·5
1962	6	106	37	74	31	108	26	96	100	90·0
1963	5	100	45	100	25	100	25	100	100	100·0

Note: The columns headed 1963=100 relate to absolute heat inputs to thermal power stations according to fuel.
Source: Heat Input data of Table 15 appended to this section.

stations. Turf's share fell to only 50% in 1963; this was partly occasioned by the poor harvest, but there is some sign that turf's share is slowly falling.

Fuel Prices

Both coal and oil prices rose in the early 1950's, coal rather more than oil, until 1952 when both began to fall again. With the shortage in Britain coal prices started rising again in 1955, followed at the end of 1956 by oil prices as a result of the Suez crisis of that year. After 1957 coal prices fell sharply until 1961; the apparent increases in 1962 and 1963 were due to the increased weighting of the more expensive Irish coal. Oil prices declined steadily, if not so sharply, since 1957 and are now less than what they were in 1950. Table 13 shows fuel prices in two ways; the average prices paid by the ESB for each fuel year-by-year, and December spot prices at the end of each year.

The average annual price of machine turf was more or less competitive—in terms of price per heat unit—with coal or oil prices, whichever was the cheaper, until 1954. Since then, machine turf prices have fluctuated relatively little, except for increases in 1961 and 1962, and have tended to be higher than the cheaper of coal and oil (with the exception of 1957). Milled peat only began to be used in 1957 and was initially priced at very competitive levels. Prices were increased in 1958, in 1961 and in 1962, to be reduced again in 1963. The effect of these price

TABLE 13: AVERAGE ANNUAL PRICES AND DECEMBER SPOT PRICES OF FUELS[5] FOR ELECTRICITY GENERATING; 1950 TO 1963

Year	Coal		Oil		Sod Turf		Milled Peat		All Fuel
	d/m. Btu	sh/ton[1]	d/m. Btu	sh/ton[2]	d/m. Btu	sh/ton[3]	d/m. Btu	sh/ton[4]	d/m. Btu
1950[7] ..	37	90/–	40	130/–	38	38/–	—	—	37·5
1951 ..	53	125/–	46	170/–	47	70/–	—	—	51·5
1952 ..	55	100/–	54	175/6	54	55/–	—	—	54·5
1953 ..	46	86/–	47	140/–	48	47/–	—	—	47·0
1954 ..	43	84/6	42	134/–	48	50/–	—	—	45·0
1955 ..	46	106/–	40	134/2	52	50/–	—	—	45·0
1956 ..	57	110/–	46	153/4	50	50/–	—	—	48·0
1957 ..	62	107/–	54	172/6	49	50/–	37	23/6	51·5
1958 ..	49	89/–	51	145/8	48	55/–	37	26/–	46·5
1959 ..	43	76/6	45	134/2	49	55/–	40	26/–	45·0
1960 ..	38	63/–	45	124/7	48	55/–	39	26/–	42·5
1961 ..	36	63/–	38	110/5	49	57/6	39	27/–	41·5
1962 ..	39	68/2	35	110/8	52	60/–	44	29/6	42·5
1963 ..	44	68/2	34	110/8	54	60/–	42	26/–	42·0

Notes: [1]Bulletin price of imported coal at Ringsend; see also Note (6).
[2]Bulletin price of fuel-oil at Ringsend.
[3]Price at Portarlington; from 1953 to 1957 the price at Allenwood was between 5/– and 8/– higher.
[4]Price at Ferbane.
[5]Spot prices (in shillings/ton) are those reigning in the last week of the year; average prices (in pence/million Btu) have been obtained by dividing the annual accumulated totals of daily consumption times price by the annual net heat inputs of Table 15.
[6]Irish coal price rose from 74/– a ton at the end of 1960 to 77/4 at the end of 1961, to 86/4 at the end of 1962.
[7]At the end of 1949, prices were: oil 100/– a ton; coal 76/– a ton.
Source: Data from ESB records.

changes was to make milled peat more expensive than the cheaper of coal and oil by 1961, and this situation has continued since. (In this discussion of relative prices no attention is given to the efficiency at which the different fuels were used, which would tend to give coal and oil an additional advantage.) Milled peat prices, it may be noted, have fallen to roughly four-fifths of those of machine turf—a fact which amply justifies the decision of the two Board's concerned to concentrate development onto milled peat.

It is interesting to trace the swings from coal to oil and back from oil to coal at stations burning imported fuel, as the relative prices of oil and coal changed. This is most simply done by comparing the average annual prices paid for oil as percentages of those paid for coal with the percentages of oil consumed in the total fuel consumption of stations burning either coal or oil, a comparision which is shown in Table 14.

The figures in Table 14 show that, since 1953, the relative proportions of coal and oil burnt have been correlated closely (and inversely) with their relative prices. (The changes in the price ratio of oil to coal in 1962 and in 1963 are magnified to some extent because almost all the coal used in these years was the more expensive Irish coal; for imported fuels only, the price ratios in 1962 and in 1963 were roughly 97 and 93.) It is apparent that the ESB have made good use of being able to turn from one fuel to the other as prices moved.

TABLE 14: OIL AND COAL; RELATIVE PRICE AND CONSUMPTION, 1950 TO 1963 — Percent

Year	Oil price as percentage of coal price[1]	Oil consumption as percentage of coal and oil consumption[2]
1950	108	12
1951	86	11
1952	99	9
1953	102	19
1954	98	57
1955	87	72
1956	80	90
1957	87	71
1958	103	48
1959	105	41
1960	118	23
1961	104	45
1962	90	85
1963	78	89

Notes: [1]Ratio of average annual prices from Table 13.
[2]Ratio of oil input in Btu to coal plus oil input, from Table 15 appended to this section.

SECTION 3: ESB FINANCES

In this section the financial results of the Electricity Supply Board's operations are considered. The analysis has three main purposes. The first is to present a summary version of the Board's accounts over the past eleven years. The Board publishes its accounts in somewhat lengthy form, which makes it difficult to compare one year's results with another's. To facilitate understanding of the accounting scheme used in the summary tables (appended to this section) the financial results of the most recent year, 1963/64, are discussed at some length.

The second purpose is to assess the financial effects of the important subsidies hidden within the accounts. Because of these subsidies electricity consumers as a whole pay more for electricity than they would otherwise need to. There is no suggestion that it is wrong for this to happen; the intention is simply to gauge the magnitude of the transfers involved.

The third aim is to examine the financial performance or profitability of the Board's use of the nation's capital resources. This is done in the conventional way by calculating the annual rates of return, gross income with respect to average net assets employed, both with and without the cross-subsidies just discussed.

The Financial Year 1963/64

During the year from April 1st, 1963, to March 31st, 1964 revenue from sales of electricity and meter and other charges, including miscellaneous revenue attributable to electricity, totalled £20,442,000. Together with £32,000 from the sale of fish (and from other receipts at fisheries controlled by the Board), £598,000 from charges for installation work and £1,301,000 from the sale of electrical appliances, total receipts were £22,373,000. To set against these receipts the direct cost of supplying electricity was £11,283,000, while those associated with the operations of Fisheries, Installations Trading and Merchandise Trading were £55,000, £544,000 and £1,238,000 respectively, bring the grand total of all operating expenses up to £13,120,000.

In the case of electricity the direct cost arose mainly from expenses associated with generating and transmitting electricity: including the cost of the small quantities of electricity purchased, generation and transmission costs totalled £7,168,000 or 63% of the total. Urban distribution costs amounted to £1,757,000, 15% of the total, rural distribution costs to £1,023,000, 9% of the total, and general administrative costs to £1,399,000, 12% of the total. From the sum of the figures just mentioned has to

TABLE 15 (APPENDED TO PART IIA SECTION 2): ELECTRICITY SUPPLY IN IRELAND; GROWTH AND CHARACTERISTICS, 1950 TO 1963

Item	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	Units
	Financial Year ended 31st March in following year														
Installed capacity:[1]															
hydro	128	147	173	178	188	188	188	215	219	219	219	219	219	219	mw
thermal	143	163	183	205	265	325	380	435	470	470	505	505	545	631	mw
Total	271	310	356	383	453	513	568	650	689	689	724	724	764	850	mw
Peak Load[2]	251	253	273	314	348	363	378	412	462	476	540	606	632	674	mw
Electricity Generated[2]	973	1,033	1,164	1,296	1,462	1,573	1,648	1,775	1,898	2,096	2,262	2,453	2,715	2,901	m.kwh
Plant Factor[3]	41	38	37	39	37	35	33	31	31	35	36	39	41	39	%
Load Factor[4]	44	47	49	47	48	49	50	49	47	50	48	46	49	49	%
Excess of Installed Capacity over Peak Load[5]	8	22	30	22	30	41	50	58	49	45	34	19	21	26	%
	Calendar Year of 52 weeks[6]														
Electricity Generated:															
hydro	423	428	418	437	771	540	577	689	871	611	989	793	697	684	m.kwh
thermal	478	576	708	829	661	988	1,063	1,016	978	1,398	1,282	1,563	1,901	2,167	m.kwh
Total	901	1,004	1,126	1,266	1,432	1,528	1,640	1,705	1,849	2,009	2,271	2,356	2,598	2,851	m.kwh
less station auxiliary uses ..	38	42	54	60	53	69	69	75	77	100	99	111	124	137	m.kwh
less losses and metering discrepancies[7]	140	144	154	197	228	195	219	234	254	272	349	283	321	363	m.kwh
Electricity Sold[8]	723	818	918	1,009	1,151	1,264	1,352	1,396	1,518	1,637	1,823	1,962	2,153	2,351	m.kwh
industry	242	268	287	329	378	404	417	420	453	532	604	653	698	745	m.kwh
commerce[9]	194	215	244	264	298	331	355	366	388	405	448	486	535	578	m.kwh
domestic[10]	287	335	387	416	475	529	580	610	677	700	771	823	920	1,028	m.kwh
Fuel Consumption:															
coal	256	293	287	259	97	105	40	89	154	255	228	201	73	69	th. tons
oil	22	23	18	36	78	167	217	125	82	103	40	113	247	333	th. tons
machine turf[11]	75	160	354	431	415	444	394	468	324	462	536	602	622	618	th. tons
milled peat[11]	—	—	—	—	—	—	—	146	404	413	635	743	941	927	th. tons
Net Heat Input:[12]															
coal	6·42	7·28	7·07	6·32	2·33	2·49	·90	1·99	3·45	5·71	5·11	4·50	1·64	1·55	10^{12} Btu
oil	·86	·90	·70	1·40	3·04	6·51	8·46	4·88	3·20	4·02	1·56	4·41	9·63	12·99	10^{12} Btu
machine turf	·95	1·88	4·54	5·57	4·87	5·41	4·94	5·77	3·78	5·95	6·92	7·25	8·00	7·42	10^{12} Btu
milled peat	—	—	—	—	—	—	—	1·27	3·03	3·24	4·71	5·24	6·92	7·18	10^{12} Btu
Total	8·23	10·06	12·31	13·29	10·24	14·41	14·30	13·91	13·46	18·92	18·30	21·40	26·19	29·14	10^{12} Btu
Heat Rate[13]	18·3	18·5	18·4	17·0	16·4	15·5	14·3	14·5	14·6	14·3	15·1	14·5	14·6	14·2	th. Btu/kwh

Notes : [1]Rounded off to the nearest thousand kilowatts; at 31st March of following year.
[2]Includes power losses and station auxiliary loads.
[3]Electricity Generated divided by Installed Capacity in kilowatts times 8,760 (hours a year), times 100.
[4]Electricity Generated divided by Peak Load in kilowatts times 8,760, times 100.
[5]Installed Capacity divided by Peak Load, minus one, times 100. These figures are inflated to the extent that plant commissioned during the last few months of the financial year would not have been available to meet the year's peak loads.
[6]The years 1954 and 1960 contained 53 weeks.
[7]The difference between Electricity Sold and Electricity Generated less station auxiliary uses.
[8]Estimated from ESB bi-monthly sales data cross-checked by comparison with estimates of electricity delivered to 38kv network (these data are not shown here).
[9]Includes public lighting.
[10]Includes rural domestic sales.
[11]Of varying moisture contents.
[12]The following average net calorific values were used:
Coal—11·2 Btu/lb in 1950 falling to 10·6 Btu/lb in 1955.
10·0 Btu/lb in 1956 and following years.
Oil—17·4 Btu/lb
Machine turf—5·95 Btu/lb at 30% moisture content.
Milled peat—3·45 Btu/lb at 55% moisture content
(allowances were made for variations in moisture content as consumed).
[13]Total Net Heat Input divided by thermal electricity generated, multiplied by 1·06 (for station auxiliary uses); refers therefore to sent-out thermal electricity. For percentage efficiencies divide into 3,412.
Source : ESB *Annual Reports* and additional data taken from ESB records.

be subtracted £195,000, charged to capital works, and to them has to be added £131,000, paid in turn-over tax. The total tax paid, including taxes on appliances sold, was £146,000.

It is interesting to note that revenue from rural sales of electricity was £5,856,000 or 35% of the revenue from all sales, and that rural distribution costs (excluding capital charges) represented just under 37% of all distribution costs. The imbalance is less than might have been expected, perhaps because the rural distribution network is of relatively more recent construction and therefore less demanding in upkeep.

The trading surplus, or surplus on operating account, was £9,253,000 in respect of all operations and £9,159,000 in respect of electricity alone. Trading surplus may be taken as the Board's gross income. Net income is what remains after depreciation charges have been met.

The provision for depreciation, renewal and retirement of physical assets was increased by £3,895,000 from 31st March 1963, to the same date in 1964. During the year assets valued at cost at £799,000 were retired from service (the difference between the value of assets brought into commission, £11,014,000, and expenditure less retirements during the year of £10,215,000). Assuming that a corresponding sum was written off the depreciation provision, the total amount credited to depreciation during the year was £4,694,000. Of this sum, £335,000 were charged to credits arising from the retirement of assets and the sale of scrapped material; the difference of £4,359,000 represents the depreciation chargeable to income for the year.

In the ESB accounting system depreciation is not provided for in the normal commercial manner by charging against income under the heading "depreciation" a sum which in some sense represents the fall in the value of the physical assets employed. A more financial view is taken: the original cost of an asset is regarded as a financial investment which is to be recouped over a given period (the lifetime of the asset) by charging a fixed sum each year against income from the use of the asset, those sums being re-invested (in other assets) and earning a notional 2½% p.a. rate of interest compound. In effect, the original cost is recouped by making payments into an internal sinking fund. The result is that the total charge against income each year is roughly the same as in normal straight-line historical-cost depreciation but that charge consists of two elements, an annual payment into the sinking fund, charged to income as "depreciation", and the interest deemed to be earned which is charged to income with other interest payments. Both elements of charge are credited to the provision for depreciation and both, therefore, reduce the depreciated book value of the asset concerned.

The author is not sufficiently well acquainted with accounting procedures to comment in any depth upon this system. For the purposes of calculating net income (or the income remaining after allowing for the loss of asset value over the year) it is a confusing system, however. Depreciation is a subject full of pitfalls for the unwary but there is general agreement that its primary accounting purpose is to determine (net) income by setting aside an amount from the year's trading profits to maintain the value of the business intact. The system used by the ESB divorces the concepts of depreciation as a charge against income and depreciation as a loss of asset value over the year.

Net income on all activities, after meeting depreciation charges (including "interest" element) of £4,359,000, was £4,894,000 in 1963/64. It is not possible to identify net income in respect of electricity alone from the Board's accounts.

Net income has to bear the weight of interest charges payable, and whatever is left over may be regarded as retained profit or surplus. Since interest charges are also incurred by capital tied up in works in progress, the amount of interest paid that is chargeable to income is not identifiable, while the interest charges apportioned are confused by the inclusion of internal interest charges. This is little hindrance, fortunately, since net income can be taken in a general sense to be the interest earned on the capital invested. Of this, part is paid to the Exchequer and to stockholders each year and part is retained within the business.

Borrowing increased during the year. The total repayable capital outstanding, after allowing for loans redeemed or partly redeemed, rose from £86,421,000 at the end of the previous financial year to £95,588,000 in March 1964. During the year borrowing was in fact increased by nearly £11 million, but loans to the value of nearly £2 million were redeemed, the net effect being an increase in loans outstanding of £9,167,000. The greater part (£1,275,000) of the capital redemption payments was charged by the Board against the year's trading surplus and the balance against an amortisation reserve built up in the previous year. However, a capital redemption payment is a transaction on capital account and the liberty is taken here of dealing with capital redemption payments as operations that reduce net borrowing. Two-thirds of the repayable capital loan outstanding, or £60·7 million, is owed to government for advances made from the Central Fund under the various Electricity (Supply) Acts and Amendments; most of the remainder is in the form of Electricity Supply Board Stock held by the general public.

In addition to its increase borrowing, the Board received a further £1,131,000 in capital contributions that are not repayable. These contributions mostly represent assistance by government towards the capital cost of the facilities for supply electricity to rural areas. Capital receipts from loans and from these contributions together totalled £10,298,000. Of this total, £2,814,000 (net) were invested in securities and other financial assets, the remainder of £7,484,000 being available for investment in assets to be employed in the business.

During the year assets valued at £11,014,000 were commissioned and an additional £2,460,000 were tied up in capital works under construction. With an increase in the working capital employed of £95,000, total or gross capital investment during the year amounted to £13,579,000 (after allowing for assets in process of retirement at year-end). This was met to the extent of £7,484,000 from external sources (see previous paragraph), and the difference of £6,095,000 was provided from internal sources, principally from retained cash flow (gross income, less interest charges *paid*). The self-financing ratio in 1963/64 was therefore 45%.

On March 31st, 1964, the total investments in fixed assets in operation at that date was £129,788,000. The accumulated reserves for depreciation, renewal and retirement of assets were £40,297,000. Thus, the book value of the fixed assets being operated by the Board on that date was £89,491,000. This figure is not shown explicitly as a valuation of assets in the Board's accounts, nor does it represent the value of the Board's assets in any but a purely accounting sense. In addition, £10,763,000 had been spent up to that date on capital works then in progress. The net book value of all the Board's fixed assets was therefore £100,254,000. To this must be added an estimate of the working capital employed. Current assets were: £4,872,000 in stocks of fuel and other materials, £281,000 spent on work in progress, and £7,969,000 owed to the Board by sundry debtors; total current assets were £13,122,000. Current liabilities were £5,844,000, owed by the Board to sundry creditors. Working capital employed is the difference between current assets and current liabilities, or £7,278,000.

Finally, the Board's financial assets totalled £9,623,000. These were made up of loan stock held by the Board, temporary investments and cash in hand and with the bank, less the Board's short-term borrowings.

The Board's net assets at 31st March 1964, totalled £117,155,000. These assets were represented, or covered, by £95,588,000 of repayable capital, the difference of £21,567,000 being, as it were, the value of the assets owned by the Board. They were acquired by receipts of capital contributions, by earmarking reserves for insurance and contingencies, and by repayment of capital loans from retained surplus.

In respect of the Board's producing and trading operations the net book value of the Board's assets at year-end is the sum of the net book value of fixed assets plus working capital employed. Net financial assets are excluded because these are not essential to the Board's functions; they arise because of yearly imbalances between capital raised and capital needed for investment. In respect of electricity alone the net book value of assets can be estimated by subtracting the value of capital works in progress at year-end. The resulting estimate includes the net values of the assets used in Fisheries and Installations and Merchandise Trading operations but these are not of great significance in the total. The ratios of the components of income to the average net book values of assets employed, in all activities and in electricity only, are shown in Table 16.

TABLE 16: GROSS AND NET INCOME AS PERCENTAGES OF AVERAGE NET ASSETS EMPLOYED; 1963/64

	All Activities		Electricity Only	
	£'000	%	£'000	%
Average Net Assets[1]	103,095[2]	—	93,562[3]	—
Gross Income ..	9,253	9·0	9,159	9·8
Depreciation ..	4,359	4·2		
Net Income ..	4,894	4·8		

Notes: [1]Average of year-end values, March 1963 and 1964.
[2]Net book value of fixed assets plus working capital.
[3]As (2), less capital works in progress.
Source: See Table 27 appended.

The difference between the two earnings rates arise mainly because of the lower value of average net assets employed in electricity only. The capital tied up in construction work brings in no income and is, therefore, not productive in the ordinary sense.

The Electricity Supply Industry in England and Wales has been recently set a target of 12½% gross income (=trading surplus) on average net assets employed. The comparable earnings rate for the ESB may lie somewhere between that for all activities and that for electricity only. Precise comparability would need further examination but it seems that the earnings rate achieved by the ESB in 1963/64 was just under three-quarters of that 12½% p.a. target.

Cross-Subsidies

It is reasonable to enquire by how much these earnings rates are reduced by cross-subsidies of any kind. A nationalised undertaking is sometimes required to bear the burden of acting in the national interest. The well-known burdens borne by the Board and by its customers arise on account of rural electrification and, in recent years at least, of its use of turf fuel. In addition, the Board's sales of electricity were required to carry the 2½% turnover tax when this tax was instituted during 1963. The tax was absorbed fully by the Board and electricity prices fell in relation to the prices of goods that took the full weight of the increase. The tax is perhaps best regarded as a siphoning-off of part of the Board's net income rather than as an operating expenditure.

The effect of the construction and operation of partly uneconomic rural supply facilities is assessed in the Board's accounts. The total invested under the scheme at 31/3/'64 amounted to £34,029,000 of which £7,970,000 had been received in direct grants, or 23·4% of the total. The Rural Revenue Account shows sales receipts of £5,856,000 and, of these, £3,280,000 were credited to electricity production and to general administration. Other operating expenses totalled £1,023,000. The Rural Account shows a deficit, after depreciation, interest, and capital repayment charges, of £899,000. This figure seems so large that it would be useful to verify it by independent means. Table 17 presents in summary form the financial results of the rural electrification scheme since 1947.

TABLE 17: RURAL ELECTRIFICATION; RESULTS SINCE 1947

£'000

Year	Total expenditure[1] at 31st March		Trading surplus	Depreciation[2]
1947/48	450	(275)	0	9 (est)
1948/49	1,263	(725)	0	25 (est)
1949/50	2,266	(1,250)	0	45 (est)
1950/51	3,456	(1,950)	0	69 (est)
1951/52	5,167	(2,500)	132	104
1952/53	7,028	(3,500)	230	149
1953/54	9,659	(4,000)	366	204
1954/55	12,854	(6,800)	588	283
1955/56[3]	16,885	(1,974)	729	358
1956/57	20,611	(1,974)	809	480
1957/58	23,051	(1,974)	1,012	587
1958/59	25,220	(2,974)	1,159	694
1959/60	27,333	(4,198)	1,070	773
1960/61	29,254	(5,151)	1,334	844
1961/62	31,016	(5,918)	1,468	911
1962/63	32,348	(6,895)	1,524	1,010
1963/64	34,029	(7,970)	1,530	1,058

Notes: [1]Bracketed figures indicate non-repayable capital contributed by government.
[2]Amounts charged against income as depreciation; excludes depreciation "interest".
[3]The fall in non-repayable capital was occasioned by the Electricity (Supply) (Amendment) Act of 1955, by which some contributions became repayable retroactively.
Source: ESB *Annual Accounts.*

The average net assets employed in 1963/64 in rural electrification are estimated in Table 18.

TABLE 18: NET ASSETS EMPLOYED IN RURAL ELECTRIFICATION IN 1963/64

£'000

	31st March 1963	31st March 1964
Total expenditure	32,348	34,029
Less accumulated depreciation[1]	8,750	10,150
Net fixed assets	23,600	23,880
Plus say 8% working capital ..	1,890	1,910
	25,490	25,790
Average Net Assets	25,650	

[1]Increased by one-third to allow for depreciation "interest"; see Note (2) to Table 17.

All the Board's activities in 1963/64 can now be separated into two parts. Rural supply operations and other activities, and their respective earnings rates are compared in Table 19.

TABLE 19: RATE OF RETURN ON NET ASSETS IN RURAL ELECTRIFICATION IN 1963/64

£'000

	All Activities	Rural	Other
Average net assets ..	103,095	25,650	77,445
Less 22% of rural net assets[1]	5,750	5,750	—
Remainder of average net assets	97,345	19,900	77,445
Net income	4,894	120[2]	4,774
% of above	5·0	0·2	6·2
Net income with equal earnings rates ..	4,895	995	5,900

Notes: [1]By 1964 government had contributed £7,970,000, or 22% of total expenditure plus estimated working capital.
[2]Depreciation shown in Table 17 for 1963/64 plus one-third to allow for depreciation "interest".

After allowing for the non-repayable capital contributed by government, for rural supply investment to have yielded the same rate of earnings as all activities (net income as a percentage of average net assets employed) would have required a net income from rural sales in 1963/64 of £995,000. This implies a deficit of £875,000, a figure which is almost equal to the deficit shown in the Board's accounts.

A more difficult problem is that of estimating the financial effects of the use of turf for generating electricity. This problem is complicated by the fact that it is not known what the Electricity Supply Board would have chosen to do had there been no compulsion to use turf. During the early 1950's turf prices were competitive with those of imported fuels. Again, in the period from 1956 to 1958 when the price of imported coal was forced up by the shortage in the U.K. and that of oil was increased

TABLE 20: OUTPUT AND FUEL COST AT COAL/OIL AND TURF STATIONS; 1953/54 TO 1963/64

Year	Coal/Oil stations		Turf stations		Excess fuel bill £'000
	Fuel cost £'000	Million units sent-out	Fuel cost £'000	Million units sent-out	
1953/54	1,300	384	1,099	325	(3)
1954/55	1,005	360	952	272	193
1955/56	1,668	680	1,195	338	367
1956/57	1,663	598	1,023	198	194
1957/58	1,542	509	1,508	489	27
1958/59	1,687	652	1,168	385	171
1959/60	1,453	609	2,015	646	475
1960/61	1,094	533	2,176	703	733
1961/62	1,443	739	2,605	866	914
1962/63	1,742	899	3,327	1,027	1,337
1963/64	2,126	1,123	2,987	980	1,133

Note: Excess fuel bill is Fuel cost at turf stations less electricity sent out from turf stations times average cost of electricity sent out from Coal/Oil stations.

by the Suez crisis, there was little to choose in price between turf and imported fuels. Even taking the relatively higher efficiency of coal and oil stations into account, milled peat was definitely cheaper than both coal and oil in 1957 and in 1958, although it seems doubtful whether machine turf has ever been cheaper than both. Relative prices and conversion efficiencies were discussed in the previous section.

Penalties other than those of fuel cost are also incurred since power stations have had to be sited away from load centres, additional transmission lines built and extra stand-by capacity installed. Moreover, losses in transmission lines are increased because of the further distances involved. Only the direct penalties due to additional fuel costs are relatively easy to estimate, presuming that the Board would have built plant to burn imported fuels had they had the choice. In 1963/64 the cost of fuel at coal/oil stations was £2,126,000 while 1,123 million units were sent out from these stations. At turf stations 980 million units were sent out, at a fuel cost of £2,987,000. These same number of units would have cost £1,854,000 at an average unit fuel cost equal to that of units sent out from coal/oil stations. The excess fuel bill for 1963/64 was therefore £1,133,000. The figures for earlier years are given in Table 20.

The effects of subsidies can now be discounted from the financial results of the year 1963/64. Before doing so, it might be helpful to state precisely what subsidies are being discounted. First, in regard to rural electrification: rural electricity consumers are not (on average over the year) paying as much as other consumers in relation to the respective costs of supplying each with electricity; the difference is only partly compensated by government subsidy. The rest of the burden is borne, not by the tax-payer, but by other and particularly urban electricity consumers. Second, in respect of the use of turf: to produce the same quantity of electricity it cost the ESB more to use turf than it would to use imported coal or oil. Only part of this extra fuel cost is now avoidable, i.e., to the extent that electricity could be generated preferentially from coal/oil rather than turf stations. But, if it is considered that the ESB would have built coal/oil and not turf stations had they not been instructed otherwise, then the Board are now paying in fuel bills an extra cost. This cost is equal to the difference between what they pay for fuel at turf stations and what they would have had to pay to generate the same amount of electricity at coal/oil stations. The extra cost of turf is a subsidy to the producers of turf that is carried by electricity consumers rather than by taxpayers. Table 21 shows the effects of these subsidies in 1963/64.

TABLE 21: INCOME IN 1963/64 WITHOUT CROSS-SUBSIDIES

£'000

	All Activities	Electricity Only
Actual trading surplus	9,253 (9·0%)	9,159 (9·8%)
Actual net income ..	4,894 (4·8%)	
Taxes paid ..	146	131
Rural deficit ..	899	899
Excess fuel bill ..	1,133	1,133
Total subsidy ..	2,178	2,163
"Real" trading surplus	11,431 (11·1%)	11,322 (12·1%)
"Real" net income ..	7,072 (6·9%)	

Note: Percentages in brackets relate to average net assets given in Table 16.

The gross earnings rate of 12·1% in Electricity Only, now looks much healthier, although it should not be thought that it approaches the 12½% target for the electricity supply industry in England and Wales. British policy on nuclear power, coal and rural electrification commits that industry to cross-subsidies similar to those carried by the Electricity Supply Board and by consumers in Ireland.

1953/54 to 1963/64

Table 27 appended to this section shows the Board's accounts for the eleven years from that ended March 1954, to that ended March 1964, in summary form, following the same procedure as was adopted above in discussing the year 1963/64. The first part of the table (I) gives an account of receipts and expenditures and shows the net income and surplus for each year. The second part of the table (II) is a statement of the sources and uses of funds. Funds come from external source through long-term borrowing and capital contributions, or are made available from internal sources from retained cash flow; these funds are used for investment in fixed assets and in working capital. The third part of the table (III) is a statement of the composition of total net assets at the end of each year.

For each year, trading surplus and net income are compared with average net assets employed in Table 22.

TABLE 22: TRADING SURPLUS AND NET INCOME AS PERCENTAGES OF AVERAGE NET ASSETS EMPLOYED; ALL ACTIVITIES, 1953 TO 1963

Year	Average[1] net assets	Trading Surplus		Net Income	
		Amount	%	Amount	%
1953/54	53,030	3,331	6·3	1,723	3·2
1954/55	60,333	4,765	7·9	2,848	4·7
1955/56	68,498	4,667	6·8	2,403	3·5
1956/57	76,870	5,440	7·1	2,978	3·9
1957/58	81,867	6,152	7·5	3,304	4·0
1958/59	84,266	6,992	8·3	3,871	4·6
1959/60	86,413	6,954	8·0	3,633	4·2
1960/61	88,828	8,348	9·4	4,764	5·4
1961/62	91,696	8,515	9·3	4,721	5·1
1962/63	95,920	8,917	9·3	4,905	5·1
1963/64	103,095	9,253	9·0	4,894	4·8

[1]See notes to Table 17.

It seems from these figures that there has been some increase in the earnings rate over the ten years, but fluctuations in the availability of water-power and in the prices of fuel have been such that it is difficult to come to any firm conclusion. It would be possible to correct for these fluctuations, at the cost of some rather tedious calculation. At a glance, such an exercise would tend to iron out the year-to-year variations in earnings rates but without affecting the trend. The other factor which would have to be taken into account is the lack of regularity in the growth of asset value: there was more surplus capacity during the latter half of the 1950's than either before or after (this was not due to lack of foresight; rather the rate of growth in consumption had fallen well below what had been expected).

The percentage shares of the different elements of income have shown only small variation from year-to-year. Such variation as there was appears to have been largely due to the fluctuations in operating expenses. Over the period as a whole, a clear idea of the stable composition of income can be seen by comparing the aggregate results of the first five years of the period with those of the latter five years. This is done in Table 23, in either case measuring each element in relation to gross income (or trading surplus) = 100.

TABLE 23: COMPOSITION OF INCOME OVER TWO FIVE-YEAR PERIODS; ALL ACTIVITIES

Item	1953/54 to 1957/58		1959/60 to 1963/64	
	Total, £'000	%	Total, £'000	%
Receipts ..	58,294	239	97,096	231
Expenses ..	33,939	138	55,109	131
Gross income ..	24,355	100	41,987	100
Depreciation ..	11,099	46	19,070	46
Net income ..	13,256	54	22,917	54

In looking at the figures in Table 23 it should be recalled, however, that average prices have changed hardly at all over the period and that these results represent a successful fight against cost inflation (to the extent that this industry suffers from it, which may be less than other industries because the purely price effects of inflation can be balanced by economies of scale and by continuous technical innovation). The simple five-year average of annual average unit prices, increased from 2·0d. in the 1953/54 to 1957/58 period to 2.1d. in the 1959/60 to 1963/64 period, a rate of increase rather less than 1% per annum.

A similar type of comparison of the shares of external and internal sources of investment funds, gives nothing like the same picture of stability, perhaps because investment activity was much greater in the early part of the period than in the later part, until very recently at least. The most useful set of figures, since trends are difficult to identify in the face of the long and erratic investment cycle, would seem to be the whole-period aggregates, which are shown in Table 24.

TABLE 24: SOURCE OF INVESTMENT FUNDS; PERIOD AGGREGATES, 1953 TO 1963

Source	£'000	%
External sources	48,188	51
Internal sources	45,716	49
Funds available=gross capital investment	93,904	100

The average self-financing ratio, measured in relation to gross capital investment, was 49%. Over the ten years from 1953/54 to 1962/63 the Electricity Supply Industry in England and Wales achieved a self-financing ratio of about 44%.

The composition of net assets, by its nature, changes only relatively slowly but over the period there is evidence of some long-period movement. This can be seen in Table 25 where the aggregates of the six end-year statements spanning respectively the first and last five years of the eleven years are shown.

TABLE 25: PERCENTAGE COMPOSITION OF NET ASSETS; AGGREGATES OF SIX YEAR-END VALUES

Item	March 31st, 1953 to 1958		March 31st, 1959 to 1964	
	£'000	%	£'000	%
Fixed assets at cost	402,536	99	676,284	120
Depreciation	(86,313)	(21)	(187,098)	(33)
Work in progress	61,208	15	34,350	6
Net fixed assets	377,431	93	523,536	93
Working capital	29,358	7	38,872	7
Sub-total	406,789	100	562,408	100
Financial assets	(3,740)	(1)	24,799	4
Total net assets	403,049	99	587,207	104
Repayable capital	366,774[1]	—	494,227	—

( ) indicates sum to be deducted.

Note: [1]For 1953 and 1954 an arbitrary split has been made between repayable capital and capital contributions.

The net book value of fixed assets in commission at year-end has increased in proportion to total net assets (excluding financial assets) from 78% to 87% over the six years separating the mid-points of the two periods compared. The percentage committed to expenditure on work in progress declined from 15% to 6%; this was due to the higher level of investment activity early in the period, mentioned above. Working capital remained constant in its share. Financial assets increased in importance, a consequence of the Board's going to the market for capital and the need to carry over capital thus raised from one year to another. The proportion of the Board's net assets represented by repayable capital fell over the period because of the self-financing nature of a considerable part of the Board's investments; measured in relation to total net assets (including financial assets) the percentage dropped from 91 to 84 between the two periods.

"Real" trading surplus and "real" income (see Table 21) are shown for each year in Table 26, with the proportions they represent of average net assets.

The increasing trend in earnings seems more

TABLE 26: INCOME WITHOUT CROSS-SUBSIDIES; 1953 to 1963

£'000

Year	Rural deficit[1]	Excess fuel bill[2]	"Real" trading surplus		"Real" net income	
			Amount	%[3]	Amount	%[3]
1953/54	10	(3)	3,338	6·3	1,730	3·2
1954/55	(44)	193	4,914	8·1	2,997	5·0
1955/56	147	367	5,181	7·6	2,917	4·3
1956/57	492	194	6,126	8·0	3,664	4·8
1957/58	552	27	6,731	8·2	3,883	4·7
1958/59	656	171	7,819	9·3	4,698	5·6
1959/60	888	475	8,317	9·6	4,996	5·8
1960/61	736	733	9,817	11·1	6,233	7·0
1961/62	690	914	10,119	11·0	6,325	6·9
1962/63	801	1,337	11,055	11·5	7,043	7·3
1963/64[4]	899	1,133	11,431	11·1	7,072	6·9

( ) indicates credit.

Notes: [1]As shown in the Rural Revenue Account each year (see ESB *Annual Accounts*).
[2]Taken from Table 20 above.
[3]Calculated against figures for average net assets given in Table 22 above.
[4]Excludes also Turnover Tax paid.

definitely established in the figures in Table 26 though the meaning of the figures must be interpreted with care since they do not relate to realised income.

Return on Investment

The conclusions to be drawn from this discussion can be stated very simply. It has been shown that in recent years the rate of return earned by the ESB on its average net assets employed has risen to about 5% a year, and that if its investments in rural electricity supply and in turf-fired generating plant had proved as profitable as its other investment then that rate of return would now be of the order of 7% a year. Alternatively, one could take the view that 5% is an adequate return on the nation's relatively risk-free investment in electricity supply, but that subsidies should be a direct charge on the Exchequer in which case the average price of electricity could be reduced by roughly 10%.

It is not easy to form an opinion of whether this rate of return is sufficiently high. The return on investment in manufacturing activity in the private sector is probably considerably higher but, then, it is also subject to a greater degree of risk. What is important, perhaps, is that it should be possible to compare rates of return in the public sector with those in the private sector in order to consider questions of national policy on public investment and the return to be expected.

In the case of electricity supply the rate of return is not set up as a target for the Supply Board's operations, nor is it shown as an indicator of the Board's economic performance; it is merely implicit in the accounting procedure. Solvency in this case implies a certain rate of profitability. The particular merits of the ratio of net income after depreciation to average net assets employed as a measure of profitability can be overstressed, but the point remains that there is considerable value in having some explicit rate of profitability to measure and compare rather than letting that rate be hidden beneath a number of accounting constraints on the Board's finances.

To have a definite target rate of return is important in investment planning. The problem of investment planning is to choose that programme of investment in productive assets that best satisfies certain given criteria. Those criteria can be more or less simply stated. For instance, the objective may be defined as to produce given amounts of electricity in future years at the lowest possible cost. Or, to take an alternative formulation, the objective may be widened to include the possibility that different future prices for electricity may be associated with different levels of consumption; the problem in this case is to choose the optimum levels of price and of investment as well as to programme investment to produce electricity at the lowest possible cost. The first formulation gives a very much more restricted objective, and it is in a sense just a special case of the second.

However, the analytical problems of investment planning are of no concern here. The point of interest is that, whatever approach is adopted, investment planning requires that the expected rate of return or "internal" interest rate must be specified. In both the approaches cited above such a rate is essential to calculating the "cost" to be attached to the use of capital in electricity supply, and to knowing what rate of discount to use to compare expenditures at different times.

The importance of the self-financing ratio can also be over-emphasised. During the eleven years considered here the Board has only had to turn to outside sources of finance for half of its gross capital investment. With respect to its net capital investment (after depreciation) the rate of self-financing has been about one-sixth, a much lower rate of course since depreciation is itself the principal internal source of funds for investment. But these rates are to a considerable extent dependent upon the Board's financial structure and upon the rates of interest it has to pay; they are not therefore convenient measures of its economic performance. They are nevertheless of some interest to the managers of the Board's, and indeed of the nation's, debt.

SECTION 4: THE PRICING OF ELECTRICITY

In Ireland, statutory control of the price of electricity extends only as far as the permitted total revenue from sales during the year, in that revenue must be sufficient and only sufficient to meet expenditure (in a defined sense) over the year. It does not concern itself with the detailed ramifications of the tariff structure. These, then, are the concern of the Board.

The Structure of Tariffs

As in other countries, a variety of different types of tariff or pricing system are used by the ESB in Ireland. Not all, but many of the tariffs used are promotional in character; that is to say they encourage consumption by setting a lower rate per unit after a certain number of units have been consumed. More recently in the historical development of tariffs it has been realised that increased consumption can sometimes be inconvenient, not to say uneconomic, for the supplier, and special rates have been introduced to stimulate off-peak consumption and the more continuous use of electrical equipment generally.

Most electricity tariffs are variations on the two-part tariff. This consists of a rate of charge for each unit consumed and a standing charge (a meter rent, for example, is a standing charge). The rate of charge per unit may be a flat rate that applies without exception to all units consumed, or it can vary in a number of ways. Like the promotional tariffs mentioned above, different rates can be set for different "blocks" of consumption; the rates for additional blocks of consumption usually, but not always, are set on a declining scale. Or the rate per unit can vary with the time when the unit is consumed. It can also vary with the load applied by the consumer; that is, a higher price per unit is charged when the consumer's power demand exceeds a certain level. In both the last two cases quite complicated metering systems are necessary since the rates of charge do not depend only on total consumption during the accounting period.

The standing charge adds on a lump sum to the customers bill for the period. That sum also can be set in a number of ways. It can depend on the installed capacity of electrical equipment in the consumer's premises (or, less accurately, on the size of his premises), on the maximum demand he declares himself to need (with either a circuit-breaker to prevent his load exceeding that maximum or a special meter to charge his consumption at a higher rate should it do so), or on his measured maximum demand. Maximum demand charges are widely applied in Ireland to industrial consumption of electricity.

There are a number of refinements of the basic structure just outlined. These include "guaranteed" supply charges, charges for "wattless" current, rates that move with the cost of fuel, and off-peak allowances which give lower rates to consumers who reduce their loads at peak times.

All tariffs do not necessarily have two parts. At one extreme is the flat rate tariff which charges an equal amount for each unit consumed, with no standing charge to pay. At the other extreme is the installed load tariff, a pure standing charge, with little or nothing to pay for the number of units consumed.

This sort of tariff is used in Norway where electricity is almost entirely made from water-power; the water costs nothing, and plant costs are passed on in the standing charge.

The other important element of tariffs is discrimination, between types of appliance or of use of electricity, and between classes of consumer. Separate meters are needed to discriminate between the types of use to which a single consumer puts electricity, for water-heating and for lighting for example. Discrimination between consumers, between households and commercial premises for instance, is more easily applied by merely charging each at appropriate rates. This is possible because the resale of electricity is physically difficult, if not to say illegal.

The Functions of the Tariff Structure

What ends must the tariff structure serve? It must be recognised at the outset that this is a relevant question: there is no "market" for electricity wherein prices are set under what the economist would call competitive conditions (i.e. independently of the amount supplied by, or of the costs of, any single producer). Electricity prices are set by the supply authority, although it is not suggested that price-setting takes no account at all of "what the market will bear".

There are three ends to be served, three functions to be performed. The first is financial and, in Ireland, a statutory obligation: the Electricity Supply Board must balance its books. It has already been mentioned that this applies only the most distant of limitations on the detailed price structure. The second is economic and arises because of the importance of electricity supply in the economy. The net output of electricity undertakings (almost entirely the ESB) represented nearly $7\frac{1}{2}\%$ of the net output of All Industries and Services in 1961, having the largest net output of any single industry. Third, and finally, the demands of equity and justice must be met. It is to the last two of the three that one must appeal in order to see how the price of electricity shall be determined.

The second and economic function of price is difficult to set out in practical terms. If one can generalise for a moment, there are two aims. One is to use the nation's existing stock of resources, of labour, of land, of fixed capital, etc., to the greatest possible extent (within certain overall constraints imposed by balance of payments and monetary stability considerations) because in this way is the national product, and the national income, maximised. The other is to direct the flow of resources in the longer term into such uses that, within a given environment of consumer preference and general national interest, the most rapid rate of expansion in the national product is achieved. Within this context the classical function of the price mechanism is to provide the machinery by which that flow of resources, under the impetus of free competition, is directed into the more productive uses.

Now, no-one will pretend that all the assumptions

TABLE 27 (APPENDED TO PART IIA SECTION 3): ESB ACCOUNTS; 1953 TO 1964

£'000

Item		1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
		Year ended March 31st											
I STATEMENT OF INCOME													
Receipts from sales:													
Electricity	1		8,555	9,565	10,515	11,602	12,948	13,839	14,780	16,312	17,774	19,496	20,442
Fisheries	2		24	26	17	21	20	21	19	21	20	33	32
Installations Trading	3		321	429	372	355	367	401	410	463	510	494	598
Merchandise Trading	4		409	663	865	616	604	753	965	1,106	1,115	1,205	1,301
Total receipts	5		9,309	10,683	11,769	12,594	13,939	15,014	16,174	17,902	19,419	21,228	22,373
Operating expenses:													
Electricity	6		5,290	4,916	5,964	6,212	6,841	6,908	7,899	8,039	9,337	10,678	11,283
Fisheries	7		16	21	19	20	20	34	33	34	36	41	55
Installations Trading	8		289	383	337	325	341	372	381	423	473	454	544
Merchandise Trading	9		383	598	782	597	585	708	907	1,058	1,058	1,138	1,238
Total operating expenses	10		5,978	5,918	7,102	7,154	7,787	8,022	9,220	9,554	10,904	12,311	13,120
Trading surplus = gross income	11		3,331	4,765	4,667	5,440	6,152	6,992	6,954	8,348	8,515	8,917	9,253
Less depreciation	12		1,608	1,917	2,264	2,462	2,848	3,121	3,321	3,584	3,794	4,012	4,359
= net income	13		1,723	2,848	2,403	2,978	3,304	3,871	3,633	4,764	4,721	4,905	4,894
II SOURCES AND USES OF FUNDS													
Sources of funds:													
Long-term loans	14		6,792	5,226	9,560	6,559	6,855	45	(862)	(908)	3,339	6,532	9,167
Capital contributions	15				87	3	14	1,028	1,313	1,055	832	1,115	1,131
Less increase in net financial assets	16		(296)	(528)	665	(199)	4,687	(295)	(1,223)	(1,154)	2,496	3,728	2,814
Total external sources	17		7,088	5,754	8,982	6,761	2,182	1,368	1,674	1,301	1,675	3,919	7,484
Internal sources	18		2,245	3,346	2,794	3,262	3,464	4,128	3,790	5,383	5,285	5,992	6,095
Total funds available	19		9,333	9,100	11,776	10,023	5,646	5,496	5,464	6,684	6,960	9,911	13,579
Uses of funds:													
Invested in fixed assets	20		9,897	9,950	11,943	8,629	6,327	5,173	5,263	5,181	6,627	9,881	13,484
Increased working capital	21		(564)	(850)	(167)	1,394	(681)	323	201	1,503	333	30	95
Gross capital investment	22		9,333	9,100	11,776	10,023	5,646	5,496	5,464	6,684	6,960	9,911	13,579

		At 31st March											
III Composition of Net Assets													
Assets in commission at cost	23	44,307	51,147	59,735	71,158	82,282	93,907	98,930	105,171	109,079	113,743	119,573	129,788
Less depreciation provision	24	9,918	11,325	13,014	14,971	17,248	19,837	22,719	25,853	29,127	32,700	36,402	40,297
Capital work in progress	25	9,180	11,910	12,867	12,891	10,073	4,287	4,053	2,809	3,437	4,985	8,303	10,763
Net fixed assets	26	43,569	51,732	59,588	69,078	75,107	78,357	80,264	82,127	83,389	86,028	91,474	100,254
Working capital	27	5,662	5,098	4,248	4,081	5,475	4,794	5,117	5,318	6,821	7,154	7,184	7,278
Financial assets	28	(1,072)	(1,368)	(1,896)	(1,231)	(1,430)	3,257	2,962	1,739	585	3,081	6,809	9,623
Total net assets	29	48,159	55,462	61,940	71,928	79,152	86,408	88,343	89,184	90,795	96,263	105,467	117,155
Represented by:													
Repayable capital	30	} 46,323	53,116 {	55,302	64,862	71,421	78,276	78,321	77,458	76,550	79,889	86,421	95,588
Capital contributions	31			3,039	3,126	3,129	3,142	4,171	5,484	6,539	7,371	8,485	9,617
Capital and revenue reserves	32	1,836	2,346	3,599	3,940	4,602	4,990	5,851	6,242	7,706	9,003	10,561	11,950

( ) indicates decrease.

Notes to Table 27:

Line 1. Includes Miscellaneous Revenue.

3. Credit taken for contracts completed and charged.

8. Cost of installation work carried out during the year, plus increase in cost of work for which credit was not taken at year-ends.

10. Operating expenses include direct costs of materials etc., wages and salaries, selling taxes, allocations of administrative costs, and overhead expenses except interest, depreciation and capital redemption charges.

12. Increase in provision for depreciation and renewals during year plus value of fixed assets retired during year less credits arising from retirement of assets and sale of scrapped material; value of assets retired was estimated by subtracting year-to-year increase in assets in commisson (line 23) plus increase in work in progress (line 25) from investment in fixed assets (line 20).

14. Increased borrowing; see line 30.

15. Increase in contributions received; see line 31.

16. Increase over year; see line 28.

18. Estimated by subtracting total external sources of funds (line 17) from gross capital investment (line 22). The principal internal sources of funds are the retained cash flow (i.e. gross income less interest payments) and the credits arising from the retirement of assets.

20. Cost value of plant commissioned, plus increased value of work in progress; figures supplied by ESB.

21. Increase over year; see line 27.

22. "Gross" indicates that depreciation is included.

23. Excludes physical assets retired.

27. Balance of Debtors, Work in Progress, Value of Stocks, less Creditors.

28. Value of stocks, securities and cash held, less short-term loans.

30. For 1953 and 1954 no split can be made, because of a retroactive adjustment in 1955; see also line 14.

32. Repaid capital, less intangible reserves written-off, plus surplus per Net Revenue Account, plus other reserves and provisions; there are errors in the last digits to make totals agree.

Source: ESB *Annual Accounts.*

of free competition are satisfied within a mixed economy like Ireland's, but it is generally admitted that such distortions as may exist should be designed to meet justifiable social purposes. These apart, freedom of choice for the consumer and free competition for the entrepreneur are regarded as desirable elements of the economic scene.

In the case of electricity the forces of competition do not act sufficiently directly to determine the price. Much of the capital invested in electricity is provided, or its use underwritten, by government, without the discipline of the capital market. At the other end (as it were) there is no "market", for electricity, as was brought up earlier. It is a point for discussion whether electricity supply should or should not be regarded as a monopoly. The facts are that there is only one supplier, and that in many uses there are no close substitutes for electricity. The latter applies particularly to the small consumer, for whom the cost of generating his own electricity for lighting would be considerably more than any price he is likely to be charged by a bulk supplier. In all but heating uses competition exercises only a distant constraint upon the price of electricity.

It has been suggested (by a number of economists, for example) that a solution to this difficulty could lie in the application of certain pricing rules that are derived from theoretical economic considerations. They are the pricing rules that can be theoretically shown to set prices at the levels that would be determined under perfect competition. At the same time these pricing rules would achieve the two aims of economic policy, outlined above, of using existing resources to the greatest possible extent and of directing the flow of resources between electricity supply and other activities in the best possible way. These propositions are disputable because their proofs depend on a large number of assumptions which are demonstrably not satisfied in practice even in an approximate sense. The pricing rules themselves appeal to the notion of marginal cost, which is an extraordinarily difficult idea to give concrete form to in practice. Nevertheless, they are not an arbitrary set of rules and they are worth considering on that account alone. They are discussed later.

The third end in view is that prices should be fair. This can mean one of two things. It can mean that each consumer should pay for electricity (and for other goods) what that electricity is worth to him in terms of other goods. It can also mean that each consumer should in some sense pay exactly the cost of the electricity he consumes. These concepts can be called respectively, price-discrimination and cost-apportionment. (Criteria relating to a consumers "need" could also be introduced, and indeed in some respects electricity supply is a social service, but it is not intended here to consider the tariff structure of electricity as a means of distributing income to the needy.)

It is interesting to note that both promotional tariffs (where the price falls with increased consumption) and two-part tariffs generally can be interpreted as tariffs that attempt to charge what the electricity is worth to the consumer. As the worth to the consumer of the marginal unit falls with increased consumption, so also does the tariff. The standing charge on the other hand is an attempt to extract some of the benefit the consumer derives because he would have been prepared to pay much more per unit had he consumed less (presuming that he obtains more satisfaction from some uses of electricity than from others).

Perfect price-discrimination is clearly impossible. Nevertheless, that the concept of worth to the consumer cannot for being impracticable be applied to discriminating between individuals (except, perhaps, for very large consumers) does not prevent its being invoked in charging different rates to different groups or classes of consumers (or to different uses of electricity). Price-discrimination in this sense of trying to extract from the consumer the full value that he himself sets on the electricity he consumes may or may not be thought of as equitable, according to opinion. But price-discrimination has a second, paradoxical aspect which leads into the other meaning of fair price.

The other interpretation of equity is effectively that of no discrimination, by which no two customers are charged different prices except on grounds of what it costs to meet their respective demands. Price-setting becomes a question of cost-apportionment, and indeed the idea that price should be related to cost has been met earlier in considering the economic function of price. It is, moreover, generally accepted that public utilities should base their prices upon their costs.

In general, the cost of supplying electricity depends not only on the quantity but also on the distribution of consumption over time. Since different classes of consumer and different types of use tend to apply loads of different patterns (in their distribution over time) and therefore to occasion different costs, from the point of view of cost-apportionment they should be charged different prices. Precisely because price-discrimination is possible can costs be recovered equitably. This is the paradox of price-discrimination; it arises because electricity is not a homogeneous good.

To sum up briefly, the pricing of electricity is either the application of theoretical economic principles (to be discussed below), or it is an exercise in price-discrimination for its own sake, or it is an exercise in cost-apportionment. In all cases except that of pure price-discrimination (which requires commercial rather than economic expertise) appeal is made to the idea of cost. What is the cost of electricity?

The Cost of Electricity

It is convenient to introduce three major categories of cost that vary, respectively, with the peak rate of consumption, with total consumption, and with the number of consumers.

Capacity costs are fixed costs associated with the provision of generating, transmission and distribution equipment. The supply system must be capable of meeting the peak load called upon, and the cost of installing, staffing and maintaining sufficient equipment are therefore directly related to the expected size of the peak. The relationship is not simple. The geographical location of generating equipment in relation to the location of consumption may be such that the peak load any part of the system has to carry does not occur at the time the supply system as a whole is carrying its peak load. Again, the total generating capacity required will depend to some extent on the type of capacity installed; for instance, the exploitation of hydro-electric resources may require the installation of stand-by thermal capacity to insure against temporary shortages of water. Nevertheless, there is a distinct correspondence between capacity costs and the expected peak load. The more homogeneous and uniformly spread the load, and the less the means of generation are subject to seasonal variation, the closer will that correspondence be.

Energy costs are the variable costs associated with using the supply system to produce and distribute electricity. They consist mainly of the cost of the fuel burnt in thermal power stations. It is a moot point whether labour, maintenance and supervision costs of operating plant should or should not be included. Theoretically only those costs that vary with the output of electricity should be included, but it may be more convenient to lump all operating costs together whether or not they do so vary. Energy costs tend to decrease from small, old and less technically efficient plant to large, new and more technically efficient plant. They vary with the type of station: steam plant is generally more efficient and therefore less costly to run than gas-turbine plant burning the same fuel, for example, while hydro plant costs almost nothing to run. Energy costs also vary at thermal plant with the degree to which the plant is used; the more the plant is used the less energy is wasted in starting and stopping (proportionately) and the lower the unit costs.

Consumer costs are the costs of delivering, measuring and charging for the electricity used by consumers. They comprise the costs of connection, of meters and of meter-reading, billing and accounting. They vary to some extent from consumer to consumer according to the amount of electricity consumed and to the type of supply. Basically, though, consumer costs vary with the total number of consumers. The costs involved in constructing low-tension distribution networks may be considered to be consumer costs rather than capacity costs. Where the line is drawn between the two categories is to some extent arbitrary and of little interest here.

In addition to these three major categories of cost there are other much less significant elements. The costs involved in administering and controlling the undertaking, in Public Relations and in such-like activities are examples. These residual costs may or may not vary with the size of the undertaking (and they may or may not be escapable). They will not be separated here.

Now, energy costs depend on the total amount of electricity produced during the accounting period. Barring hydro-electricity (about which reservations have to be made, but hydro-electricity is not sufficiently important in Ireland to invalidate the argument), the range of variation in energy costs in Ireland is a little more than 2:1. In practice the variation is much less since most of the electricity generated is produced in stations with fairly similar cost characteristics. The point is that if in the price of any unit of electricity were recovered the average energy cost of all electricity (neglecting, that is, the variation in energy cost and a more precise apportionment of cost between consumers), the distortions introduced would not be important enough to worry about.

Similarly, consumer costs present no problem. Since they are occasioned by individual consumers or groups of consumers they can be allocated directly to those consumers, and recovered in a standing charge or in the higher initial rate of a block tariff.

The problem arises with capacity costs. The production of a unit of electricity does not incur a direct capacity cost, for if the unit can be produced then capacity is already available and only a direct energy cost is occasioned. Capacity costs are joint costs. Capacity, moreover, has to be installed in advance, and so, in a real sense, capacity costs are sunk (or short-run inescapable) costs. The same is true, of course, of the fixed costs of any industry and is not peculiar to electricity supply, but the point is important. In the relating of price to cost the next step depends on the point of view of the tariff-setter. According to the latter's interpretation of the ends the tariff structure must serve he can adopt one of two procedures.

First, the tariff-setter can decide that his starting-point is the statutory obligation to cover all costs, sunk or otherwise, from revenue. He then tries to assess—in advance, of course—which consumers (or which uses) occasion what proportion of the given lump sum of capacity costs, which tells him how much is to be recovered from each consumer (or from each type of use) if each is to pay a fair price. His remaining problem is to set rates at such levels that each consumer (or group of consumers, or use of electricity) pays the appropriate contribution to capacity costs, either through a standing charge or through an increased rate for some or all of the units consumed. This is the basis for apportioning costs between consumers, as was discussed earlier.

There are two objections to this procedure. Even in theory there is no unique solution to the problem of the allocation of joint costs (without taking the broader economic point of view that is described later). They can be allocated to consumers according to their peak loads, according to their loads at the time of the system peak, or according to the annual sum of the average capacity costs per unit of electricity generated of the plant that has to be run to meet their annual consumption.[4] All that can be said about the various solutions is that some are better than others.

The other objection is that the allocations of capacity cost yielded by whatever method is adopted are not generally passed on to the consumer in such a way that he realises how they arise and can take action to avoid them, should it be in his interest. This is not an insult to the intelligence of the tariff-setter but a reflection of the real difficulties (and expense) of applying suitable tariffs. Maximum demand charges, subscribed demand charges, off-peak rates, and block tariffs are all examples of partial solutions; they try to lead the consumer to use more electricity when supply facilities are less fully loaded. However, even if this aim is achieved and a reasonably shaped load curve is presented to the supply system in the short-term (as well as recovering costs, of course) there is no guarantee that the same pattern of tariffs will produce equally good results in the future. It will not be a self-adjusting system of tariff-setting that applies appropriate corrections automatically.

Price equals Marginal Cost

Second, the tariff-setter can decide that the economic function of price (in the sense used earlier) is of paramount importance, and that the obligation to cover costs be secondary to it (although still to be fulfilled). He finds that under free and perfect competition the supply curve of a firm in the short-run is identical to its short-run marginal cost curve; the firm increases its output, or decreases it, until the additional costs occasioned by the last unit of output is equal to the price per unit of output. He finds that the short-run in the case of electricity supply (which may be defined here as the shortest period during which *both* demand *and* supply conditions remain constant, to extend the usual definition) is a very short period indeed. During this short period, of say an hour, the idea is to charge for electricity such a price that just so much electricity is consumed that the price chosen is equal to the marginal cost of producing the last unit, which (with increasing costs, which is the general case and certainly true of electricity supply) is the most expensive unit. This provides him with a rule for setting the price of electricity at any time for given conditions of supply and demand. Price, be it noted, is by this rule set on short-run considerations alone to secure maximum use of facilities subject to the condition that price be not less than incremental unit cost.

The principal characteristic of such a tariff system is that price varies with the buoyancy of demand, and therefore with time—demand for electricity is much greater, for example, at noon on a winter day than at midnight on a summer day. One envisages a number of tariff periods with the rate per unit changing from season to season, possibly from weekday to weekend, and certainly from off-peak to peak periods during the day.

There are several practical difficulties. The first is to determine the shape of the marginal cost curve. If generating stations are called on in the reverse order of their energy costs per unit, which is the cheapest way of operating a group of stations, then marginal cost will rise in steps as the rate of output of the system increases (see Chart A appended). The rate of output cannot exceed supply capacity. If demand tended to exceed capacity voltage reductions would ensue and load would eventually have to be shed. This situation can be regarded as so undesirable as to be avoided at all costs; it can be expressed by supposing the marginal cost curve to rise vertically when the rate of output reaches the supply capacity of the system. Then, as demand increases so price will rise until eventually the vertical part of the curve is reached and price must exceed incremental energy cost. This is the typical peak situation.

Because some types of generating plant are subject to seasonal variations in their availabilities, and because plant has to be temporarily withdrawn from service from time-to-time for maintenance and repair, supply capacity and therefore the shape of the short-run marginal cost curve varies during the year. This complication cannot be resolved within the limited

[4] This method is referred to briefly on page 35 of the UNIPEDE publication *General Principles Governing Electricity Tariff Framing*, Congress of Scandinavia, June 1964.

dimensions of the short-run; it will be discussed later.

The other difficulty is that price has to be set in advance, for, if it were not, users of electricity would not be able to plan their consumption in advance, and would therefore be prevented from acting rationally. To set price in advance involves assessing the level and elasticity of demand in advance, and amounts to drawing demand curves to see where they intersect the marginal cost curve. *Ex ante* assessment of demand is a feature of all tariff-setting; the requirements in this case are simply more explicit and more detailed.

In the longer-run, inescapable (capacity) costs become for the most part escapable and the problem becomes more complex. It is now a matter of determining the supply capacity of the system in the future (and therefore current investment) in order that supply and demand should be in some sort of balance. Theory again provides an answer: supply capacity should be increased, or allowed to fall (as plant is retired and not replaced), until the incremental cost of the last unit of capacity added, or retained in the other case, is just being recovered in the price of electricity at that time (or at those times) when that last unit of capacity has to be used to produce electricity. Price, of course, is to be determined according to the short-run considerations of the rule just described. If that rule is called the price rule, then this may be called the investment rule.

Some of the difficulties are obvious. The level and elasticity of demand has to be predicted for as many years ahead as it takes to install new plant, and in detail for each of the tariff periods envisaged, which will not be easy. Again, costs are not easy to forecast, and indivisibilities of capital equipment may make incremental costs hard to identify. However, all these difficulties are implicit in any investment planning, whatever the analytical approach used. The most important particular difficulty of this approach is due to the complications of the analysis required.

The accounting period of, say, a year is split into a number of tariff periods. The incremental capacity cost can be estimated for the accounting period; it will consist of the depreciation and interest charges associated with the plant needed to expand the supply capacity of the system by one unit. This incremental capacity cost has to be shared between the prices during those tariff periods when demand threatens to outrun supply capacity—not directly, but by considering various levels of supply capacity, applying the price rule in each tariff period for each level of capacity, and examining the resulting prices for the year to see whether more or less than the incremental capacity cost is being recovered. The method is exemplified in a short but theoretically correct[5] procedure that is depicted in the charts appended to this section.

It must be recognised that demand can only be predicted in probabilistic fashion, because the factors—particularly weather conditions—that influence demand are to some extent random in their occurrence. The same is also true of supply, and more especially so in the case of water-power. Thus it is important to consider not merely mean predicted conditions of supply and demand but also the possible variations about mean conditions and the degree of risk of abnormal conditions causing load-shedding that can be accepted. Again, this would be necessary in any case and is not a feature peculiar to the marginal-cost tariff. In effect, a safety margin would have to be added to the planned capacity of the system, and the incremental capital cost would have to be increased in the proportion in which the additional unit of capacity incurred the need for more stand-by plant.

Finally, the difficulty has to be faced that the short run cost curve is not fixed (for given projected supply capacity) over the accounting period because of the seasonal variation in output and the periodic withdrawal of plant, mentioned above. The effect is to introduce additional variables into the investment planning problem, as to the type of plant to be installed, the way that plant is to be operated, and the pattern in which plant is to be withdrawn for maintenance. To each of the tariff periods into which the accounting period is broken there will correspond not one but a family of possible short-run cost curves. Because of this the analysis may reveal a number of solutions, each satisfying the criterion that incremental capacity cost is just recovered in the price, but yielding different optimum levels of supply capacity, different patterns of plant installation and operation, and different patterns of tariff. Additional criteria will have to be called upon to select the best of these solutions. One that may be suggested is to reduce the variation in price to a minimum; this will tend to have the common-sense result that seasonally-affected plant will be used during periods of buoyancy in demand, and plant maintenance will be carried out during periods of slack demand.

The pricing rule sets the price for units of electricity consumed during a tariff period which may be as short as one hour. The total revenue from the units of electricity sold during the whole accounting period will bear no predetermined relation to total accounting costs. If assets prices are rising revenue will tend to exceed cost, and vice-versa, but the relation is not at all simple. Now, if an

[5]The basic method is due to P. O. Steiner and is described in the *Quarterly Journal of Economics*, Vol. LXXI, November 1957, p. 585.

accounting constraint is to be applied—as it is in Ireland—then the financial balance must be secured through the standing charge. It will be recalled that consumer costs have already been allocated to the standing charge. This must also bear any deficit of revenue from sale of units in relation to cost, which is more likely, or indeed be reduced by any surplus. Economic theory has little to say (that is generally agreed) about who should make up the deficits of falling cost industries or who should benefit from the surpluses of rising cost industries. Their absorption in the standing charge passes the surplus or deficit back to the consumer himself without seriously disturbing the marginal cost principle—except to the extent that new consumers have to pay a price greater than marginal cost for their first unit of consumption, but most people are already consumers anyway and this is not a serious objection.

In the appendix to this section an attempt is made to calculate what the marginal-cost rates of tariff would have been for the ESB system in 1963/64. It is appropriate to conclude here with a statement of the difficulties in applying time-related charges for electricity.

Difficulties of Time-Related Charges

Theoretically, the theorems on which marginal cost pricing is based contain many loopholes and not all economists would agree that they have any general application to the real world. It is, for instance, not possible to verify that the results of their application approach the optimum more closely than would have been the case otherwise. This is because only one set of results can be observed: that which actually occurs. Again, economists disagree about what the optimum is and whether it is any use in seeking it in one isolated sector of the economy: the consequence may be an even greater distortion of the whole. Finally there is no question of a pure application of marginal principles in any field of endeavour because of the presence of uncertainty and because so many short-cuts and so much arbitrary guesswork is necessary in applying them. Theory, moreover, does not answer all the questions involved: the covering of ultimately inescapable costs is a case in point. The sceptic might ask whether the resulting partial application still retains any demonstrable optimum properties. The answer must always rely on an intuitive weighting of the patent advantages and disadvantages involved.

The practical disadvantages are two-fold. First, there is the direct cost of applying time-related charges and, second, there is the possibility of unfavourable reactions by the consumer.

Meters to charge different rates for consumption at different times might cost, say, between £5 to £20 for each consumer. Including the expenses of publicity and instruction to consumers in the use of meters, the total direct cost might rise to the £16 million mark. The other factor is that a change-over could not occur overnight and difficulties might arise with a necessarily lengthy change-over period.

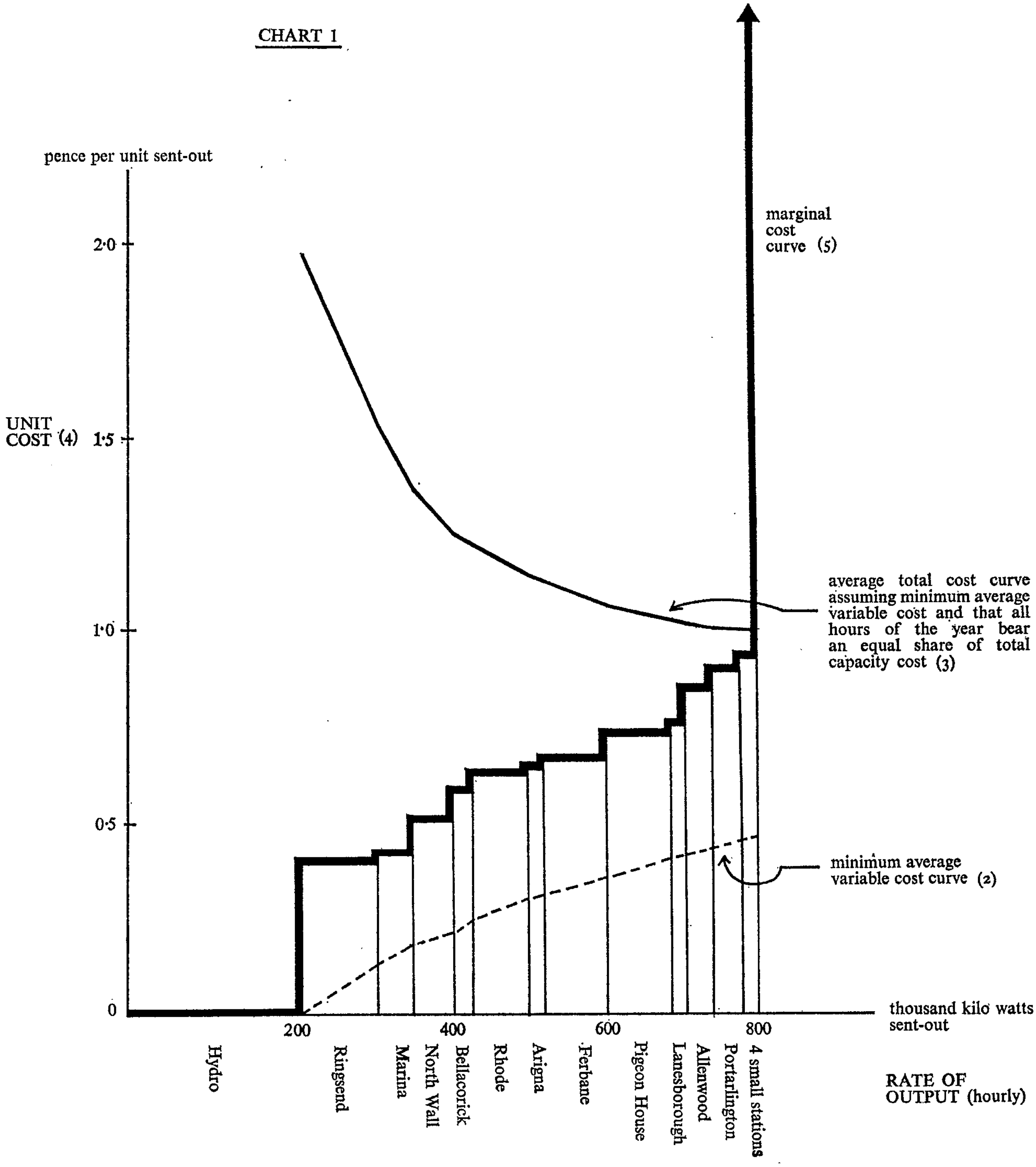
Since time-related tariffs do not discriminate between consumers there seems little to suggest that consumers might react unfavourably to the idea of these tariffs. Consumers who identifiably have a high peak rate of consumption are already discriminated against by the present tariff system and would not suffer more than they do currently, whereas they would benefit from being able to reduce their electricity bills by distributing their loads appropriately. Currently unidentifiable peak consumers, users of radiant electric heaters for example, would suffer, but this is in a way the whole object of the exercise. In the first instance this might victimise certain sections of the community, like urban old-age pensioners, but there is no evidence to suggest it.

Finally, one should consider whether the consumer would be able to understand the tariff system and be able to plan his behaviour accordingly. With regard to industry and commerce the matter needs no consideration; only the behaviour of the domestic consumer is of importance. The domestic consumer is an unknown quantity. It is to be doubted whether under the present system of tariffs he knows how much he pays for each unit of electricity, although he might be familiar with the size of his two-monthly bill. However, the idea of time-related charges is already familiar to him with night-storage rates and there seems little reason to suspect that he could not easily assimilate the idea of, say, six different rates of charge. To be effective he should be able to check how much he consumed under each rate and this would possibly require a much more expensive type of meter.

All told, the major obstacle is that of cost.

CHARTS (APPENDED TO SECTION 4, PART II)

CHART 1



Notes :

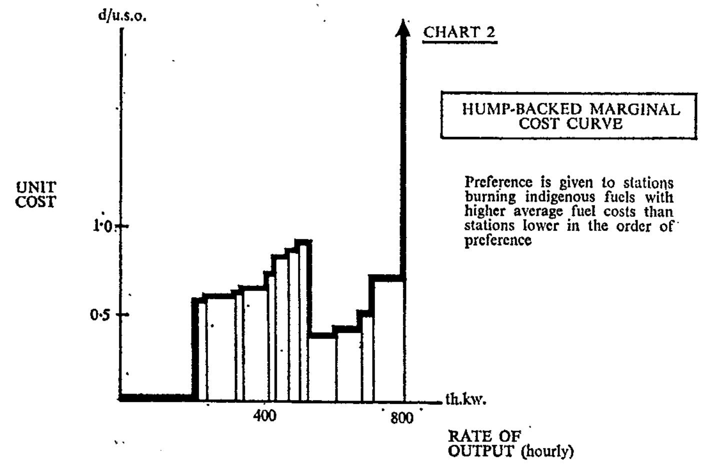
(1) Variable costs include only fuel costs; they correspond to an hour when all installed capacity (including hydro) is fully available; stations are assumed to be called on in reverse order of 1963/64 average fuel cost per unit sent-out.

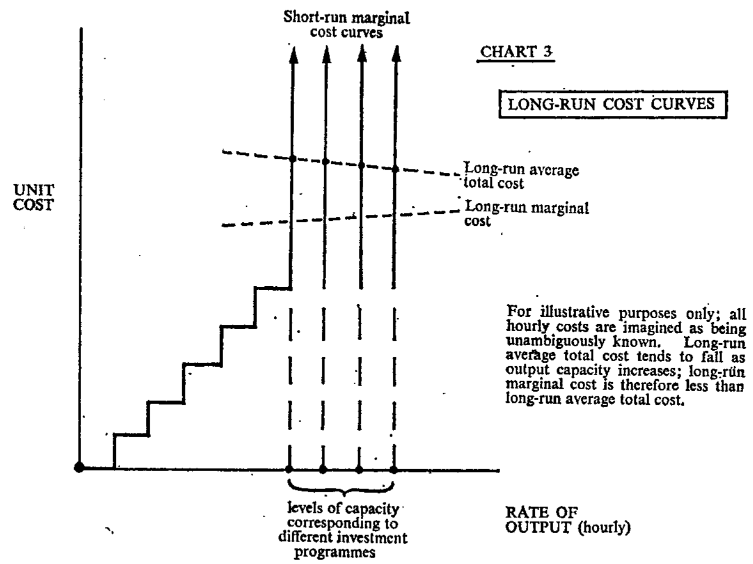
(2) average variable cost is described as minimum since any departure from the order of use of stations shown or any unavailability of stations will increase average variable cost.

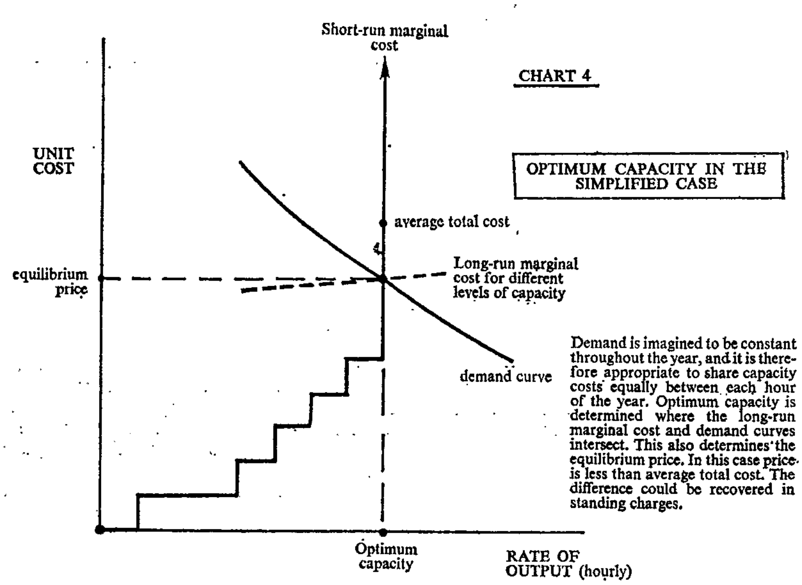
(3) total capacity cost for the year is taken as total receipts from sales less total expenditure on fuel; thus, consumer costs are not identified separately. Annual capacity cost is divided by 8,760 to give total capacity cost for a typical hour of the year, and the latter is divided by the output (for different rates of output) to give average capacity cost per unit. Average capacity cost is then added to minimum average variable cost to give average total cost, which is the curve shown. The point to notice is that average total cost is always greater than marginal cost except on the vertically rising section of the marginal cost curve.

(4) unit costs must be increased by about one-fifth in considering price, to allow for losses of electricity in transmission, distribution etc.

(5) marginal cost is equal to the variable cost at the station with the highest variable costs; at full capacity marginal cost is undefined and is shown here rising vertically.


d/u.s.o.
CHART 2
HUMP-BACKED MARGINAL COST CURVE
UNIT COST
Preference is given to stations burning indigenous fuels with higher average fuel costs than stations lower in the order of preference
1·0
0·5
400
800
th.kw.
RATE OF OUTPUT (hourly)


Short-run marginal cost curves
CHART 3
LONG-RUN COST CURVES
UNIT COST
Long-run average total cost
Long-run marginal cost
For illustrative purposes only; all hourly costs are imagined as being unambiguously known. Long-run average total cost tends to fall as output capacity increases; long-run marginal cost is therefore less than long-run average total cost.
levels of capacity corresponding to different investment programmes
RATE OF OUTPUT (hourly)


Short-run marginal cost
CHART 4
UNIT COST
OPTIMUM CAPACITY IN THE SIMPLIFIED CASE
average total cost
equilibrium price
Long-run marginal cost for different levels of capacity
demand curve
Demand is imagined to be constant throughout the year, and it is therefore appropriate to share capacity costs equally between each hour of the year. Optimum capacity is determined where the long-run marginal cost and demand curves intersect. This also determines the equilibrium price. In this case price is less than average total cost. The difference could be recovered in standing charges.
Optimum capacity
RATE OF OUTPUT (hourly)

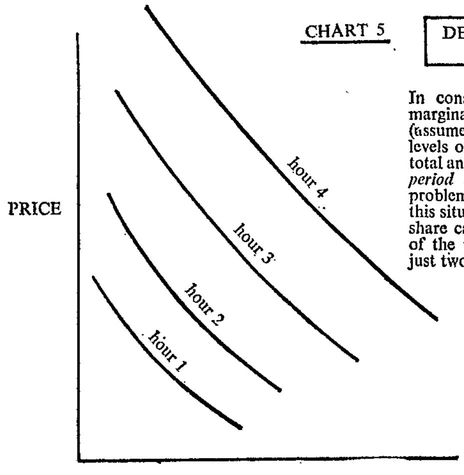


CHART 5

DEMAND VARIES FROM HOUR TO HOUR

In considering price, what is known is the marginal cost curve for each of the hours (assumed not to vary, for simplicity) for different levels of supply capacity (see Chart 3), and the total and incremental capacity costs *for the whole period* at each of these capacity levels. The problem is to determine optimum capacity in this situation when it is no longer appropriate to share capacity costs equally between the hours of the period. The solution for a period with just two hours is shown in the following charts.

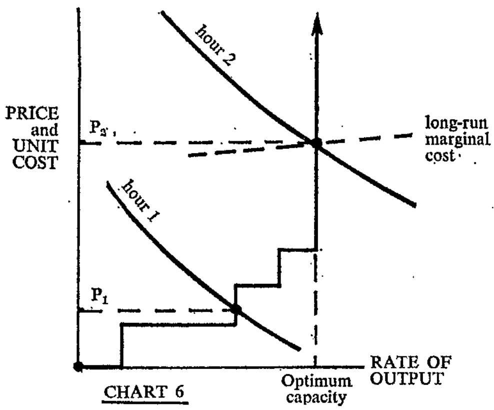


CHART 6

TWO-HOUR "ISOLATED-PEAK" CASE

The price at hour 2 (the peak) recovers the incremental capacity cost of the whole period. At hour 1 incremental fuel cost alone is recovered.

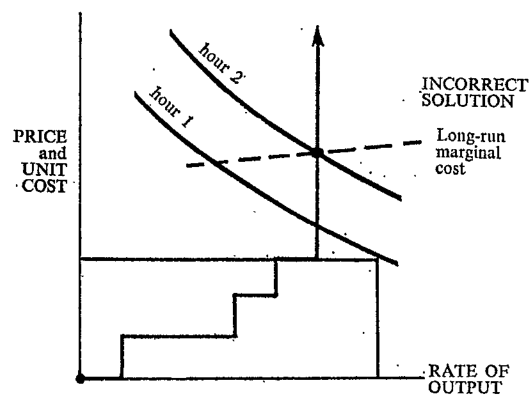


CHART 7

TWO-HOUR "SHIFTING-PEAK" CASE

The same solution is not satisfactory. At hour 1 to charge only incremental fuel cost would mean out-running capacity.

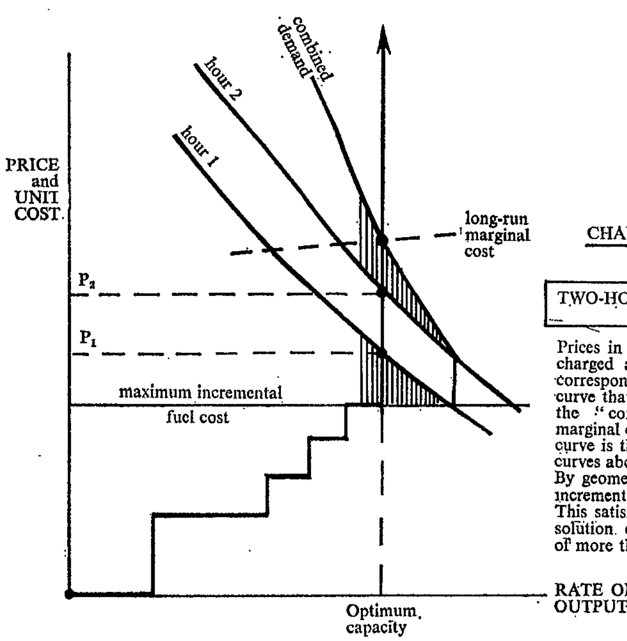


CHART 8

TWO-HOUR "SHIFTING-PEAK" CASE: CORRECT SOLUTION

Prices in excess of incremental fuel cost are charged at both hours. Optimum capacity corresponds to that (short-run) marginal cost curve that passes through the intersection of the "combined demand" and long-run marginal cost curves. The combined demand curve is the vertical sum of the two demand curves above maximum incremental fuel cost. By geometry, in the two prices together the incremental capacity cost is just recovered. This satisfies all the marginal conditions. The solution can be generalised for a period of more than two hours.

APPENDIX TO SECTION 4, PART IIA

A ROUGH ESTIMATE OF THE MARGINAL COST PRICES APPROPRIATE TO THE ESB SYSTEM IN 1963/64

The simplest possible estimate of capacity cost will be derived here and no effort will be made to distinguish incremental costs from average costs or to separate consumer costs. Total cost will be defined as gross trading receipts and from total cost will be subtracted the energy and other direct costs of generating electricity to give what will be defined as capacity cost. Capacity cost, therefore, comprises all expenses other than those of generating electricity. The deficits on rural account will be added into receipts to give costs which more closely represent normal capital costs. The average capacity cost for each kilowatt of peak load is shown for the five years up to 1963/64 in Table 28.

This method of estimation is extremely rough. To define cost in this way is a convenient procedure but it suffers from the disadvantage of admitting a random element of cost: unexpected variations in expenditure and in receipts. A better indication of cost would be given by the revenue aimed at in setting prices rather than the revenue which resulted. For the sake of argument the average of the last five years, or £22 per kilowatt per annum, will be taken here as average capacity cost and also as incremental capacity cost.

This estimate of capacity cost covers the cost of providing capital equipment of all kinds. An estimate of the capacity cost associated with generating plant alone will also be required. Generating equipment costs about £55 per kilowatt to install. With a 25 year life, a 7% interest rate and assuming equal annual contributions to capacity cost over the plant's lifetime, the annual cost associated with the use of one kilowatt of generating capacity would be £4·7. This figure has to be scaled up to reflect the 20% or so excess of installed capacity over peak load, to give an estimate of £5·7 or 33% of total capacity cost. Roughly this same proportion of total depreciation is charged to generating alone, £1,224,000, out of £3,428,000, or 36%, in 1963/64 which lends support to its accuracy.

In continuing the argument to a discussion of the hour-by-hour costs of supplying electricity one very important reservation must be stated. These costs will be calculated as if existing supply capacity were at an optimum level. This is highly unlikely since to achieve an optimum depends on marginal principles being applied both in pricing and in investment planning. For any level of supply capacity it is possible to estimate incremental costs but these are merely the prices that would obtain if the given level of capacity were also the optimum. The optimum corresponding to current demand conditions may be so different from the actual level of capacity installed now that the structure of costs under optimum conditions would differ radically.

To think in terms of 8,760 tariff periods (i.e. the number of hours in a year) is impracticable and a more convenient classification must be found. France is the only country to have applied marginal cost pricing to any degree and then only for high tension sales to essentially industrial consumers. In

TABLE 28: AVERAGE ANNUAL CAPACITY COSTS PER KILOWATT OF PEAK LOAD; 1959 TO 1963

Item	1959/60	1960/61	1961/62	1962/63	1963/64
			£'000		
Gross receipts[1]	14,780	16,312	17,774	19,496	20,442
Plus rural deficit[1]	888	736	690	801	899
Less works cost[2]	4,680	4,597	5,524	6,747	6,920
Total capacity cost[3]	10,980	12,451	12,940	13,550	14,421
			'000 kilowatt		
Peak load	476	540	606	632	674
			£ per kw per year		
Average capacity cost per kilowatt of peak load.	23·1	23·1	21·3	21·4	21·4

Notes: [1]The sum of gross receipts plus rural deficit is taken to define total cost.
[2]Taken to define total energy cost.
[3]Includes consumer costs.

the French systems the hours of the year are separated into five periods and for each period a different rate is charged. These periods are:

(*a*) off peak winter hours; 10 p.m. to 6 a.m. Monday to Saturday and all day Sunday.

(*b*) as above for summer: April to September inclusive.

(*c*) full-load winter hours; 6 a.m. to 10 p.m., except peak hours.

(*d*) as above for summer.

(*e*) peak winter hours; four hours a day, November to February inclusive.

It will be observed that this scheme comprises three daily rates (off-peak, full load and peak) and winter and summer seasonal rates. This seasonal breakdown also corresponds roughly to Irish conditions in so far as they can be known from the existing pattern of consumption. There appears, however, to be some call to include perhaps half of April in the winter period. Further, off-peak hours might extend in Ireland from midnight to 7 a.m. rather than from 10 p.m. to 6 a.m. Full-load hours would then run from 7 a.m. to midnight. The winter peak might need to be applied to six hours of the day, but on five days of the week only, and there may be need to introduce a summer peak of four hours a day, five days a week.

A simple calculation gives the number of hours that falls in each of the periods (denoting the summer peak period by F). Table 29 shows the number of hours in each period. It also shows, for 1963/64, a rough estimate of the load during each of the periods, taken at a glance from the winter and summer daily load curves in the 1963/64 Annual Report. As a quick check on the accuracy of these estimates the total outputs are calculated for each period, aggregated to give an annual output and compared with actual output. The difference is sufficiently small bearing in mind that the figures are intended simply to illustrate the principles involved.

The next problem is to determine how much generating capacity is available. The supply of waterpower is higher seasonal. More water is available in the winter than in the summer. Over the five years from 1959 to 1960, hydro plant could be run at average load factors of 64% during the four months covered by the winter peak period, 56% during the whole of the winter period and 20% during the summer period. It seems reasonable to assume that the water available would first be used in peak hours. In summer to do this would absorb almost all the water available if hydro plant were run at its 219,000 kw capacity during the four peak hours. In winter, running hydro at capacity during peak hours would leave sufficient water to run at 85% plant factor during the full-load periods, say a capacity of 180,000 kw available on average. At all other times there would, under normal conditions, be no water power.

In 1963/64 there were, taking the average of year-end values, 590,000 kw of steam capacity in the system. It will be assumed that the average proportion of the total out of action for maintenance and repair is about 15% over the year but that only during the summer will plant be withdrawn on this account. Thus, in summer, 30% of the total will be out of action. In the winter, steam plant may not always be available, and particularly at non-peak times, because of turf shortages. It will be assumed that, in the winter, all plant is fully provided with fuel at peak hours but that 10% may be unavailable through lack of fuel in full-load periods and 20% in off-peak periods.

Finally, it will be assumed that 10% of available steam capacity must always be regarded as stand-by, plus a further reserve of 50% of available hydro capacity. These margins should give adequate security. They have been taken with an eye to the resulting margins over average loads and may be exaggerated if there is temporarily too much capacity in the system. Supply capacity is compared with load in Table 30.

The right-hand column of Table 30 shows mean

TABLE 29: TARIFF PERIODS, DURATIONS AND MEAN LOADS; 1963/64

Period	Number of hours	% of total	Load '000 kw	Output Million kwh
(A) Winter off-peak	2,331	26·6	300	699
(B) Summer off-peak	1,992	22·7	160	319
(C) Winter full load	1,881	21·5	520	978
(D) Summer full load	1,340	15·3	320	429
(E) Winter peak	516	5·9	650	335
(F) Summer peak	700	8·0	420	294
	8,760	100·0		3,054 (Actual: 2,901)

TABLE 30: MEAN PERIOD LOADS AND "GUARANTEED" SUPPLY CAPACITY

'000 Kilowatts

Period	Availability		Guaranteed Capacity	Mean Period Load	Peaking Tendency %
	Hydro	Steam			
	(1)	(2)	(3) 50% of (1) + 90% of (2)	(4)	(4) as % of (3)
(A) Winter off-peak	0	470	420	300	75
(B) Summer off-peak	0	410	370	160	45
(C) Winter full load	180	530	570	520	90
(D) Summer full load	0	410	370	320	85
(E) Winter peak	220	590 (max)	640	650	100
(F) Summer peak	220	410	470	420	90

load as a proportion of capacity available less stand-by and reserve (or what amounts to the capacity of generating plant that can be guaranteed to be available). This proportion measures, in effect, the potential threat that consumption will outrun capacity. It will be seen that, even when the supplier exercises the choices open to him in such a way as to have the most capacity available when demand is greatest, the three periods in winter remain clearly identified from each other, as do the three summer periods. Both in winter and in summer the threat against capacity is greatest during peak hours, while the position in winter is more serious than that in summer. Were this not so, of course, the summer maintenance programme would have to be spread out more.

It will be assumed[6] that demand only threatens generating capacity when average period load is more than 70% of guaranteed generating capacity i.e. in winter and summer full-load and peak periods. Further, it will be assumed[6] that other supply capacity (excluding generating plant) is only threatened when average period load is more than 70% of winter peak period average load, i.e. in winter full-load and peak periods only. Thus the generating capacity cost of £5.7 must be shared by periods D, F, C and E in the proportions by which the percentages in the right-hand column exceed 70%[6], namely 15, 20, 20 and 30, giving £1.0, £1.3, £1.3 and £2.1 respectively. The capacity cost of other than generating plant, of £16.3, must be shared by periods C and E only in the proportions by which average load exceeds 450,000 kw, namely 70 and 200, giving £4.2 and £12.1 respectively. In sum the capacity costs corresponding to periods D, F, C and E are £1.0, £1.3, £5.5 and £4.2. These figures have to be scaled up by, say, 20% to cover the difference between the total quantity of electricity generated and the total sold. Scaling-up gives £1.2, £1.6, £6.6 and £17.0 respectively.

For each of the four periods these are the incremental capacity costs corresponding to a one kilowatt increase in average load. Since each hour of any period is assumed identical to all other hours in the same period, the cost to be borne at that hour can be found by dividing by the total number of hours in the period. The four hourly costs are 0.2, 0.6, 0.8 and 7.9 pence per kw per hour, which are the capacity cost elements of the marginal costs in the four periods. To these must be added the energy cost element of marginal cost, which will be taken as 1.0 pence per unit in periods C, E and F, and as 0.8 pence per unit in period D. In the two remaining periods marginal energy cost alone applies. Estimates of 0.7 and 0.8 pence per unit will be taken for simplicity's sake for periods B and A respectively.

The prices (marginal costs) and sales revenues corresponding to each of the six periods are shown in Table 31, and aggregate revenue is compared with what sales revenue would have been at the realised average price of 2.06 pence/unit.

TABLE 31: MARGINAL COST PRICES AND REVENUE FROM SALES

Period	Unit rate d/kwh	Revenue £'000
(A) Winter off-peak	0·8	2,330
(B) Summer off-peak	0·7	930
(C) Winter full load	1·8	7,330
(D) Summer full load	1·0	1,790
(E) Winter peak	8·9	12,430
(F) Summer peak	1·6	1,960
Total calculated revenue	—	26,770
Realised revenue	(2·06)	26,200

The variation in unit costs by a factor of more than ten may surprise some. It is an inevitable consequence of the considerable variation in demand because the more buoyant demand has to bear the

[6]Implicit in these arbitrary assumptions are assumptions about the elasticity and possible variation of demand, and of what level of risk is satisfactory.

weight of its much greater influence on supply capacity. The revenue that would be realised were such a scheme of prices to be applied agrees very closely with what would have been realised at the 1963/64 average selling price. This is an accidental consequence of the rather arbitrary figures used. Consumer costs have not been treated separately. Were they deducted from capacity cost, as used here, and were truly incremental costs calculated, one would expect revenue to fall short of total cost because of the presence of fixed costs like the expenses of administration. This deficit would have to be recovered, with consumer costs, in the standing charges of two-part tariffs of various kinds if this industry is required to cover its total costs.

It is interesting to note that in France the range of variation in price between winter peak and summer off-peak is only six to one and that the winter full-load price is just over half the winter peak price. This may partly be a consequence of the importance of hydro-electricity in the French supply system and partly a consequence of a restricted consumption during the winter peak resulting from the very application of marginal cost prices. It should also be recalled that this system of pricing is only applied to industrial consumers whose consumption is relatively less peaky than that of domestic consumers.

Part IIB Turf Supply in Ireland

Historical Background

Turf has been used as a fuel in Ireland for many hundreds of years. Indeed, it seems that without turf Ireland could hardly have supported its large population, which increased to number about seven millions in the early part of the last century. Despite this, the earliest documented interest in the bogs was concerned with their reclamation and use for agriculture rather than with extending their use for fuel production. Perhaps the burning of turf was so taken for granted that it scarcely deserved special mention. After the famine years of the late 1840's the emphasis gradually shifted from reclamation to production of fuel and already attempts were being made to win peat commercially. A full account of the development of the use of peat was given by Dr. C. S. Andrews in a paper read to the Statistical and Social Inquiry Society of Ireland in 1954.

Nowadays, the emphasis remains on the commercial potentialities of turf as a fuel and this situation is likely to continue until large areas of bog have been drained and cut away and reclamation work can begin in earnest. Within 40 years or so most of the large Midland bogs will have been exhausted and some will have been cut out within 20 years. To prepare for this, considerable research is at present being carried out into the problem of turning cutaway bog (and the shallow bog which is not suitable for commercial exploitation) into productive land.

The using of turf as a source of fuel in Ireland brings two major advantages. The first of these is that associated with the reclamation of otherwise useless bogland and the second is the economic advantage to be gained from the utilisation of a fuel from native sources. The production of turf gives employment to several thousand Irish workers and its use reduces the quantities of fuel that need to be imported to satisfy the nation's need of energy. The larger the quantities of fuel imported the larger the sums that have to be spent abroad rather than at home and the greater the reliance on sources of supply outside the country's control. During the last war practically no coal was available from abroad and only the supply of turf prevented the fuel shortage from having serious consequences; without turf the position would indeed have been hopeless. To set against these advantages, turf is a very wet and bulky fuel and is intrinsically more costly to extract and to prepare for use on a commercial scale than are its direct competitors, coal and oil.

On a very small scale for local use the physical unsuitability of turf is balanced by its being available without drilling or mining merely by investing a certain amount of labour and time into cutting it. To this day more than a million and a half tons of turf are still being cut by hand from the bog each year and burned in homes in rural areas of the country. Only a small part of this large output is sold commercially and even then only within the district of the bog; very little is transported more than a few miles from its source. Hand-cut turf is the product of off-season employment of farmers and agricultural workers; the annual harvest of this turf is regarded in output statistics as part of the country's agricultural production.

Inspired by the prospect of creating a national fuel industry, attempts to win peat commercially were begun as long ago as the middle of the last century. One venture after another failed in the face of the severe problems of cutting and drying turf by mechanical means. Semi-automatic machines were introduced in 1904 but it was not until 1924 that there was a real breakthrough with the introduction of fully automatic machines at Turraun, Co. Offaly. Machine turf of first-class quality was produced and to this development the modern history of turf in Ireland can be traced.

In 1933 a special section of the Department of

Industry and Commerce, charged with the task of turf development, was formed. The Turf Development Board Ltd. was founded in the following year under the direction of Dr. Andrews, then head of that special section at the Ministry. In 1935, this Board acquired the plant and stock that had been used and developed at Turraun and very soon it had commenced work on bog drainage. The purchase of additional machinery was slowed down by the war but research and planning continued apace.

Meanwhile, in 1933 the process of milling peat and making briquettes from the product had been introduced by a private firm called the Peat Fuel Company Ltd at Lullymore on the Bog of Allen. This company failed for lack of capital and was taken over by the Turf Development Board in 1940, thus widening the latter Board's range of interest.

The first legislation concerning the use of turf was passed in 1936. The Turf (Use and Development) Act of that year was intended to promote the domestic and household use of turf. It gave the Minister powers to require coal retailers in appointed areas to sell prescribed quantities of turf along with the coal they sold. The turf had to be purchased from the Turf Development Board Ltd. or from co-operatives authorised by that Board. Similarly, the Act required customers in these appointed areas to buy the prescribed amounts of turf. In fact, the provisions of this Act have never been applied.

By 1946 the Government was satisfied, from the experience so far gained, that a comprehensive plan should be adopted for the mechanical exploitation of turf. In that year it laid down this plan in a White Paper which set a ten-year production target of 1,000,000 tons a year, this turf to be consumed mainly in the producing areas for electricity and for industrial and domestic purposes. Government policy that new thermal power stations should, when possible, use turf was clearly set out. Local authorities were required to use turf in new institutions and houses built under the auspices of state or local authorities were required to install turf-burning boilers and equipment.

The Turf Development Act of 1946 is (together with the 1950 Act which amended and extended it) the principal act to do with the development of turf. It established Bord na Móna as a fully autonomous body, financed by repayable advances from the Exchequer, to replace the Turf Development Board Ltd. Its duties were (and are) to produce and market turf, to promote the production and use of turf, to acquire bogs, and to manage and develop bogs. The provisions of the 1936 Act were made applicable to the new Board.

Except for grants for experimental and research work advances from the Exchequer were to be repayable with interest; conditions of repayment were fixed by the Minister for Finance in consultation with the responsible Minister. Provisions for exemption from interest payment were laid down, to extend for five years from the date of establishment. Annual accounts were to be presented in a form laid down by the responsible Minister.

In the 1950 Act the advances given under the 1946 Act came to be referred to as first programme advances, and similar exemption provisions were laid down for further advances to finance a second programme of development. The 1950 Act also increased both the grants and the limits on the borrowing powers of the Board. These limits were further increased by the 1953, 1959, and 1961 Acts and now total some £24 million.

An Act of 1957 enabled the Board to raise loans on the capital market by issuing stock or other forms of security and authorised the Minister for Finance to underwrite any such issues. Up to 31st March 1964 some £850,000 had been raised from sources other than the Central Fund (apart from loans from internal sources), out of total capital borrowings of nearly £23 million.

Bord na Móna has no statutory monopoly powers. Turf is sold in competition with other forms of fuel and receives no special advantage except in the case of sales to the Electricity Supply Board, which will be discussed later. Thus, any monopoly powers Bord na Móna may have can only derive from the fact that it has no significant competitor in the production and sale of turf. This can be of little advantage because turf has no technical advantages in comparison with coal or oil and a number of noteworthy drawbacks in its bulkiness, moisture content and general variability of quality.

The prices charged by the Board are essentially set by market forces since there are no restrictions on the import and sale of competitive forms of fuel. It may be a reflection of this that there are no provisions laid down in the various Acts dealing with turf for any form of financial control of the Board's activities. Apart from the requirement that the Board repay advances with interest there is no mention of financial aims nor of the way in which profits or losses should be dealt with. Implicitly this is taken care of, for large profits are unlikely and, to some extent at least, losses can be covered by further exemption from interest payments and by delaying repayment of advances. Powers are granted to the Minister for Finance to permit both of these measures.

The relevent legislation provided for the exemption from interest for the period of five years of advances made to Bord na Móna for their turf development programmes. The period ran from 21st June 1946 in the case of the first development programme and from 1st July 1950 in the case of the second development programme. When these dates were reached the Minister for Finance examined the finances of the Board and by order declared the Board liable to pay interest on first programme advances as from 1st October 1952 and on second programme advances as from 1st April 1956. In the case of the first programme advances the rate of interest fixed was less than the cost of borrowing to the Minister for Finance. The rate was subsequently raised to the economic level.

All first programme advances are now in course of repayment. Repayment of a portion of the second programme advances commenced in 1960 and a further block of advances making a total of just over £9 million is at present being repaid. Theoretically, repayment of advances should commence as soon as the bogs development of which the advances were used to finance come into production. In determining when repayments of capital should commence regard has been had to the Board's financial position. Once Bord na Móna commenced to pay interest or to repay blocks of capital, there was no default.

The present managing director, Mr. D. C. Lawlor, has interpreted the Board's financial aim as to earn enough revenue to meet its expenditure taking one year with another.[7] Expenditure is taken by Mr. Lawlor to include the charges on account of depreciation and of interest. In effect, then, the Board's aim to achieve financial solvency is similar to the statutory obligation of the Electricity Supply Board. One small difference arises because the Electricity Supply Board shows redemption payments as current expenditure, as well as charges for depreciation and interest.

Turf Production

By 1950 the Board was producing between 50,000 and 80,000 tons a year of milled peat and nearly 140,000 tons of machine-cut sod turf. Milled peat is produced by machines which scrape the exposed surface of the bog. It has a very high water content and is only suitable for very large-scale use; in 1950 it was entirely used for making briquettes. Nearly 14,000 tons of briquettes were produced and sold in that year.

Machine turf is produced in block form but dries in irregular shapes. It is produced by a mixing and macerating process which combines different layers of the bog together to give a fuel of even quality. In 1950, some 31,000 tons of machine turf were sold to the Electricity Supply Board and a further 100,000 tons to other consumers.

In addition to the production mentioned above, about 100,000 tons of turf were produced and sold by the Board under a special scheme begun in the post-war years by the Department for Industry and Commerce to stimulate turf production throughout the country. These activities were not considered part of the Board's normal operations and were discontinued after 1954.

In recent years production has expanded rapidly. In the 1963 financial year 1,640,000 tons of milled peat were produced. In this year, indeed, the harvest was restricted by the poor summer, for 1,890,000 tons had been produced in the previous year. Nearly 750,000 tons of milled peat were used (in 1963) for making briquettes; over 280,000 tons of briquettes were produced and sold mainly to household and domestic customers. Just over one million tons of milled peat were sold to the Electricity Supply Board and a very few thousand tons were sold direct to industrial consumers. Some 960,000 tons of machine turf were produced; 570,000 tons were sold to the Electricity Supply Board, 43,000 tons to industrial consumers, 99,000 tons to institutional and commercial consumers and 230,000 tons to domestic consumers.

Table 32 gives details of the production and sales of turf for the fourteen years from 1950 to 1963 inclusive. The figures in this table refer to calendar years except for the output figures for machine turf and for milled peat, which are given for the corresponding financial years.

The rapid expansion in output of all forms of turf is readily apparent from this table. Over the fourteen-year period under review here the output of machine turf has more than quadrupled. That of milled peat has risen by more than thirty times its 1950 level; there was an extraordinarily rapid increase between 1956 and 1959. The period since 1954 has been remarkable for the violent fluctuations in output that have occurred. These fluctuations were caused by variations in rainfall and in other climatic conditions that affect the turf harvest. Briquette output has expanded more steadily and only since 1959 has there been significant growth, since the commissioning of briquetting factories at Cruachan and Doire an Locha. Nevertheless, over the whole period output of briquettes has expanded by more than ten-fold.

Sales of turf have grown correspondingly and the rapid expansion in the Electricity Supply Board's use of turf is particularly to be noted. That Board's consumption of machine turf rose rapidly, particularly between 1950 and 1953, but its consumption of milled peat has grown even faster since 1957 when the first milled peat-fired station was put into operation. Consumption for briquetting has expanded in line with briquette output and in line with the recent rapid increase in sales of briquettes to the public. There seems little doubt that briq-

[7] *Administration*, Spring 1959, p. 10.

Table 32: PRODUCTION AND SALES OF TURF; 1950 TO 1963

thousand tons

Bord na Móna	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Machine turf														
production[3] ..	214	458	619	653	627	697	829	820	507	904	887	996	924	958
sales to ESB ..	72	173	367	417	398	443	393	447	281	434	473	531	548	556
other sales ..	159	145	120	213	265	265	289	295	372	301	357	326	334	370
—industry												38[1]	39	43
—institutions	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	100[1]	101	102
—households												188[1]	194	225
Milled peat[2]														
production[3] ..	54	71	106	103	105	342	290	652	168	1,661	510	1,184	1,886	1,757
sales to ESB ..	—	—	—	—	—	—	—	167	392	422	598	689	907	932
briquetting[4] ..	73	69	78	107	110	104	128	87	108	111	244	511	576	752
other sales ..	—	—	—	—	—	—	—	—	—	23	22	19	13	11
Briquettes														
production ..	24	23	26	36	36	37	49	33	38	40	92	188	218	283
sales	24	21	22	38	39	37	49	32	37	35	88	156	228	303
—industries												16[1]	21	29
—institutions	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	22[1]	32	43
—households												118[1]	175	231
Hand-cut turf production.	2,848	3,361	3,221	3,132	2,072	2,647	2,495	2,217	1,622	2,243	2,551	1,832		

Notes : [1]Estimated from part-year data.
[2]At 55 per cent moisture content.
[3]Data refer to the year from April 1st of the year shown.
[4]Estimated from financial year data for milled peat used in briquetting and from quarterly data for briquette output.

Sources : data relating to Bord na Móna production and sales were supplied by Bord na Móna; data relating to hand-cut turf from *Statistical Abstract of Ireland.*

uettes are a very popular form of fuel. They are often used along with coal to give a brighter fire, while they are easier to light than coal and thus can also serve as fire-lighters. Direct sales of machine turf to the public have shown much slower growth, largely confined to the years up to 1958. The quantity sold in that year was roughly equal to the quantity sold in 1963.

Bord na Móna ceased to expand sod-turf production when milled peat began to be produced. There is now a limited market for sod-turf. For household use in towns the handier briquettes are preferred and for boiler fuel the uniform size of "Brickeens" (one-third size briquettes) may be more suitable.

Financial Results

Consider now the financial results of Bord na Móna's operations. The Board's accounts are presented in summary form in Table 35 (I, II, and III) appended, for the eleven years from the 1953/54 financial year to 1963/64. The first table, Table 35 I, shows receipts and expenses, income, and surplus for each year, the second shows the magnitude of the Board's investments and how they were financed and the third shows the growth and composition of the book value of the Board's assets.

In the 1963/64 financial year, for example, receipts from sales totalled just over £5,500,000. Taking into account the increase in stocks of turf during the year, the effective receipts corresponding to this year were rather more (£5,683,000). The relative importance of stock changes justifies taking them into account in this way even though the resulting total receipts are unreal in the sense of containing an element of potential rather than realised sales. Over the last ten years effective receipts from sales (including stock changes) had grown to 3.4 times their level ten years previously.

Operating expenses amounted to £4,334,000. This figure includes all expenses of production, supervision and administration but it makes allowance for small items of revenue including grants for research and experimental work. It is, thus, the net amount chargeable to sales income for the year. Operating expenses had increased since 1953/54 to 3.1 times their level in that year.

The trading surplus of £1,349,000 had to meet depreciation charges of £460,000, which represent the fall in the net book value of the Board's assets that was chargeable to income for the year. In fact, the increase in depreciation from March 1963, to March 1964, (given in Table 35 III) was £486,000. A difference of the same order is also to be observed in previous years. The difference could be due to the depreciation of assets not yet in commission, which would not be chargeable against income (exactly as only part of the total burden of interest is charged against income, the rest being incurred because of the capital tied up in works under construction). The depreciation charged to income had risen to 4.2 times its 1953/54 level. From year-to-year there have been substantial fluctuations in depreciation; between 1955/56 and 1958/59, for instance, the annual charge against income fell from £376,000 to £174,000, i.e. to less than half. This suggests that there is some consideration given to the use of assets during the year in calculating depreciation; 1955 was a year of high output, 1958 one of very low output. There is also some hint that the amount of depreciation charged to income is regarded as a variable that can be adjusted in accordance with the income available to meet it. Finally, it is interesting to note that depreciation is regarded as being written off and not as a provision for replacement, which reminds one that turf resources are limited.

Net income after depreciation in 1963/64 was £889,000, 5·2 times the corresponding figure for 1953/54. This had to meet interest charges totalling £881,000, which left a balance or retained surplus of only £8,000. This situation corresponded closely to that in 1953/54 when almost the whole of net income was absorbed by interest charges. During the intervening years interest charges have fluctuated quite considerably. It is understood that interest charged to revenue dropped in 1958/59 and 1959/60 as interest on development work was capitalised.

There has been considerable fluctuation also in the retained surplus declared by the Board. Indeed, this fluctuation would have been of greater amplitude on account of varying weather from year-to-year had not it been dampened by compensating reductions and increases in depreciation and interest charges. The total effect is that no one year's financial surplus can be considered in isolation as an accurate reflection of the year's performance. The retained surplus (or deficit) varied over the period from a net loss of £905,000 in 1958/59 to a net profit of £352,000 in 1962/63. The results for the eleven years in aggregate are shown in Table 33 and compared with the results for 1953/54 and for 1963/64.

TABLE 33: NET INCOME OF BORD NA MÓNA

Income	£ thousand					
	1953/54		Eleven years 1953/64		1963/64	
Trading surplus	282	=100	7,933	=100	1,349	=100
Depreciation	110	39	3,224	41	460	34
Net income	172	61	4,709	59	889	66
Interest	170	60	4,968	62	881	65
Retained surplus	2	1	(259)	(3)	8	1

( ) indicates deficit.
Source: Bord na Móna Annual Accounts.

The figures in Table 33 give some indication of the fluctuation in depreciation, measured as a proportion of the annual trading surplus, and of the upward trend in the burden of interest. The aggregate loss, 3% of the aggregate trading surplus, represents less than 1% of aggregate receipts from sales over the period as a whole. However, roughly half the Board's receipts come from sales to the Electricity Supply Board and to these sales competitive pricing principles are not necessarily applied. Thus, while they indicate that over the eleven years Bord na Móna's operations have, roughly speaking, been solvent, the above results should be interpreted with some care.

Table 35 II shows the Board's capital spending each year and the source of that capital, separated between internal sources and external borrowings. In 1963/64 the value at cost of the Board's capital assets increased by £1,350,000 and this has been taken as the investment in fixed assets undertaken during the year, although it does of course neglect the value of any assets written off during the year. The Board's working capital also increased during the year, by £236,000 (annual asset values and details of working capital are shown in Table 35 III). Thus total spending on capital account, or gross investment, amounted to £1,586,000.

The source of this capital was principally increased borrowings from the Central Fund. Net capital receipts (less redemptions) including borrowings from the Superannuation Fund, which may rank here as an external source, totalled £1,082,000. The balance of £504,000 was forthcoming from the Board's internal resources. In fact this figure cannot be reconciled exactly with the amounts apparently available according to the details of the year's financial operations presented in the Board's accounts. Some £486,000 would seem to have been available from depreciation plus £8,000 retained surplus for the year to make a total of £494,000. The discrepancy is slight in this and in other years.

In 1963/64 the Board was in a position to finance 32% of its own investment. Over the period from 1956/57 to 1963/64 as a whole 19% of its investments were financed from internal sources. This proportion is considerably less than the percentage of self-financing the ESB were able to achieve over a similar period but it should be recalled that Bord na Móna has been, during the years studied here, in a relatively early stage of growth.

In Table 35 III the annual book values of the Board's assets are set out. The net or depreciated value of fixed assets totalled £17,769,000 at 31st March 1964. This figure included £507,000 representing the written-down value of houses built by the Board for its workers (after deducting the grants of £326,000 received from the State towards their construction). In working capital a net sum of £2,612,000 was tied up, which brought the Board's total net assets to £20,381,000. These were balanced by outstanding borrowings (mostly from the Central Fund) of £20,554,000, and by an accumulated deficit of £293,000. The Board's total net assets had grown over the period to 3·0 times their 1953/54 level.

Finally, it is interesting to calculate the earnings rates implied by the figures shown in these tables. In Table 34 trading surplus and net income are shown as proportions of average net assets employed (average of year-end values). The net value of the Board's investment in housing is excluded from the asset values used, since it is not part of the Board's productive function to build houses.

Apart from the very poor results in 1958/59, the figures in Table 34 show some signs of an upward trend in earnings. Quantitatively, the two sets of earnings rates are closely similar to those achieved by the Electricity Supply Board before allowance is given for the subsidies hidden within that Board's financial results.

Electricity from Turf

The use of turf to fuel an electric power station was envisaged as long ago as 1917 when a committee was set up under the chairmanship of Sir John Purser Griffith to consider the possibility of developing turf commercially. The committee's report recommended the erection of a power station of a size to consume 100 thousand tons of air-dried peat annually, the peat to be cut and collected by electrically-powered machines. Unfortunately the report produced little result, but the chairman of the committee a few years later pioneered the development of mechanical turf-winning at Turraun. At the same time he built the first power station in Ireland to burn turf. The next stage was not reached until twenty-five years later, partly because the harnessing of the water resources of the Shannon had meant that there was little need for additional electricity generating capacity to be built during the intervening period. In 1949 the first generating unit at Portarlington was commissioned. This was a station to be fuelled entirely by machine turf and to have a generating capacity of 25,000 kilowatts (and in 1962/63, a further 12,500 kilowatt generating unit). It was followed two years later by a similar but slightly larger station at Allenwood and in the later 1950's by a station at Lanesborough.

It had been realised that milled peat offered a potentially cheaper source of electricity than machine-cut sod-turf because its harvesting, delivery and firing could be mechanised to a greater extent. The decision to go over to milled peat was made in 1950, but the problem was to design a boiler that could successfully and reliably burn a fuel with such a high water content. This problem was not overcome until 1957 with the commissioning and successful operation of the first unit at Ferbane power station. It had been decided to develop a bog intended for sod-turf production for producing milled peat instead, and to burn milled peat in the power station planned for that site. This plant, which is now Ferbane, was designed, built, and run with no experience of either pilot plant or prototype in Ireland (but taking advantage of experience on the Continent and in Sweden and of some information available from the USSR).

Today there are milled peat-fired power stations in operation at Ferbane and Rhode in Co. Offaly and at Bellacorick in Co. Mayo. Additional capacity to burn milled peat is being built at Lanesborough, the site of the second machine turf station, and a new station is under construction at Shannonbridge, Co. Offaly. The milled peat stations have so proved their superiority in cost and efficiency that since their inception no new machine turf stations have been considered.

Certain inevitable elements of controversy can be discerned in the history of turf development. These

TABLE 34: TRADING SURPLUS AND NET INCOME AS PERCENTAGES OF AVERAGE NET ASSETS EMPLOYED

Year	£ thousand				
	Average Net Assets	Trading Surplus		Net Income	
		amount	%	amount	%
1953/54 ..	5,420	282	5·2	172	3·2
1954/55 ..	6,450	376	5·8	174	2·7
1955/56 ..	7,710	637	8·2	261	3·4
1956/57 ..	8,560	672	7·9	336	3·9
1957/58 ..	9,080	781	8·6	490	5·4
1958/59 ..	10,020	(409)	(4·1)	(583)	(5·8)
1959/60 ..	11,890	969	8·1	722	6·1
1960/61 ..	13,720	836	6·1	561	4·1
1961/62 ..	14,920	910	6·1	615	4·1
1962/63 ..	15,920	1,530	9·6	1,072	6·7
1963/64 ..	16,820	1,348	8·0	889	5·3

( ) indicates deficit
Derived from Bord na Móna *Annual Accounts*

originated in the second and third decades of this century when there was a lack of official concern with turf and a lack of private capital willing to undergo the very considerable risks involved. By the mid-1930's it had become fully realised that the prospective returns were too distant, the hazards too great, and the rewards generally too intangible to attract private capital and that only the State could foster the development of turf. Thus, eventually, had Bord na Móna been set up to produce turf, much as the Electricity Supply Board had been set up to produce electricity from the Shannon scheme.

The problem was what to do with the turf produced and whether this indigenous fuel should be sold in domestic or industrial markets. An attractive major alternative which was visualised at the time the Board was set up was to use the turf for generating electricity; this would give turf an assured market where its disadvantage of bulk was of least account, for power stations could be built on or close to the bog to cut transport to a minimum. It must have seemed, then, an obviously desirable national policy that turf should be used to make electricity. At prices then ruling, turf was quite competitive with other fuels and no question of protection or subsidy arose.

Special price arrangements operate between Bord na Móna and the Electricity Supply Board. The price charged to the Electricity Supply Board is fixed annually on the basis of ascertained turf production costs and is subject to a sliding scale related to the moisture content of the turf supplied. Presumably the price is also to some extent subject to negotiation between the two Boards. For the last few years the cost of electricity from turf has been higher than the cost of electricity from imported fuel.

In accordance with government policy the Electricity Supply Board must give preference to fuels from native sources. This has meant that for several years now the ESB has been using turf stations at times when it would have been cheaper for the Board to have used stations burning imported fuel. As long as output is less than supply capacity, which it is quite often because of daily and seasonal variations in electricity consumption, it is possible to use one power station or one type of fuel in preference to another. The ESB could have used less turf by reversing its preferences and it would in consequence have been able to reduce its costs (given that fuel prices remained unaffected).

There is some residual element of controversy over turf, then, in these two particular respects: in regard to the price paid for turf used for generating electricity and in regard to the preference given to that turf. Of course, if the price of turf were competitive with the price of imported fuels then these points would not be at issue.

Under these conditions and at present relative prices, the effect is that the electricity consumer subsidises the production of turf. In the financial year 1963/64 the cost of fuel at power stations burning coal or oil was £2,126,000, while 1,123 million units of electricity were sent out from these stations. Turf stations sent out 980 million units of electricity at a fuel cost of £2,987,000. This same number of units would have cost £1,854,000 at an average unit fuel cost equal to that of units sent out from coal/oil stations. The total excess fuel bill on account of the use of turf was therefore £1,133,000 in 1963/64; this represents just over one-tenth of a penny on each unit of electricity sold, or 5% of the average unit price. Thus, if the price of turf for generating electricity had been brought down to a level such that the ESB would, on commercial grounds alone, have chosen to use turf rather than imported fuels, Bord na Móna's revenue from sales of turf would have fallen by more than a million pounds (by roughly 20%). This loss in revenue would have wiped out most of the Board's trading surplus in 1963/64.

What the effect would have been in 1963/64 had turf been given no special preference is more difficult to gauge. In this case coal/oil stations would have been used to the greatest possible extent and turf stations would have been operated only when the load was greater than that the former stations could supply. The appendix to this section discusses the possible consequences and shows that the ESB could have cut down its consumption of turf in a normal year by at least a quarter, with a reduction in its total fuel bill of at least £250,000. This would have reduced Bord na Móna's revenue by some £650,000 (by about 10%, thereby reducing its trading surplus by a half in 1963/64).

These figures give some idea of the financial burden being borne by the ESB and ultimately by the electricity consumer on account of the preference that must be given to turf. The two cases are distinct in that they presuppose different quantities of turf being used for generating electricity and different prices being paid for that turf. These two considerations are quite separate.

The quantity of turf used affects the amount of fuel that has to be imported. Roughly speaking, a reduction in the value of the turf used of £650,000 would lead to an increase in the value of fuel imported of £400,000. These figures in fact apply to 1961/62 (see appendix) and larger sums may now be involved, but their relative values are probably more or less the same. The difference between them represents a premium that the country as a whole must pay to reduce its import bill and to

TABLE 35 (APPENDED TO SECTION 5, PART II): BORD NA MÓNA ACCOUNTS; 1953 TO 1963

I. STATEMENT OF INCOME

£'000

Financial year—	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64
Receipts											
—by sales for year	1,608	1,835	2,207	2,167	2,558	2,247	3,105	3,734	4,316	5,379	5,506
—to nitial stocks[1]	(601)	(674)	(687)	(670)	(1,292)[2]	(1,580)	(1,021)	(1,311)	(1,535)	(1,745)	(1,609)
—from final stocks[1]	674	687	670	991	1,580	1,021	1,311	1,535	1,745	1,609	1,786
Total effective receipts ..	1,681	1,848	2,190	2,488	2,846	1,688	3,395	3,958	4,526	5,243	5,683
Operating expenses											
—production	1,156	1,188	1,210	1,466	1,561	1,611	1,936	2,515	2,848	2,972	3,477
—administration etc. (less miscellaneous revenue and grants) ..	243	284	343	350	504	486	490	607	768	741	857
Total	1,399	1,472	1,553	1,816	2,065	2,097	2,426	3,122	3,616	3,713	4,334
Trading surplus = gross income ..	282	376	637	672	781	(409)	969	836	910	1,530	1,349
Depreciation[3] [4]	110	202	376	336	291	174	247	275	295	458	460
Net income	172	174	261	336	490	(583)	722	561	615	1,072	889
Interest[3]	170	172	202	331	482	322	382	596	710	720	881
Retained surplus	2	2	59	5	8	(905)	340	(35)	(95)	352	8
Earned in respect of:[5]											
—machine turf	(3)	7	47	2	12	(571)	236	(135)	(41)	261	175
—briquettes	6	(5)	5	7	—	(74)	40	11	(285)	(116)	(96)
—peat moss	(1)	—	7	(3)	(4)	(39)	22	(10)	30	32	17
—milled peat	—	—	—	—	—	(220)	42	169	201	175	(88)

( ) indicates an entry to be subtracted.

Notes (to Table 35 I):

[1]Stock changes from year-to-year are large enough to justify this way of calculating income, that is, assuming the whole of the year's production had been sold in that year.
[2]The discrepancy between this year's initial stocks and the preceding year's final stocks seems to have arisen because stocks of milled peat were not shown as such at the end of 1957.
[3]Note that depreciation fluctuates from year-to-year, as do interest payments.
[4]The depreciation charged against income each year is about £25,000 less than the depreciation written off the value of assets.
[5]These figures have been rounded off individually.

Source: Annual Accounts of Bord na Móna.

TABLE 35—*continued*

II. Sources and Uses of Funds

£'000

Financial year—	1953/54	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64
Sources of Funds:											
external borrowing[1]	590	1,326	1,336	944	943	1,695	1,464	1,610	1,509	1,178	1,082
capital grants	179	51	11	—	—	—	—	—	—	—	—
net cash flow and other internal sources[2]	112	204	435	391	324	(706)	614	268	229	836	504
Total funds available	na	na	na	1,335	1,267	989	2,078	1,878	1,738	2,014	1,586
Uses of Funds:											
increase in value of assets ..				951	819	1,572	2,633	1,606	1,402	1,399	1,350
increase in working capital ..				384	448	(583)	(555)	272	336	615	236
Gross investment	na	na	na	1,335	1,267	989	2,078	1,878	1,738	2,014	1,586

( ) indicates an entry to be subtracted.

Notes (to Table 35 II):
[1]Includes borrowings from Superannuation Fund.
[2]Gross investment less external borrowing and capital grants; mainly from depreciation.

III. COMPOSITION OF NET ASSETS

£'000

As at 31st March	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
Fixed assets:												
assets at cost	na	na	na	10,142	11,093	11,912	13,484	16,117	17,723	19,125	20,524	21,874
less depreciation provision ..	na	na	na	(1,355)	(1,720)	(2,037)	(2,235)	(2,508)	(2,811)	(3,134)	(3,619)	(4,105)
Total net fixed assets	5,614	6,217	7,552	8,787	9,372	9,876	11,250	13,609	14,911	15,990	16,905	17,769
Current assets and liabilities:												
stocks	988	1,195	1,102	1,083	1,493	2,013	1,465	1,769	1,984	2,284	2,207	2,395
debtors	464	279	304	286	345	682	574	372	461	655	1,096	1,002
cash, securities etc.	60	59	147	327	133	7	216	73	54	—	1	92
production expenses in advance	41	41	14	163	312[4]	7	3	58	27	46	20	17
Total current assets	1,553	1,574	1,567	1,859	2,283	2,709	2,258	2,272	2,526	2,985	3,324	3,506
short-term loans[1]	127	128	108	—	—	—	—	—	—	135	26	—
creditors	168	191	200	400	440	418	550	1,119	1,101	1,089	922	894
Total current liabilities ..	295	319	308	400	440	418	550	1,119	1,101	1,224	948	894
Working capital net	1,258	1,255	1,259	1,459	1,843	2,291	1,708	1,153	1,425	1,761	2,376	2,612
Total net assets	6,872	7,472	8,811	10,246	11,215	12,167	12,958	14,762	16,336	17,751	19,281	20,381
Represented by:												
repayable capital[2]	6,867	7,457	8,783	10,119	11,063	12,006	13,701	15,165	16,775	18,284	19,462	20,554
reserves	33	43	53	100	120	120	120	120	120	120	120	120
repaid capital *plus* surplus *less* write-offs[3]	(29)	(27)	(25)	27	32	41	(863)	(523)	(559)	(653)	(301)	(293)

( ) indicates an entry to be subtracted.

Notes (to Table 35 II, III):
[1]Including indebtedness in respect of interest payments in 1953, 1954 and 1955.
[2]Total borrowings less redemptions.
[3]Or deficit.
[4]Mostly in stocks of milled peat; see also Note (2).

Source: Annual Accounts of Bord na Móna.

ncrease its earnings from production by the stated amounts.

It is not known whether employment in the turf industry would or would not be reduced by the supposed marginal fall in output. If not, then the fall would simply reduce Bord na Móna's ability to meet its overheads (for there must be few other operating costs apart from labour) and merely increase the government's liability in this respect. Only if employment were reduced and alternative productive employment available, would the reduction in output be worthwhile. To put it another way, only if the part of the £650,000 that is escapable exceeds £400,000 should any change be contemplated; otherwise, the premium the country has to pay is an unavoidable result of previous commitments. Given the importance of industrial employment in hitherto rural areas of Ireland, even if employment in turf could be reduced it would be highly undesirable. The indications are, therefore, that there is little to be gained and much to be lost by reducing the output and use of turf, for electricity generating in particular.

Further new investment in turf production cannot be justified on the same grounds, but must be considered on its own merits; whether, essentially, the employment created is worth the extra cost of fuel that would have to be borne (given that relative prices and costs of fuels remain unaltered and that there would be an extra cost). However, turf development has taken place under a phased programme and, to the author's knowledge, no entirely fresh investment is now envisaged.

Although the extra cost[8] of turf is inescapable it still must be paid. Either it must be paid by the electricity consumer or by the government, that is to say, the taxpayer. There are two arguments in favour of the electricity consumer bearing the burden. First, it is he who benefits from the increased security of supply associated with the use of indigenous fuels. The second argument is that the use of electricity is so widespread that the electricity consumer is almost identical with the taxpayer. Considered as a tax on electricity it is progressive, because of the income-elasticity of electricity consumption, and there are some administrative conveniences. The resultant increase in electricity prices is not large enough to incite public opinion, nor large enough to affect by much the consumption of electricity. Thus there is some reason not to disturb the present arrangement. The important disadvantage is that true costs are being hidden with the possible result that at some time a wrong decision will be made because the situation is taken at its face value. For government to bear the subsidy directly would expose the situation and would remove one constraint on the commerical operations of the ESB.

APPENDIX TO PART IIB
THE COST OF THE PREFERENCE GIVEN TO TURF STATIONS

In Section 3 of the earlier part of this paper the additional fuel bills that the ESB has had to meet because of its use of turf fuel were estimated on the simple assumption that the economic price for turf was that price which would bring the average cost of electricity from turf stations equal to that of electricity from stations burning imported fuels. A second approach is also possible: to assume that with current prices turf would only be given that preference due to it on account of the relation of its price to that of imported fuels. At present the use of turf is automatically given preference whenever turf is available.

Consider the operation of two groups of generating stations during the year 1961/62, this year being chosen because turf was in normal supply: on the one hand stations burning imported coal or oil, and on the other hand the large turf-burning stations. Table 36 below shows the respective capacities, outputs and fuel costs of these two groups of stations. From coal/oil stations with an installed capacity of 195,000 kilowatts a total of 634 million kilowatt-hours of electricity was generated; the average station load factor was therefore 37%. Turf stations with a capacity of 185,000 kilowatts generated 819 million kilowatt-hours, an average plant factor of 51%. Suppose that preference had not been given to turf but to imported fuels which in that year were considerably cheaper than turf. As a rough approximation to what might have been the result it seems reasonable to imagine these two plant factors to have been reversed. Coal/oil stations would then have produced about 850 million kilowatt-hours and turf stations only 600 million. In fact, the switch could possibly have been of greater magnitude because coal/oil stations are not subject to fuel supply shortages and might have taken an even larger share of the load.

Assuming average unit fuel costs to remain unchanged it is now possible to calculate the fuel cost that the ESB would have avoided by giving preference to coal/oil stations in this way. The calculation is shown in Table 36.

In 1961/62 by reversing its preference the ESB would have saved itself at least £250,000 and cut

[8]It could be argued that this "extra cost" is a cost differential over which this country has no control, and that it is inescapable only while the prices of imported fuels are at present levels.

TABLE 36: COST OF ELECTRICITY FROM TURF STATIONS; 1961/62

Station	Capacity	Actual		Reversed Preference[1]	
	th. kw	Output m. kwh	Cost £'000	Output m. kwh	Cost £'000
North Wall	45	55	122	—	—
Marina	60	195	361	—	—
Ringsend	90	384	681	—	—
Coal/oil	195	633	1,163	850	1,560
Portarlington	25	138	464	—	—
Allenwood	40	184	616	—	—
Ferbane	60	231	628	—	—
Lanesborough	20	93	272	—	—
Rhode	40	173	444	—	—
Turf	185	819	2,424	600	1,776
		Total cost	3,587		3,336
			3,336		
		Difference	250		

Note: [1]Individual station outputs not calculated

down its turf bill by more than a quarter. Had it been possible to run coal/oil stations at 60% load factor this difference would have risen to £440,000.

The simple ruse of reversing the load factors is also possible for 1960/61 because in that year also the installed capacities of coal/oil stations and of turf stations were of about equal size and the average load factor of turf stations was rather greater than that of coal/oil stations (see Table 37).

In both 1962/63 and 1963/64 coal/oil stations were on average run more than turf stations. This was due partly to turf shortages and partly to the commissioning of some turf capacity during each year, which, of course, brought down the average use of all turf capacity in each of the two years. It would seem unrealistic to attempt to guess how high the average load factors of coal/oil stations could have been, given the load and hydro conditions during each of the years. It seems preferable, therefore, to rely on the tangible evidence of 1960/61 and 1961/62. Thus, as an indication of the possible savings the figure of £250 thousand can be taken. With fuel prices steady, turf in normal supply and electricity consumption growing, this figure will tend to increase with time. This will happen because base load will increase in relation to the amount of turf-burning capacity in the system, and the latter will be able to operate at higher load factors.

TABLE 37: COST OF ELECTRICITY FROM TURF STATIONS; 1960/61

Station Type	Capacity	Actual		Reversed Preference	
	th. kw	Output m. kwh	Cost £'000	Output m. kwh	Cost £'000
Coal/oil	195	447	886	675	1,340
Turf	185	667	2,046	440	1,350
		Total cost	2,932		2,690
			2,690		
		Difference	240		

Appendices

GLOSSARY OF TERMS

Energy is the source of heat, light and mechanical power; as used here the term excludes human energy.

Fuels are vegetable and fossil sources of energy, including turf, coal, oil and natural gas.

Power is energy in the form of electricity (although this usage is not strictly correct).

Primary Energy is energy in its first-obtained form, before conversion into other forms of energy, e.g. fuel into electricity.

Secondary Energy is energy that has been converted from its primary form, e.g. townsgas.

Commercial Energy is energy that is supplied and sold for financial reward.

Total Energy includes both commercial energy and energy from non-commercial sources, e.g. hand-won turf in Ireland.

Final Energy Consumption is the eventual use of energy to provide heat, light or motive power; it excludes the conversion of energy into secondary form.

Effective Energy Consumption is final energy consumption with each component form of energy weighted in the total according to its relative efficiency in use.

Final Consumption Sectors include Industry and Services, Transport, Agriculture and Other Sectors (Domestic and Commercial); all automotive fuels are considered to be consumed within the Transport Sector.

Transformation Sectors include the Electricity and Townsgas Industries.

LIST OF TABLES

CHARTS
(Appended to Part II A, Section 4)

BIBLIOGRAPHY AND REFERENCES

General :

Man and Energy by A. R. Ubbelohde, Hutchinson 1954.
Geography of Energy by G. Manners, Hutchinson 1964.
Gas Journal Directory 1963.
General Reports of European Coal and Steel Community.
National Power Survey 1964 Federal Power Commission.
Report of the National Fuels and Energy Study Group on An Assessment of Available Information on Energy in the United States, September, 1962. Committee on Interior and Insular Affairs, 87th Congress.
L'Économie de l'Énergie dans le Pays in voie de Développement by Pierre Sevette, 1963, Presses Universitaires de France.
Étude sur le Perspectives Énergétiques á long terme de la Communauté, December, 1962, Luxemburg.
Rapport Général de la Commission de l'Énergie, 1961, Paris, Imprimerie Nationale.

Economics of State Corporations :

Investment, Financing and Valuation of the Corporation by M. J. Gordon, 1962, R. Irwin, Inc.
Lessons of Public Enterprise (ed.) M. Shanks, 1963, Jonathan Cape.
Overhead Costs by W. A. Lewis, 1949, Allen and Unwin.
Depreciation and Replacement Policy (ed.) J. L. Meij, 1961, North-Holland Pub. Coy.
Financial and Economic Obligations of Nationalised Industries Cmnd. 1337, 1961, HMSO.
Studies in Accounting Theory (ed.) W. T. Baxter and S. Davidson, 1962, Sweet and Maxwell.
Economic Performance under Public Ownership by W. G. Shepherd, 1965, Yale University Press.

Conditions in Britain :

Statistical Digest (annual) Ministry of Power, HMSO.
Annual Reports (HMSO) :—
Electricity Council
Central Electricity Generating Board
Atomic Energy Authority.
Gas Council.
Select Committee Reports (HMSO) :—
Electricity Supply Industry, 1956 and 1963.
Gas Industry, 1961.
Fuel Policy Cmnd 2798, HMSO.
Price of Fuel by I. M. D. Little, 1953, Oxford University Press.
Marginal-cost Price of Coal 1956-57 by Millard Long, *Economica* XXIX, No. 116, November 1962.
Bulk Supply Tariff for Electricity by R. L. Meek, OEP, Vol. 15, July 1963.

Electricity Prices/Economics of Tariff Systems

Theory of Marginal Cost and Electricity Rates, 1958 OEEC.
Genesis of Present Pricing System in Electricity Supply by I. C. R. Byatt, OEP, March 1963 Vol. 15.
Practical Applications of Marginal Cost Pricing in Public Utility Field by J. R. Nelson, AER, May, 1963, Vol. LIII, No. 2.
Fully Distributed Costs in Utility Rate-Making by J. C. Bonbright, AER, May, 1961, Vol. LI, No. 2.
Peak Loads and Efficient Pricing by P. O. Steiner, QJE, November, 1957, Vol. LXXI, No. 4.
Statistical Cost Analysis by J. Johnson, 1960, McGraw-Hill.
Critique of Welfare Economics by I. M. D. Little, 1957, Oxford University Press.
Theory of Pricing in Public Enterprise (unpublished paper) by R. H. Barback.
Electricity Tariffis in Theory and Practice by H. S. Houthakker, EJ, Vol. LXI, No. 241, March 1951.
Electricity Tariff Systems in Europe, ECE, EP/Working Paper No. 267, 5 July 1963.
Theoretical Welfare Economics by J. de V. Graaff, 1962, Cambridge University Press.
General Principles Governing Electricity Tariff Framing, UNIPEDE, June 1964.

Ireland–General

Second Programme for Economic Expansion, 1963, Stationery Office, Dublin.
State-Sponsored Bodies by G. Fitzgerald second edition (revised) 1963, Institute of Public Administration.
Financial Administration of Ireland by J. B. O'Connell, 1960, Mount Salus Press.
Report on Internal Public Transport, Parts I and II, October 1963, CIE Dublin.
Irish Atomic Energy Committee Report, 22nd May 1958.
Electricity, Energy and Turf (unpublished papers) by D. J. Reynolds.
Internal Finance for Capital Investment in ESB (unpublished paper) by D. Walker.
Bord na Móna, Journal of Inst. of Public Administration, Spring, 1959.
Ireland's Future in World Demand on Energy Resources by D. Flood, JSSISI, 1963–4.
Some Precursors of Bord na Móna by C. S. Andrews JSSIS, 1953–4.
Electricity Supply Board, by R. F. Browne, JSSISI, 1951–2.
Electricity Supply Board Journal of Inst. of Public Administration Autumn 1957.
Some Aspects of Inland Transport by D. J. Reynolds JSSISI, 1962–3.
Turf Development Programme Paper No. 7385, 1946 Stationery Office, Dublin.

Turf

Developments in Production and Utilisation of Turf in Ireland, by H. M. Miller, BnM, 1961.
Review of Peat Resources and Development in Ireland by C. S. Andrews, BnM.
Peat Industry of Today and Tomorrow by H. M. Miller, *Bull. Inst. Civ. Eng.* January 1955.
Use of Peat in Industrial Installations in Ireland by F. Lunny, WPC, 1956.
Production of Peat Briquettes in Ireland by Brown and Belitz, WPC, 1962
(selection of titles).

Air Pollution

Air Pollution on Ireland by F. B. Dawson, Administration 1959, Vol. VI, No. 2.
Breath of Life by D. E. Carr, 1965, W. W. Norton, New York.
International Clean Air Conference 1959, National Society for Clean Air, London 1960.
Air Pollution; Irish Times Features, June 29 and 30, and July 1 1964.
Removal of Sulphur from Fuels and Products of Combustion by T. T. Frankenberg 1964, American Society Mechanical Engineers.
(selection of titles).

Statistical Sources

Statistical Abstract of Ireland.
Trade Statistics of Ireland (monthly).
Trade and Shipping Statistics (Annually).
Annual Reports of: Revenue Commissioners.
Electricity Supply Board.
Bord na Móna.
Córas Iompair Éireann.

Abbreviations

ESB	Electricity Supply Board
BnM	Bord na Móna (Turf Board)
CIE	Córas Iompair Éireann (Transport Authority)
CSO	Central Statistics Office
CIP	Census of Industrial Production
HMSO	Her Majesty's Stationery Office, London
OEP	Oxford Economic Papers
OEEC	Organisation for European Economic Co-operation
AER	Americal Economic Review
QJE	Quarterly Journal of Economics
EJ	Economic Journal
UNIPEDE	Union of Producers and Distributors of Electricity
ECE	United Nations: Economic Commission for Europe
JSSISI	Journal of Statistical and Social Inquiry Society of Ireland
ERI	Economic Research Institute, Dublin
GDP	Gross Domestic Product
GNP	Gross National Product
Btu	British Thermal Units
kwh	kilo-watt-hour 1 kwh=3,412 Btu
kw	kilowatt
MW	Mega watt; 1 MW=1,000 kw
p.a.	per annum
WPC	World Power Conference

Reprint Series:

1. *Commentary on "Europe's Future in Figures"* R. C. Geary
2. *Forms of Engel Functions* C. E. V. Leser
3. *The Cost Structure of British Manufacturing*, 1948–61 E. T. Nevin
4. *The Life of Capital Assets: An Empirical Approach* E. T. Nevin
5. *Estimation of Quasi-linear Trend and Seasonal Variation* C. E. V. Leser
6. *The Pattern of Personal Expenditure in Ireland* C. E. V. Leser
7. *Some Remarks about Relations between Stochastic Variables: A Discussion Document* R. C. Geary
8. *Towards an Input-Output Decision Model for Ireland* R. C. Geary
9. *Do-It-Yourself Economics of the Firm: First Draft of a Statistical Scheme* R. C. Geary
10. *Recent Demographic Developments in Ireland* C. E. V. Leser

THE ECONOMIC RESEARCH INSTITUTE

Publication Series :

1. *The Ownership of Personal Property in Ireland* Edward Nevin
2. *Short Term Economic Forecasting and its Application in Ireland* Alfred Kuehn
3. *The Irish Tariff and The E.E.C.: A Factual Survey* Edward Nevin
4. *Demand Relationships for Ireland* C. E. V. Leser
5. *Local Government Finance in Ireland: A Preliminary Survey* David Walker
6. *Prospects of the Irish Economy in* 1962 Alfred Kuehn
7. *The Irish Woollen and Worsted Industry*, 1946–59*: A Study in Statistical Method* R. C. Geary
8. *The Allocation of Public Funds for Social Development* David Walker
9. *The Irish Price Level: A Comparative Study* Edward Nevin
10. *Inland Transport in Ireland: A Factual Survey* D. J. Reynolds
11. *Public Debt and Economic Development* Edward Nevin
12. *Wages in Ireland*, 1946–62 Edward Nevin
13. *Road Transport: The Problems and Prospects in Ireland* D. J. Reynolds
14. *Imports and Economic Growth in Ireland*, 1947–61 C. E. V. Leser
15. *The Irish Economy in* 1962 *and* 1963 C. E. V. Leser
16. *Irish County Incomes in* 1960 E. A. Attwood and R. C. Geary
17. *The Capital Stock of Irish Industry* Edward Nevin
18. *Local Government Finance and County Incomes* David Walker
19. *Industrial Relations in Ireland: The Background* David O'Mahony
20. *Social Security in Ireland and Western Europe* P. R. Kaim-Caudle
21. *The Irish Economy in* 1963 *and* 1964 C. E. V. Leser
22. *The Cost Structure of Irish Industry*, 1950–60 Edward Nevin
23. *A Further Analysis of Irish Household Budget Data*, 1951–1952 C. E. V. Leser
24. *Economic Aspects of Industrial Relations* David O'Mahony
5. *Psychological Barriers to Economic Achievement* P. Pentony
26. *Seasonality in Irish Economic Statistics* C. E. V. Leser
27. *The Irish Economy in* 1964 *and* 1965 C. E. V. Leser
28. *Housing in Ireland: Some Economic Aspects* P. R. Kaim-Caudle
29. *A Statistical Study of Wages, Prices and Employment in the Irish Manufacturing Sector* C. St.J. OHerlihy
30. *Fuel and Power in Ireland: Part I. Energy Consumption in* 1970 J. L. Booth
31. *Determinants of Wage Inflation in Ireland* Keith Cowling
32. *Regional Employment Patterns in the Republic of Ireland* T.J. Baker
33. *The Irish Economy in* 1966 The Staff of The Economic Research Institute
34. *Fuel and Power in Ireland: Part II. Electricity and Turf* J. L. Booth

Printed by Cahill and Co. Ltd., Parkgate Printing Works, Dublin.