Present and future patterns of energy usage in rural areas.

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PRESENT AND FUTURE PATTERNS OF ENERGY USAGE IN RURAL AREAS

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ABSTRACT

Present and Future Patterns of
Energy Usage in Rural Areas

H. Martin Edge.

The hypothesis presented in this study is that:

> "There exists considerable potential for a greater degree of rural energy autonomy, especially through the medium of increasing integration between agricultural/forestry and domestic sectors, to make better use of rural energy resources".

This is investigated by two basic lines of inquiry. A study of the future of rural areas and their energy resources and use was carried out, firstly by reference to the available literature, and then by a three round 'Delphi' survey of a panel of 'experts' in rural and energy fields. The results of this survey are presented in the form of a single most likely scenario for a fifty year rural future.

The second major constituent of the study is a door-to-door survey of houses and farms in areas of the North-East of Scotland, which investigates current energy use and energy resources for a simplified rural system, as well as attitudes to energy in the future.

Current energy use and the energy resource in these rural areas is then projected into the future, by application of the characteristics of the most likely scenario in the 'Delphi' study, to the results of the local survey. The ability to extrapolate the results from these survey areas to the more general British rural environment is also explored.

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DECLARATION

The candidate has not, while registered for this C.N.A.A. Ph.D. submission, been registered for another award of the C.N.A.A. or of a university during the research programme.

None of the original material contained in this thesis has been used in any other submission for an academic award. Acknowledgements for assistance received are given under the heading acknowledgements, and any excerpt from other work has been acknowledged by its source and author.

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Those who were kind enough to assist with the'Delphi' survey, and the regional survey of fuel suppliers, are listed in the appendices. I would also like to thank the people of Cuminestown, Lumsden and Dunecht, too numerous to mention individually, who participated in the local surveys.

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1.1. Introduction to the Project-

This project aims to take a detailed look at energy use and the energy resources of, rural areas in the U.K., largely by study in the North East of Scotland, and to produce a comprehensive picture of these facets of rural life.

To carry out a study which purports to deal with 'the rural areas of Britain' seems perhaps a little sweeping, given the vast differences which exist between say, a Hebridean island and East Anglia, or between a village in the stockbroker belt and a Welsh mountain. Yet in spite of these differences, there remain certain quintessential similarities between rural areas, not least the fact that they are not 'urban'. Thus agriculture as the, or a, main land use, overall population densities, access and travel distances and, as explained in section 2.1.3., energy use densities, all distinguish rural areas, of whatever kind, from urban areas. It is also suggested that 'rural energy resources' are a definable set of items, and that they differ in essential characteristics from urban energy resources (section 2.1.4.). A level of rural energy autonomy is suggested as being desirable on the basis that, although rural areas are seen as being reliant on urban areas, in fact urban areas do not even have the potential for a level of energy autonomy on the local scale, whereas rural areas do.

The rural energy resource as defined in this study is one that is essentially rural, and springs from all, or almost all, rural areas, rather than from specific sites. This study is an integrated look at rural system energy use. A characteristic of many studies on 'rural energy' is a completely different interpretation of the rural energy resource, and a non-integrated approach to its problems. Such studies consider the impact of urban energy based developments on rural, or previously rural areas, rather than considering energy resources which remain rural during their exploitation. The characteristic of these studies is an environmental viewpoint and the lack of a constant unit of measurement by which to measure effects (1).

By contrast, the present project aims to present a picture of a simple rural system (simple in terms of the number of societal sectors which it admits), measuring inputs and outputs in energy equivalence terms, but also including assessment of sociological, economic and technical factors.

There are other areas of 'rural energy' than the above on which research is traditional. Firstly, many renewable energy technologists adopt the prefix 'rural' when discussing the application of their devices. Yet with a few exceptions (2), no integrative look at energy use is taken, and the approach is merely to demonstrate the solution of perceived energy supply problems, which may or may not exist (3). Secondly, and closer to the intent of the present study, various people have studied inputs and outputs of energy from agriculture (4). This thesis aims to go a stage further than this, and to look at domestic and transportation energy use in the same geographical areas as the agricultural energy use, with a view to assessing the potential for integrating agricultural and domestic sectors, and making the best use of the available rural energy resource.

1.2. Hypothesis and Methodology-

The hypothesis under study in this research, as stated at various points in the report, is that;

> "There exists considerable potential for a greater degree of rural energy autonomy, especially through the medium of increasing integration between agricultural/forestry and domestic sectors, to make better use of rural energy resources."

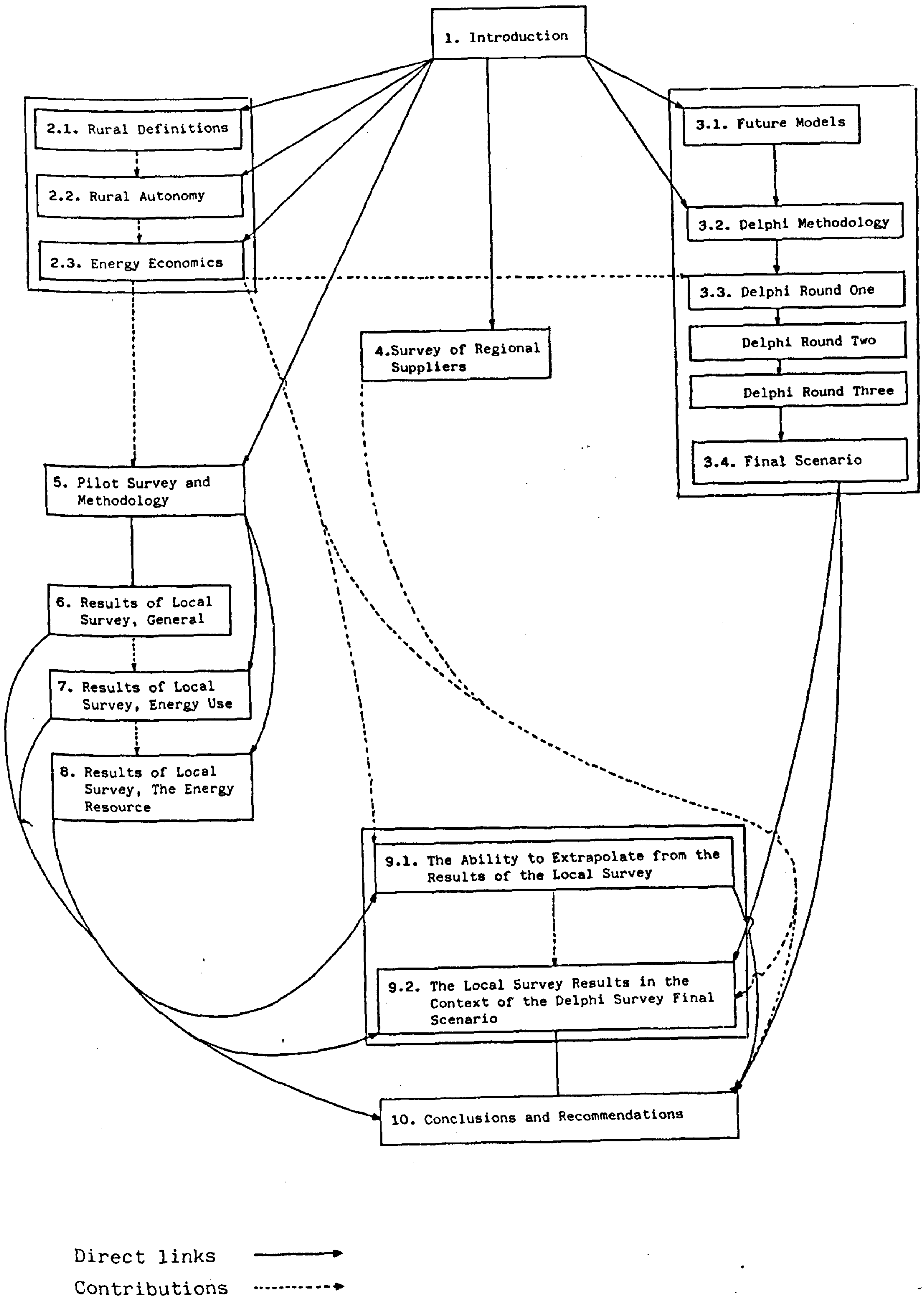
Thus it is necessary within the methodology of the research, to describe the nature of rurality and define its limits, to look at the meaning of and justification for the idea of 'energy autonomy', to describe the rural energy resource, to study present energy use and resources at the present time, and to forecast in some way how these patterns are likely to change in the future. The remainder of this section describes in brief how this methodology is presented in the succeeding pages, whilst Figure 1.1 presents the project structure in diagramatic form.

Section 2 looks at the nature of and defines the boundaries of rurality for the present project, going on to define rural energy resources and their characteristics. It presents a brief overview of the rural energy resource on a national scale, and looks at rural energy use, comparing its characteristics with those of urban energy use.

The justification for the 'self-sufficient', or autonomous approach suggested by the hypothesis is explained, and a 'rural system', within which the study of such autonomy will occur, is defined, and subsequently broken down in terms of its energy inputs and outputs.

Following this defining role, section 2 goes on to consider energy analysis, as an alternative to monetary economics, and assesses its value in a 'post-industrial' society. Different rural energy resources are assessed by looking at specific projects in both monetary and energetic terms, assessing the validity of current conversion technologies for these resources, and summarising the most useful types. Thus the potential for increasing energy autonomy, in terms of the availability of suitable technology, is explored.

Figure 1.1. FLOW DIAGRAM OF PROJECT STRUCTURE.



Section 3 begins by assessing 'information on the future' in terms of the many global and national, general and energy based forecasts available, looking particularly at the apparent motives of the forecasters in question, and at factors such as the general tendency to link energy use directly to Gross National Product (G.N.P.) in an inevitable direct linear relationship. This process builds up three alternative scenarios for a 50 year time horizon rural future, in preparation for a survey of experts in rural and energy fields, which aims to produce a single 'consensus' scenario of rural futures for application to local survey results. A 'Delphi' method survey is used for this purpose.

The section then explores the nature of the 'delphi' interaction process, selecting a panel of experts and developing and applying a three round postal survey. The results of this survey are presented as a single scenario (without, it must be said, complete consensus on all issues), and a listing of ideas for increasing rural energy autonomy which are felt to be the most likely to succeed. Thus the potential for rural energy autonomy in the future can be assessed by applying the resulting scenario to the recorded present characteristics of rural areas.

Section 4 describes the evolution and application of a survey of fuel suppliers to rural areas in the North East of Scotland. Conceived both as a means of checking the ability to generalise from the results of the local survey, and in its own right to provide a full supply, and by implication use pattern over a wide area. This survey proved somewhat abortive.

All possible suppliers of fuels to rural areas in Grampian were contacted by letter, telephone or personal interview, yet the available information from this technique proved so limited as to make the results rather meaningless.

In order to test how far the hypothesis is supported by actual local conditions, section 5 looks at the methodology of interview surveys, and selects 2 areas for study, as well as a pilot area, going on to describe the design of domestic and agricultural questionnaires for application in these areas, and the subsequent refinement of those questionnaires after application in the pilot area.

The questionnaires elicit information on all fuel use, housing standards, travel, social data and attitudes from an intended 100% sample of houses and farms in specific areas.

Section 6 presents general results from these three surveys, whilst sections 7 and 8 examine in more detail energy use and heat loss, and the energy resource, respectively.

Section 9 puts the survey results into the context of the "most likely future" suggested by the results of the Delphi survey, and explores how far it is possible to extrapolate from the results of the surveys of specific areas to the generalities of the wider rural context.

Section 10 presents conclusions with regard to the original hypothesis, and recommendations on policy and other measures which might be employed to improve the situation with regard to energy use and the energy resource in rural areas of the U.K.

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2. DEVELOPING THE CASE FOR RURAL ENERGY AUTONOMY

2.1. The Characteristics of Rurality and of 'Rural Energy'-

2.1.1. Introduction-

This section looks at some of the problems of definition concomitant with trying to make any separation of rural from urban. Given a suitably agreed definition of what is rural, it then explores the changing nature of, and variations between rural areas, and the resource and energy use characteristics which are peculiar to them. Finally potential future changes in the rural situation are explored. Thus the concept of a 'rural system' within which to explore the potential for a degree of rural energy autonomy is postulated.

The field of Rural Sociology impinges heavily on the section, due to its ability to cut across specialist boundaries and reach general truths about the differences between the two basic environments under discussion. In particular, Howard Newby's much acclaimed book on rural change, 'Green and Pleasant Land?' is heavily drawn upon to expose some of the stereotypes characterising opinions on rural areas conditioned by the values of an urban environment (1). Although much of Newby's work, relating as it does to the late 1970's, is becoming out of date, and relates specifically to English rural areas, with emphasis on arable areas of East Anglia, the trends described by him still have their influence on the present structure of rural areas.

2.1.2. Emotional and Rational Views of Rurality-

As Newby has pointed out, perhaps the majority view as to what constitutes 'rurality' or 'the countryside' is best likened to the picture on a biscuit tin (2). It tends to be a naive viewpoint which treats the countryside, and often the people in it, entirely as a flat aesthetic 'landscape', in much the same way as a painting.

The idealisation of the countryside is very much based on its visual appreciation, our views on which are highly conditioned by historical culture and art. These aesthetic views are very much at odds with the 'landscape appreciation' of those involved in agriculture and rural living, whose ideas of beauty might quite logically constitute a well ploughed field or a healthy crop of cereals. The largely urbanite view of rural beauty, as it is derived from historical art and the etiquette of an ancient upper class elite, is in fact diametrically opposed to any truly economic use being made of land, allowing only a few antiquated symbols of an outdated, inefficient agriculture to impose as points of interest on an otherwise unspoiled vista (3).

In reality there is hardly any such thing in Britain as a natural landscape, and there has not been for many centuries, if natural is taken to mean unaltered by man.

The word 'landscape' initially just meant a picture of a scene, but it came to mean the actual scene that was represented by the painting, and eventually any part of the countryside, and this changing definition mirrors the way the landscape, and our appreciation of it, have also changed. Seventeenth and eighteenth century romantic artists in particular so imposed their views on composition and aesthetics on the minds of the elite that landscape gardening became, through the work of such practitioners as Capability Brown, a slave to creating the types of landscapes which looked good on the walls of art galleries. Rules of etiquette amongst the rich demanded that their means of aquiring money should not be seen, so these new 'natural' landscapes had to be more or less cleared of productive farming, and often of whole villages, with only the odd grazing deer or besmocked yokel being permissable within the gracious view.

Although these alterations to the form of the countryside were nowhere near as severe or widespread as for instance the enclosures or earlier wholesale deforestation, their pretentions to naturalness and aesthetic beauty fixed them so firmly in the mind that they remain yardsticks by which to measure natural beauty even today. Thus practically all National Parks and Areas of Outstanding Natural Beauty are also areas of low agricultural production, and agriculture and 'the environment' are still seen as being entirely opposing interests (4).

Since the countryside is supposed to be so natural of course, it is not supposed to change or be changed by man, which puts it at a distinct disadvantage to the urban areas which, even though they may be of great historic interest, are man-made and therefore open to the possibility of change. So in reality there seems to be little difference between urban and rural areas in terms of their 'naturalness', but as long as such a difference is perceived to exist by people, their misconceptions can have a very strong influence on the rural areas.

To the people that have historically occupied and worked in rural areas, the countryside is basically an economic environment like any other, but with its own distinctive features, whilst to the urban dweller or urban influenced individual, the countryside is a largely 'aesthetic good'. This latter viewpoint tends to see town and country as being essentially conflicting elements, rather than symbiotic, and the suspicion that the urban areas are 'winning', in terms of their encroachment onto rural areas, stirs a desire, such as that found in environmental groups, to side with an imagined underdog, albeit that their vision of the underdog's nature is rather imperfect.

2.1.3. Defining Rurality-

In order to test the assertion in the hypothesis that there is potential for a degree of rural energy autonomy, it is important to be able to define what is meant by 'rurality', and to delineate a 'rural system'.

Few would argue with the statement that central London is urban, whilst the Cairngorms are rural; the two terms are, in their extreme conditions, too well understood to require definition. Therefore it may be more important to define the borderline between urban and rural areas than it may be to define rurality per se.

Although statistics are usually based on relatively arbitrary administrative boundaries, (i.e anything which is neither a City District nor a Metropolitan Region is deemed to be rural), academic definitions have generally relied on settlement sizes, and taken some arbitrary population, below which an area is described as being rural. This minimum urban settlement figure tends to vary in European definitions from 1000 to 15000 inhabitants, though in the extremes Iceland has a threshold population for urban areas of 300, whilst in Japan the figure is 30,000 (5). These figures reflect not only bureaucratic whim, or even overall population densities, but differing economic, agricultural and cultural structures. For instance in Japan a farming landscape might be as densely populated as many cities in the U.S.A. Such difficulties of definition due to diversity between areas applies to some extent even within a relatively small country such as the U.K. Thus an area which is rural by the standards of the south east of England, might be considered urban in the north west of Scotland. Such diversity means that a simple categorisation of areas as either urban or rural is not merely difficult to arrive at, but largely meaningless.

Three or more categories are needed to arrive at any meaningful generalisation, and such definitions have been attempted using more sophisticated techniques for separating localities. Yet the more sophisticated the technique, the more difficult it becomes to remain objective. For instance, Cloke's 'Index of Rurality for England and Wales' (6), developed in order to study 'rural deprivation', includes variables for house occupancy rate, household amenities (such as inside toilets) and the percentage of the population over 65. With the index calculated in terms of deprivation it is hardly surprising that Cloke is able to conclude that rural areas suffer from deprivation.

The present study has avoided the issue of definition rather by concentrating largely on extreme rurality, surveying only settlements with low populations, far from the urban centres. (In fact survey areas are all under a population size of 400, and are 40 miles from any settlement with a population of 20000 or more). Thus many of the characteristics of the rural-urban fringe are avoided in favour of more intrinsically 'rural' characteristics.

Thus we come back to the definition of rurality per se, an exercise which has been attempted at some time by most rural planning writers, often in a rather vague and ambiguous way. Some, such as Cherry (7)and Lassey (8), have just employed negative definitions, and said that countryside is anything which is not urban. Others, such as Moss (9) and Thorburn (10), are able to avoid proper definition by leaving it up to the population at large, stating that countryside is anything which people think is countryside, and that a village is anything which people think is a village. Thus Moss states:-

> The village can be described as a place where the countryside meets the town and where distinctions between rural and urban lies very much in the eye of the beholder.

And Thorburn....

> A village is any place which most residents think of as a village.

Although there may be some validity in such statements they appear to be rather inadequate. For instance many people may see their habitats as being rural even when they show no other rural characterisics, (Greenwich Village in New York is a case in point). Others may perceive Hyde Park as countryside, when it is so in practically no meaningful sense of the word.

However the spirit of this type of definition is meaningful, for it exposes one view of the usefulness of the countryside, that of being appreciated aesthetically and emotionally, as countryside.

More positive definitions prove somewhat more useful, stressing population densities or settlement types or instance Lewis suggests that rural settlement types....

> ...range from isolated farmsteads to the market towns serving a tributary area.(11)

An interesting variation on the theme of density is the extensiveness of land use, suggested by Wibberley....

> The word....(rural)...., describes those parts of a country which show unmistakable signs of being dominated by extensive uses of land, either at the present time or in the immediate past. (12)

....Thus avoiding the need for definitions based entirely on perception.

Yet defining what constitutes an intensive or extensive use of land may also be difficult. Agriculture can be considered to be a more exensive land use than manufacturing industry perhaps, unless one is talking about intensiveness of organic matter concentration. So even with this more precise definition individual perception is important, unless some relatively objective measure of intensiveness can be found.

2.1.4. Energy and Definitions of Rurality-

In the context of the present study, a definition of rurality in energy terms is of particular relevance. A suitable measure of the intensiveness of land use might be its average energy intensiveness, particularly in developed temperate countries, where most of the activities of man are characterised by a high use of energy. The usefulness of energy in this context derives from the fact that, although different energy types vary considerably in their usefulness, it is basically a single commodity which can be measured and is present in all environments.

Although locations in the countryside, such as individual buildings and main roads, will have relatively high energy use intensiveness, averaging over an area will produce much lower figures for rural than for urban areas, as long as it is energy use that is considered, and total energy gain through solar radiation is omitted. Even the high use of energy made by modern agriculture cannot compare to the amounts of energy used in the urban setting, which is virtually a massive machine for the consumption of fuel. Removing the direct solar gain to an area from the energy use of that area would accentuate this difference still further, rendering areas with low populations and extensive forms of agriculture as negative energy users, or energy producers on a massive scale.

Such a general definition, though perhaps rather more objective than some others, still takes no account of regional differences between rural areas, which can be extreme, but it provides a link to the rationale for the study of rural energy as an individual entity separate from urban energy.

Aside from the special cases of coal mines, oilfields and the like, urban areas are characterised as great consumers of energy, whilst rural areas, though they may in fact be energy consumptive in the case of modern agricultural methods, exist almost solely for the production of energy, usually very high value energy in the form of food. Every rural area has a continually renewed stock of energy, whereas most urban areas must by their very nature import large quantities of energy, largely from other urban areas, but also from the rural areas.

2.1.5. Rural and Urban Energy Resources-

Aside from nuclear power, and the special cases of geothemal energy and tidal power (which utilises the gravitational energy of the moon), all energy sources used by man utilise the dispersed energy of the sun in some form. In this sense all energy sources are 'rural' in their origin, since they originate in relatively low concentrations of energy per unit land area. It is the subsequent concentration of this energy, and the ease with which it can be used, that gives fuels their varying usefulness.

The rise of oil to a position as the worlds most important fuel is due to a convenience derived from a concentration of the sun's energy over millions of years in a very flexible, usable form. This concentration is shared with coal, and to a lesser extent, peat. The renewable source, hydropower, uses topography to concentrate the highly dissipated gravitational energy stored in the precipitation caused by solar heat. Other renewables lack the more recent historical success of hydropower, due to the fact that they are trying to use dissipated, rather than concentrated forms of energy. Timber is the only widely used fuel which makes use of more dissipated energy.

Thus, on the basis of a definition of rurality using energy concentrations per unit land area, coal, oil and nuclear fuel extraction, and hydropower generation, might be considered to be urban, whilst other renewable sources, and perhaps peat, might be considered to be rural. For the most part these definitions are confirmed by common sense, except in the case of hydropower, where most schemes are in obviously rural locations. The fact that average energy concentrations remain low, and that hydropower installations are generally restricted to single locations within rural areas, justify its inclusion as a 'rural resource'. The scarcity of untapped large single resources of hydropower means that large schemes are likely to be very localised in their impact, and will be of little importance for rural areas in general, though small schemes might have more general application.

Most of the material written on energy resource industries in rural areas tends to consider the problems arising from the development of rural or greenfield sites into urban or industrial sites, such as coal or oilfields, and therefore are considering the pros and cons of producing urban areas, rather than considering energy sources which remain rural during and after their extraction. This latter type of energy development is of more interest in the present context, since aside from peat all these resources are, at least to some extent, present in all rural areas of reasonable size, and thus various universal conclusions about them can be drawn.

By contrast, 'urban' energy resources are by no means universal to all urban areas, but are highly specific to certain sites, so that most rural areas have the advantage of a potential for a certain amount of internal energy autonomy. Rural people have always had the opportunity of obtaining some local fuel supplies, even though they may only utilise a fraction of the potential resource to provide a small proportion of their needs. Although it is difficult if not impossible to envisage a small, modern rural area which is entirely energy autonomous, it is absolutely impossible to envisage any meaningful internal autonomy in many urban areas, which may have no useable energy resources at all, being stocks of 'human resources' which are positioned in such a way as to best be able to consume other resources.

Yet in economic reality, rural areas remain as subservient hinterlands of urban areas, which serve as distribution points of energy and other resources to them. Thus rural areas are seen as being highly consumptive of urban resources, often at high cost. In order to get away from this view of rural areas as subsidised consumers of urban resources, their strengths, of low energy consumption per unit land area, and of quite high local resource potential, might be built on.

2.1.6. The Differing Characteristics of Rural and Urban Energy Use-

A comparison between agricultural and industrial energy use characteristics is relatively meaningless, since the two are in no sense comparable. Yet the mix of fuel types in direct energy use shows a weighting towards oil in agriculture, as might be expected, due to the preponderance of mobile equipment, whilst electricity is rather less used in agriculture than in industry.

However in the transport, and particularly in the domestic sectors, the needs for energy are comparable, and a look at how urban and rural areas compare, both in terms of total fuel use and the types of fuel used, is justified.

Surveys carried out for the present study, and reported on fully in sections 5 to 9, have been able to break down figures for household energy consumption to show the total amounts and types of fuel used in rather remote rural areas. These can then be compared with other figures for the national consumption of fuel per household which, though they contain the rural element within them, are reasonable approximations to the majority urban fuel use patterns. The figures represent delivered fuel values except in the case of electricity, where allowance is made for generator losses. These generation losses are taken at the same value for both urban and rural areas. The rural figure should perhaps reflect the greater efficiency achieved in the survey area due to the higher use of grid hydropower than nationally. On the other hand rural areas should show lower conversion efficiency due to higher transmission losses (Table 2.1).

Table 2.1. Rural and Urban Mean Domestic Fuel Use Per Household Per Annum(13)

FUEL TYPE	RURAL % Cumines Town	RURAL % Lumsden	URBAN %
coal	39.6	34.5	
smokeless fuel	2.7	12.4	
purchased wood	6.4	11.4	
wood from free sources	3.4	7.6	
purchased peat	4.4	1.0	
peat from free sources	5.2	3.3	
total local resources	8.6	10.9	
total solid fuels	61.7	69.2	15.7
oil	1.5	5.7	4.8
gas (urban natural gas, rural bottled gas)	2.1	0.9	42.8
mains electricity	31.0	23.6	36.8
private generators	0.0	0.3	
parafin	0.1	0.1	
TOTAL MEAN HOUSEHOLD ENERGY USE(MEGAJOULES)	161555	176688	101200

Table 2.1 shows large disparities between both types of fuel used and the total amount consumed per household. Differences in types of fuel are by and large predictable, thus practically no gas is used in the rural area simply because mains gas is not available, whilst more solid fuel is used in the rural areas. It is perhaps surprising that solid fuels occupy such a position of strength in these rural areas that they not only replace all the gas used in urban areas, but also much of the electricity. 13.3% of the rural solid fuel comes from local resources, with 50% of this fuel being free, though these figures could be higher in areas with a more plentiful supply of better peat, or with a greater availability of timber through the work of an estate or

of an individual marketing the product. Since the urban figure is an approximation which includes rural households, the actual figure for solid fuels in urban housing should be still lower.

Yet the advantage accruing through the use of local resources, laudable though it might be, is dwarfed by the fact that the rural houses appear to use some 75% more energy in total than the urban ones. There are various reasons why this might be the case. There will obviously be a rather higher proportion of detached dwellings in the rural case, and a lower proportion of flats and terraced houses. Rural areas also tend to be more exposed. The older housing stock may well consist of rather larger dwellings, with only a small number of houses having adequate insulation or good standards of draught proofing. The northern location of the survey areas mean that they experience low temperatures and a longer heating season. The main reason however is likely to be the low efficiency of many solid fuel burning devices.

Without exception, houses in the rural survey area with only electric heating are the lowest energy consumers, and whilst this may be partly caused by householders having inadequate heating due to the cost of electricity, it also reflects electricity's high end use efficiency. It is often suggested that using electricity for domestic heating is a scandalous waste of a very high grade energy, since power station efficiencies are low, but this is assuming that burning appliances for other fuels in the home are as efficient as they can be. Where they are not then the use of electrical heat, at a very high conversion efficiency at the appliance, may be comparatively quite efficient. Most of the solid fuel burning appliances in the rural survey area are highly inefficient, and compare very badly with maximum achievable efficiencies of 85 to 90%, perhaps falling to only 10% for old open fires with wide flues and inadequate grates. Introducing simple efficient stoves in these areas could be much more effective than the quite extensive exploitation of local energy resources.

Attitudes to fuel burning also differ from those of the urban areas. In the rural areas a lower premium is put on convenience and cleanliness, for instance of electricity, whilst there is a liking for open fires for their own sake, and a desire to keep the building fabric continuously heated. Many bemoan the lack of availability of timber and good peat, and the fact that they must turn to coal and smokeless fuels. The local scarcity of these fuels is in a way urbanising the rural areas by making them more dependant on the lifeline of urban based fuel suppliers.

Although it might be thought that, due to the longer distances involved, rural people would travel much more than urban people, in areas largely unaffected by inmigration this appears not to be the case, owing to the characteristic high proportion of not very mobile retired people in the population. Those few urban incomers that there are travel far more than all other sectors of the population. Average passenger miles per year travelled nationally by car, motorbike, bus and taxi (rail and air travel are omitted since they represent long distance travel and are not associated with rural areas), accounts for some 14,564MJ per person (14). Figures for total distance travelled for the purposes of work or education in the rural survey area account for some 5613MJ per person per year. Since many of these journeys in reality use no fuel, for they are short journeys on foot (such as to the village school), this partly balances out the fact that non-work journeys are not included. The low rural figure is in spite of the fact that most employed people travel at least 7 or 8 miles to work (incomers from urban areas typically travel 40 miles each way daily, in a car with a single occupant), and is due to the large number of retired people typical of the indigenous populations of such villages.

Obviously rural inhabitants are dependent on high grade 'urban' sources of energy for their travel, but that dependence is now leading to a withdrawal of the means by which to travel, and in a sense 'ruralising' villages by isolating them (77).

2.1.7. Summary of Rural/Urban Energy Use Differences-

The above is only a brief look at energy use discrepancies between rural and urban areas, and a full description of survey results follows in section 6 onwards. The current project is not concerned with assessing all differences between rural and urban areas, merely in defining rurality in terms of some of the most important of these differences.

So rural areas show distinctive energy use characteristics, whilst whether or not these characteristics are becoming more urban is doubtful. The urban decline in the use of solid fuels, particularly throughout the 1960's appears not to have affected rural areas much, and their dependence on imported coal might easily be reversible given the correct conditions, since solid fuel appliances are often quite flexible in the type of fuels they can burn.

Perhaps the main problems to be associated with rural energy use patterns, aside from dependance on urban sources of fuel, are to do with the poorness of the housing stock and fuel using appliances. In this sense many incomers from the towns, through their command of greater financial resources, may be able to improve the situation somewhat, if only for themselves.

Although many of the differences between rural and urban areas are self evident, many of the implications of these differences may not be. This section has attempted to expose some of these implications, through a definition of rurality tying it to energy use and resource patterns.

Perhaps the main implications of changes which are occurring in rural areas are to do with the progressive urbanising influence, which occurs even where rural conservation has preserved an ostensibly rural physical structure. This urbanising influence is felt in terms of the attitudes of incomers, types of land use, social structure and the mobility of the richer part of the population. The only shift towards a more 'rural' influence has been the increasing isolation of the poorer, usually indigenous population.

As influences such as working from home, aided by improvements in information technology, become stronger (15), most of these trends are likely to continue in the future.

There is some chance that agricultural forms, with mounting concern over conservation and pollution and a drive to make better use of local resources, together with concern about intensive animal breeding due to both the animals' condition and the wastefullness in food value terms, might turn back somewhat towards mixed farming, to less intensive land use including leaving more fallow land, and to greater areas of hedgerow and woodland. This is unlikely to happen however, if current policies of food production maximisation are not changed, and, as discussed in section 3.4, though such a change might be of practical benefit in the short term, it would be retrogressive in principle.

Given the continuation of these trends, opportunities to utilise rural energy resources could be capitalised on by small scale investment to help in reducing rural areas' dependancy on urban areas, though it is not clear where the impetus for such development might come from, if not born of necessity due to economic deprivation.

Whether urbanisation will cause rural and urban attitudes to become fused in the rural areas, or whether a dualistic society will continue to develop in areas affected by inmigration, is also uncertain. The extremes of both privilege and deprivation which have always been characteristic of rural areas are likely to continue. There has however been a shift away from the extremely rich individual in the big house, towards a larger group who are merely relatively rich compared to the indigenous inhabitants.

2.2. Rural Energy Autonomy; An Introduction to Agricultural/Domestic Integration in Rural Energy Use-

2.2.1. Introduction-

Section 2.2 aims to explore the structure and nature of rural agricultural and domestic energy use and resources at a local scale. A systems approach is used to isolate those factors of rural domestic and agricultural energy use which are more or less universal variables in the developed world, and the potential for optimising the use of the rural energy resource is discussed.

The difficulties of justifying and defining a 'self-sufficient' approach to the problems of rural energy provision are first discussed, and a discrete rural system is developed. The intention of this section is to move away from the generalities of rural energy use towards the generation of detailed survey techniques for the study of the potential for domestic/agricultural energy integration, and the practical optimisation of the use of the rural energy resource base.

2.2.2. A Justification for a 'Self Sufficiency' Approach-

It has been suggested (16), that modern society, with the help of its media, has generated a 'crisis mentality', which can only identify problems which it can perceive as crises. Thus we have 'the nuclear crisis', the 'population explosion crisis', and the 'energy crisis', as topics of widespread concern, perhaps often at the expense of other, more pressing issues. In reality, the problems of energy and food provision can be considered as economic problems, to do with optimum balances, rather than crises. Yet the idea of a 'crisis mentality' provides some justification for taking the view that a 'self-sufficiency' approach to rural energy provision has its advantages.

The types of situation in which problems are turned into crises are invariably those in which either a unilateral reliance has grown up in one particular commodity, as in the 'oil crisis' of 1973, or where the number of links between a particular society or community and the rest of the world system has grown too large, and dependency relationships have arisen, such as between the whole world system and nuclear weapons, and the structure of much of world agriculture and food shortages.

Thus a greater level of self-sufficiency can provide a level of security against turmoil external to the system, albeit that it may open up the dangers of some other kind of disruption. For instance, due to the greater degree of local reliance entailed, greater all-round small-scale agricultural energy self-sufficiency might render the local system susceptible to crop failure due to climatic conditions, but it would make it less sensitive to the vagaries of international oil prices. However, the basic difference between these two possible crisis situations, local and global, is that whereas the former can be quickly averted by reference to a larger system, in this case by temporary food transfer, in the latter case inertia in techniques and methods means that solving the problems inherent in changing the major source of energy used is a long term task with little immediate flexibility. Thus, from the point of view of inducing a level of stability in the rural system, so long as it is not carried far enough to preclude future changes, moves towards self-sufficiency can be justified.

On the subject of agricultural self-sufficiency Ritson (17), in common with many other commentators, centres the main part of his argument against ideas of agricultural self-sufficiency on entirely chauvinistic, national economic matters. Defining self-sufficiency as "A measure of the proportion of consumption derived by domestic farming", he concludes that the only valid argument for it is as a means of preserving national security in an emergency situation. Thus he takes a mainstream economics view of farming, and stresses price differences between home production and imports, advocating continued import where it proves economic. Yet as soon as one expands one's horizons to argue from a wider rationality, it becomes obvious that such a short-sighted, present economics view of domestic agriculture is not justified.

Given that Britain has both a large overall shortfall in domestic agricultural production, and greater technical and monetary resources than most other countries in the world, and given the current world food shortage, which seems almost certain to worsen in future, it seems hard to justify deliberately not making maximum use of potential agricultural resources. Under Ritson's strategy, we continue to import agricultural produce from third world countries which are not producing enough food for their own needs, thus providing them with a certain amount of foreign exchange, rather than encouraging basic needs strategies in those countries. At the same time we import on the world market from surplus producing countries such as the United States, thus helping to keep up world prices for agricultural commodities above the range which could be afforded by the poorer countries of the world.

Though it may be the case that the result of Britain's ceasing to draw on these countries' agricultural surpluses would merely be a drop in developed world food production, at least such an example would allow more food to be available on the world market, if the surplus producing countries chose to take the relevant moral, if not necessarily economic, decisions. So if self-sufficiency is viewed in Ritson's terms, as the proportion of consumption supplied by domestic production, there is every reason to aim for a greater level of agricultural self-sufficiency.

This concept is echoed by Mellanby (18), in terms of agricultural energy use, rather than food production, thus:-

> "Although British agriculture uses a great deal of energy, an amount far greater than that stored in the crops it produces, only some three percent (19) of our total energy budget is consumed on our farms. This seems relatively trivial, and any savings by our farmers can make little contribution to conserving global energy resources. However, until recently, the rate of growth of energy use was considerable, a reversal of this process has occurred, and has clearly affected the situation. Further economies in energy use in farming in Britain are desirable, but mainly to save farmers money and to make farming more profitable. But the problem, on a world scale, is different. If all farmers in developing countries used as much energy as does the British farmer, this would seriously affect world energy reserves. So, methods of energy saving developed in Britain may help those in other countries."

So the long-term reasons for adopting a more self-sufficient approach, at least to agricultural energy use and food production, are clear. Yet thus far it has been assumed that the meaning of the term 'self-sufficiency' is a single and clear one. This is not the case, and there is a need to clarify some terms and concepts used in connection with this idea.

The concept of the integration of agricultural and domestic energy use is a function of the scale at which one is looking at a community. Were agriculture not to be integrated with the domestic sector at all, there would be little point in producing food. In energy use however, the products of agriculture and the domestic environment are at present little integrated within the rural community, at whatever scale such a community is considered. For the purposes of this project such integration is intended to operate at quite a small scale, and to encompass a definition of rurality which describes merely those functions which are necessarily and universally rural, omitting activities which are limited to a few rural areas or which have an urban base.

Due to difficulties of definition, or perhaps to the rather clichéd image of a small scale rural idyll that it conjures up, many authors are loth to study energy in terms of 'self-sufficiency'. Indeed Ritson goes so far as to say that, due to the difficulties inherent in the definition of self-sufficiency, there is no value in discussing it at all (20). Yet merely because the definition is difficult does not mean that the phenomenon does not exist, or that it should not be studied.

Energy self-sufficiency can have two different and quite distinct meanings: firstly, it may mean a kind of energy equivalence, i.e. that a rural system imports energy, but strives to be able to export an equivalent or greater amount of energy, perhaps in terms of fuelwood or food. Alternatively, a kind of true self sufficiency might be aimed at, the achievement of which has more to do with the kinds of philosophy advocated by Schumacher (21) and others than with present day societal and economic goals. Under this latter system, the aims are changed from trying to optimise the balance of inputs and outputs to achieve the maximum net gain, to an isolationist approach of trying to cut out the input sources altogether, perhaps at the expense of the output from the system.

There is little to argue with in the first case, that of minimising the 'gross energy requirement' (22), or trying to make it negative. However, the idea of a high level of true self-sufficiency is a more questionable goal. Yet it is reasonable to suggest that, if a system can really be isolated and remain stable, the reduction of external variables tends to make it more robust than it might otherwise be.

So in the context of this study, self-sufficiency can be taken to mean the reduction in size of, or elimination of, energy links between the rural system in question and all other systems, largely by the utilisation of indigenous energy resources to replace imported resources, and by savings in the total amount of energy used, but without diminishing present system outputs except in so far as they can be equally well used within the rural system.

In this context of course, energy inputs to the system do not merely include direct inputs such as petroleum for machinery and transport, or electricity for domestic use, but also the energy inputs which have been consumed in the manufacture and transport of capital and consumer inputs such as building materials, plant, imported foodstuffs and fertilisers. Any apparent increase in energy self-sufficiency must be checked for increased inputs of energy in capital, and only internal transfers of energy do not need to be quantified. A discrete system must be defined which has no overlooked inputs or outputs, in spite of the extreme complexity of the fully integrated national and international system which produces these inputs.

2.2.3. A Rural Energy System-

Any systems approach demonstrates the extreme complexity of relationships within and to the outside of a rural system, to the extent that the definition of that system, however arrived at, tends to become extremely arbitrary. Slesser (23), discussing isolated communities, states that; "As no man is an island, no physical island is an economic island", and that interactions always exist with other areas. Newby (24) has shown that such an assertion applies sociologically as well as economically, thus destroying all illusions about rural isolation and stability.

The inability to isolate a closed system applies equally to physical, geographical systems, such as specific rural areas, as it does to functional systems such as 'agriculture', taken as a whole. If rurality were to be considered as being defined by, say, rural administrative districts, and a system were described encompassing this rural economy, it would necessarily include all the functions of these areas, which might cover a sample of every different type of human function, including many of the 'urban' activities of industry and the like. Domestic, agricultural, transportation, industrial and all service sectors of the economy would need to be included, whilst the system would remain an open one, connecting to urban areas through every sector.

Yet what it is important to be able to do is not to isolate every energy input and output in every area which can, somewhat arbitrarily, be described as rural, but to consider those factors of rurality which are essential to all rural areas, however defined. The system is not confined by geographical area, but by rural sector, and thus can claim a more or less universal application to all rural areas, as defined in section 2.1.3.

Thus industrial and service sectors are removed from the analysis due to the impossibility of generalisation about their presence on the small scale in rural areas. This leaves agricultural and domestic sectors for consideration, with transportation as an essential services link between these two sectors and to the outside of the system. The resulting system is only valid as long as all its inputs and outputs are considered, and as a functional, rather than geographical system, providing a kind of basic rural area to study possible energy interactions. Such a rural agricultural/domestic system would thus pertain to the 'most rural' area possible, in terms of the number of different human activities occurring, thus avoiding problems of defining the limits of rurality by considering the extreme case.

Most systems approaches to rural areas which do not merely consider one small aspect of the subject area, concentrate on biological energy flows, either quantitatively or otherwise, from solar energy to food and other commodities (e.g. Carruthers (25)), Stout (26) goes one stage further than this, particularly for the United States, by itemising and quantifying energy inputs to the food production system, demonstrating that for every 16 kilocalories of energy fixed in crops, only one kilocalorie finds its way into human food, whilst waste products make up some 9 kilocalories. Yet Stout makes no attempt to identify either present or potential uses for this waste, or to include domestic energy flows in the picture.

A flow diagram (Figure 2.1.), attempts to isolate a rural domestic and agricultural system, showing all the inputs in terms of direct and indirect energy sources, all its exports in terms of useful outputs to other sectors, all the intra-sectoral links and the production or existence of under or unutilised rural energy resources. For the purposes of this research, the magnitude of the internal links of different types is not important, the importance of the system lies in its externalities, the quantification of the rural energy resource sector of the diagram, and the minimisation of inputs to the system through their substitution by elements in the energy resource base.

Elements of the diagram which might be considered not to fit strictly into the purely agricultural and domestic secotrs are the food processing activities, however these are intended to cover on-farm activities, without the consideration of which a substantial proportion of the agricultural energy flow would be omitted. The many service inputs which are outside the system are specifically excluded at this stage and their existence is merely recorded.

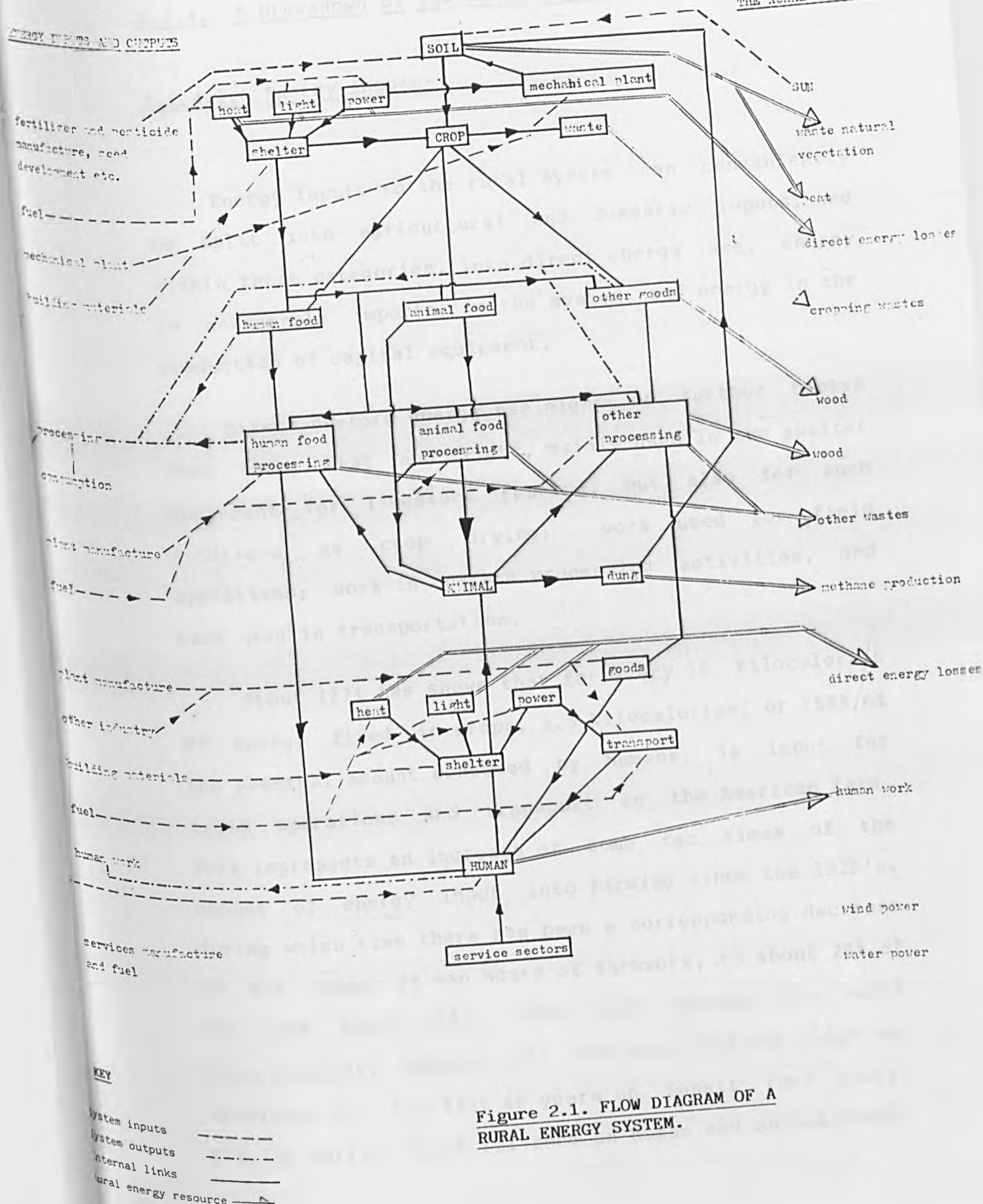


Figure 2.1. FLOW DIAGRAM OF A RURAL ENERGY SYSTEM.

2.2.4. A Breakdown of the Rural Energy System-

2.2.4.1. Energy Inputs-

Energy inputs to the rural system can conveniently be split into agricultural and domestic inputs, and within these categories, into direct energy use, energy in consumable imports to the system, and energy in the production of capital equipment.

Direct on-farm energy use might be further broken down into, heat and light, mainly used in the shelter component for livestock rearing, but also for such functions as crop drying; work used for field operations; work in on-farm processing activities, and work used in transportation.

Stout (27) has shown that for every 16 kilocalories of energy fixed in crops, 1.5 kilocalories, or 150% of the eventual amount consumed by humans, is input for field operations and transport on the American farm. This represents an increase of some ten times of the amount of energy input into farming since the 1920's, during which time there has been a corresponding decrease in the number of man hours of farmwork, to about 20% of the 1920 level (28). That both changes can occur simultaneously demonstrates the huge reliance which has developed over the last 60 years on fossil fuel power, from an earlier total reliance on human and animal power.

The use of commercial energy sources has risen to the extent that, if we were living in an economy whose currency was measured in terms of energy, recent yield increases would seem counter-productive when set against the additional fuel needed to obtain them. For instance, a traditional form of rice production such as that practiced in the Philippines achieves yields of 1250kg/hec, for a commercial energy expenditure of 173MJ, whilst modern American rice production achieves yields of 5800kg/hec by expending energy amounting to 64885MJ (29). Thus a 4 fold increase in yields is achieved only at the expense of a 400 fold increase in energy consumption, with around half this figure being attributable to direct on-farm energy inputs.

In Britain the replacement of the 0.1 to 0.2 horsepower output of the average agricultural worker by vast amounts of readily available energy in petroleum products, has enabled output per worker to rise from around 500kg/annum to around 10000kg/annum, allowing each agricultural worker to feed an average of 50 other people, whilst average energy use per worker has risen from 1000MJ/annum to 100000MJ/annum. (78)

This freeing of the agricultural workforce, made possible by the use of commercial energy, is one of the most important factors enabling the development of a country, yet the past tendency to maximise, rather than optimise, external energy inputs, is one which no longer seems appropriate in a more energy conscious world.

Stout estimates that the total energy inputs to agriculture in the UK outweigh food energy outputs by a factor of nearly three, with direct energy, excluding transport off the farm, making up nearly a third of the total. By far the bulk of this direct input comes in the form of diesel or gas oil for power units, electricity for non-domestic uses, and petroleum for heating and drying. This is a similar balance of uses, if not of fuels, to that discovered in the survey areas.

As well as direct inputs to the agricultural/domestic rural system, the energy involved in the primary production and manufacture of imported commodities must be considered. This of course represents a long chain of energy interactions, which, if taken to its logical conclusion, would eventually encompass the whole national and international economy, and the accurate calculation of indirect energy inputs for each commodity becomes an impossibility. Figures do already exist for these energy inputs however, based on their proportion of national energy consumption.

The main consumable, commercial indirect energy inputs to agriculture are nitrogenous, phosphoritic, potassium and lime fertilisers, pesticides and herbicides, and maintenance work to plant and buildings. These items together make up around 30% of total agricultural energy inputs, with nitrogenous fertilisers making up some 60% of this figure.

Total energy expenditure in the manufacture of nitrogenous fertilisers amounts to 2180PJ worldwide per annum, producing an average of 0.059 tonnes per hectare for cereal crops, which rises to 0.16 tonnes in Western Europe. This sum would represent an application of 'average' manure of a dry weight of nearly 1 tonne per hectare per annum.

Significant amounts of phosphorous and potassium, as well as nitrogen, are also to be found in organic manure, as shown in table 2.2.

Table 2.2. Comparison of the Nutrient Contents of Manure and Fertiliser- (31)

Nutrient	Total (000' t.)	Kg. per dry tonne	Pounds per wet tonne
Nitrogen			
manure	7367	31	10
fertiliser	7540	191	-
Phosphorous			
manure	1463	6.2	2
fertiliser	2222	56	-
Potassium			
manure	5342	22	7
fertiliser	3836	97	-

Of the total indirect consumable inputs, the energy used in pesticide and herbicide production accounts for some 10%, whilst no direct substitution possibility exists for these items. There is however scope for the indirect substitution of these elements by such measures as on-farm monitoring of pest attacks, better weeding procedures, and by gaining increased knowledge of such factors as pest life cycles. This enables the control of pesticide applications in more sensible ways, so as to regain a level of self-sufficiency in these inputs without losing any production.

Thus, as with direct energy inputs, it is possible to identify possibilities for the reduction of demand for external energy consuming inputs.

Capital equipment on farms, in terms of buildings, machinery, fencing and the like have, as well as running costs, energy costs inherent in their manufacture and distribution, and in the case of buildings, a highly variable on-site energy cost of erection.

Variations in the energy capital cost of machinery, aside from savings which might be made in manufacture, are a function of the level of on-farm technology employed, and would tend to vary in proportion to the amount of on-farm direct energy use in the form of petroleum products. It is in farm buildings that the greatest variation takes place in the amount of external energy used in production. Traditional building methods used little energy which was not produced entirely within the agricultural/domestic rural system, whilst the modern farm building, minimising local energy use,maximises the external energy use needed in its production.

Capital energy inputs have a dependant relationship to other inputs, since they depend very much on the methods used on the farm. Although the total amount of such inputs is only around 15% of total energy inputs to farming, at 54.54PJ per annum in the U.K. (32), large changes in these inputs may have a considerable impact on potential energy savings.

The basic uses for direct energy within the domestic environment are; heat, light and power used within the dwelling, and energy used in personal transport within and to the outside of the rural system. It is in these areas that energy use has recieved some of the greatest interest, and has become part of public policy in a number of different ways.

Personal transportation is perhaps the most studied form of rural energy use, albeit not always viewed from an energetics point of view. The relative ease with which transport can be related to much studied and easily observed geographical settlement patterns, and the relative speed and ease with which conclusions on transportation patterns can be incorporated to some extent into public policy through public transport systems, make it a clear cut and much studied area of rural energy use. In rural areas transport is a particularly important factor, in as much as there is an immediately obvious necessity for more energy to be used here per capita than in urban areas. It is also an area in which use has been rising more recently than in other sectors, for whereas, between 1971 and 1981 national energy use dropped by 10%, in transport it rose by 17%.

Solutions to the provision of transport in rural areas have been suggested which, though they do not specifically aim to reduce energy use, tend to have this effect as an incidental gain. Thus such solutions as the post bus, travelling services, transport brokerage etc, tend to use less fuel per passenger mile than the private car.

For the purposes of this study, the assumption is made that the only personal journeys which need be considered are journeys to work.

The use of energy for power, heat and light in the household is a major consumer nationally, with domestic space heating figuring as the largest single energy use. Space heating requirements per dwelling are also likely to be higher, as described in section 2.1.6., particularly in the unfavourable climate of the Northern Scottish survey areas. It is the task of the surveys to ascertain how far opportunities for energy saving by such measures as optimising amounts of living space per person, improving building structure, insulation provision, juxtaposition of new buildings, fuel substitution and changes in fuel conversion equipment can assist in achieving a greater level of local energy use autonomy.

Domestic consumer goods are such a widely diverse field that they defy proper categorisation. Many such consumer goods would be difficult to substitute without a regression to the lifestyles of previous ages, in which the range of available goods was drastically reduced. It is certainly beyond the scope of this project to suggest such deliberate deprivation unless attitudinal surveys and future forecasts point to an actual movement in this direction.

Only in the field of agricultural produce can any suggestions be made, and a localising of food distribution, together perhaps with a reduction in present levels of packaging for many foods, might help in substituting energy imports. Yet this is already done to an extent in most rural areas, and in energy terms, the quantities involved are minimal.

In the domestic sector, as in agriculture, many major capital inputs are directly related to measures taken in direct energy use conservation. Thus the insulation cost of housing is a capital energy input variable. Energy use in construction is also a variable which can change with construction materials and method. Thus vernacular building forms consume much less imported energy in their construction than more modern forms, albeit that much of the material may come from a part of the total rural system far removed geographically.

In certain circumstances the capital energy requirements of buildings are by no means an insignificant proportion of the running costs. Wright and Gardiner (33), give figures of 7GJ/m2 for capital energy costs in dwellings, and 0.16 to 0.9GJ/m2 for annual energy running costs, or a pay-back period of between 8 and 44 years. These figures are however rather low for running costs and high for capital costs, being for urban, high to medium rise flats. Detached rural dwellings could be expected to have higher running costs and lower capital costs.

The energy cost in construction of the private car is also a major item of consumption, yet aside from perhaps suggesting smaller cars or better public transport, it is beyond the scope of this study to start suggesting changes in production line methods.

2.2.4.2. System Outputs-

Useful system outputs from agriculture are, human food, both processed and unprocessed, animal and plant derived, and non-food outputs such as wool and timber. Animal feeds might be exported from the geographical area, but remain within agriculture.

It is outside the scope of the present research to suggest changes in food producing patterns which might lead to energy savings in this area, and only presently wasted products for which a use might be found can be considered. Only when such resources are too large to be used within the agricultural/domestic system do they become system exports.

Aside from sewage and domestic refuse, the only domestic system output or product for general use within and outside the system is human work. The use of this resource within the rural system has decreased dramatically in the past due to decreases in agricultural workforce, to such an extent that human work, unlike in many third world countries, can no longer really be considered as a significant energy source. A suggestion in round one of the Delphi survey that more agricultural operations could be done by hand, thus saving energy, was not well received by panelists.

The main additional uses for excess human labour which can be found, in an energy context, are fuel gathering operations, where the energy output is far greater than the energy input.

Domestic refuse and sewage, though considerable energy sources on a national scale, are insignificant in sparsely populated rural areas, and whilst the use of domestic refuse is probably already quite high, organising the use of sewage, either as a fertiliser or as a fuel, is difficult in the small-scale situation.

2.2.4.3. The Rural Energy Resource-

All the inputs to the agricultural/domestic system described above, with the addition of the solar radiation resource and other renewable sources, combine to provide, as well as the system outputs described, a large rural energy resource, defined as the under or un-utilised or wasted process energy which is likely to be common to many or all major rural areas. Many of these resources could be added to if major changes were to be accepted in the structure of agriculture, for instance if the national diet were to shift away from a concentration on animal products. But for the purposes of this study, food production patterns are assumed to remain more or less static.

The rural energy resource can be broadly broken down into; process wastes, the results of the lack of utilisation of the energy products of deliberate, human controlled processes; land based resources, the potential in land which is presently not controlled by human activity; and under-utilised resources which do not rely directly on a particular acreage of land to determine their size.

Under the category of process wastes would come cropping residues such as straw, animal residues such as dung, food and non-food processing wastes such as forestry waste and perhaps inefficiencies in grassland utilisation by animals, domestic refuse and sewage, and direct heat, light and power wastage through such factors as poor building insulation.

The land based unused resources include; first and foremost, direct solar incidence on all land unused for crops, which might be used more or less directly or by processing it through photosynthesis; presently neglected or underutilised areas of land such as natural vegetation, shelter belts and other untended forest and woodland, hedgerows, and poor heath and moorland; and a resource found in only certain areas which, though a sun derived one, is to all intents and purposes non-renewable and thus finite, peat.

The resources which are not so directly based on land area, but which one would expect to find some evidence of in most rural areas, albeit in varying quantities, are renewables like wind and water power, and underutilised human work.

Thus, aside from domestic wastes and the direct wastage of fuel in the dwelling, all the resources fall outside the domestic sphere and are more agricultural in nature. Yet as a major user of energy (some 20% of national consumption (34), which would convert to something like 4% of national energy consumption in rural domestic situations, rather more than total agricultural energy use), dwellings provide a useful potential outlet for the more agriculturally based products.

A summary of the unutilised or underutilised rural energy resources mentioned above is shown in Table 2.3. The figures in this table ought to be taken as demonstrating the order of magnitude of the potential, rather than representing a necessarily realistic prediction under any particular scenario.

Each resource in the table represents an attainable useage level, so that the use of present waste products is maximised, as is the use of biofuel crops, whereas such resources as solar and wind are more conjectural, with very little limitation on the size of the resource, but considerable limitations on the technical diffusion and capital investment needed to tap them. Resources which would not be common to all rural areas, such as coastal and sea resources like tidal and wave power, are omitted, yet the semi-industrial base which is needed for the exploitation of some resources moves outside the purely agricultural/domestic rural system to include certain new rural industries.

Table 2.3. Summary of Britain's Rural Energy Resource- (76)

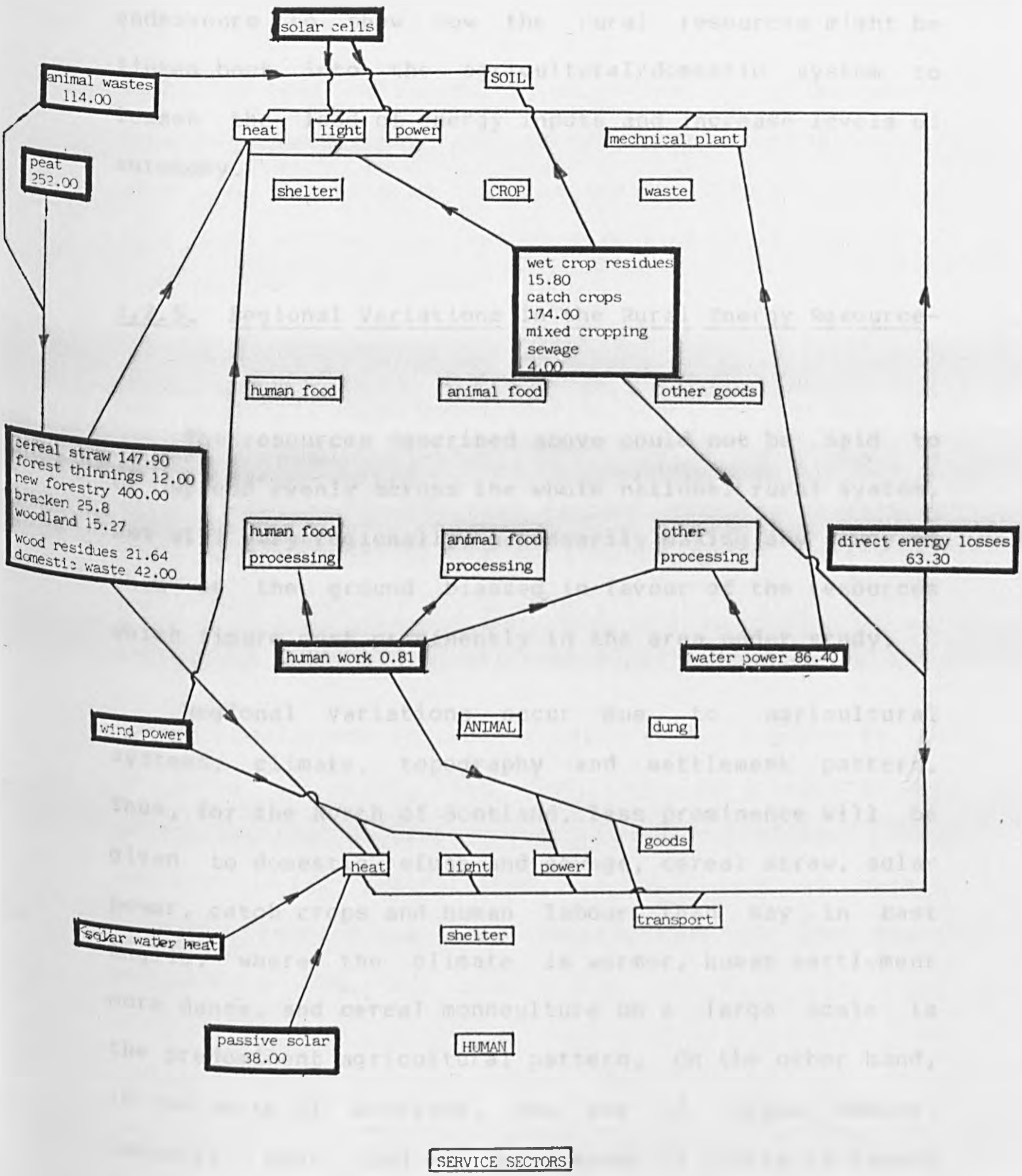
RESOURCE	POTENTIAL SIZE (PJ)	CONVERSION METHOD
cereal straw	147.90	direct burning
wet crop residues	15.80	methane
animal wastes	114.00	methane
forest thinnings	12.00	direct burning
wood residue	21.64	direct burning
domestic wastes	4.00	direct burning/methane
sewage	4.00	methane
direct energy losses(a)	63.30	conserved
solar cells	-	electrical
solar water heat	-	hot water
domestic passive solar(b)	38.00	direct heat
new forestry(c)	400.00	direct burning
bracken	25.80	direct burning/methane
woodland on farms	15.27	direct burning
catch crops	174.00	methane
mixed cropping	-	methane
peat(d)	252.00	direct burn/liquefaction
wind	-	electrical/mechanical
hydro(e)	86.40	electrical/mechanical
human work	0.81	mechanical substitution
TOTAL(f)	1212.92PJ/annum	
TOTAL NATIONAL ENERGY USE.	8600.00PJ/annum	

NOTES-

a. Calculated as 33% of space heating requirement.
b. 20% of total space heat useage.
c. Based on 15 tonnes dry matter/hectare/annum, 1.3 million hectares.
d. Based on a depletion rate of 24m tonnes/annum for Scotland alone, reflecting a 100 year period to depletion.
e. Assuming use of all streams presently unused.
f. Not including solar or ind resources, for which total resource figures are rather meaningless, particularly in the case of solar, since theoretical resource figures are huge, but bear no relation to the actual resource use potential.

Figure 2.2. FLOW DIAGRAM OF RURAL ENERGY RESOURCES AND USE.

(Figures in picojoules)



The quantification of resources enables amendments to be made to the flow diagram in figure 2.1., and thus figure 2.2. shows this rough quantification and endeavours to show how the rural resources might be linked back into the agricultural/domestic system to lessen the load of energy inputs and increase levels of autonomy.

2.2.5. Regional Variations in the Rural Energy Resource-

The resources described above could not be said to be spread evenly across the whole national rural system, but will vary regionally, necessarily making any study of them on the ground biassed in favour of the resources which figure most prominently in the area under study.

Regional variations occur due to agricultural systems, climate, topography and settlement pattern. Thus, for the North of Scotland, less prominence will be given to domestic refuse and sewage, cereal straw, solar power, catch crops and human labour than say in East Anglia, where the climate is warmer, human settlement more dense, and cereal monoculture on a large scale is the predominent agricultural pattern. On the other hand, in the North of Scotland, the use of animal wastes, forestry, peat, wind and hydro power is likely to figure more prominently than elsewhere. Thus generalisations about energy resource use extrapolated from one area to another need to be made with care if they are to have any validity.

The physical size of the resources is not the only factor influencing their use or potential, other factors being the level of technology available, the discrepancy between conventional and energy based economics, the locational fit between resource availability and area of usage, and attitudinal factors affecting the diffusion of resource use to all areas.

The data gathered in the questionnaires therefore had to fulfil these requirements, assessing resource and use size and potentials in areas of different agricultural system and land quality, the physical fit of the resource to the use, the technology available for the use of the resource, and attitudes to the conservation of energy and the use of local resources.

A requirement in testing the initial hypothesis is to show, in order that there can be a resource use potential, that a rural energy resource exists. This section having demonstrated the existence of such a resource, Section 2.3 goes on to look at the means available to tap it.

2.3. Energy and Economics, a Look at the 'Energy Accounting' of Small-Scale Rural Energy Projects-

2.3.1. Introduction-

In order to test whether the potential for a degree of rural energy autonomy exists, it is important to explore the availability of and economics of the technology for the use of the rural energy resource. This section does this, looking also at changing attitudes to the economics of energy resource use.

When loosely defined as 'a study of the value of energy resources and use', the area of 'energy economics' might include anything from a treatise on O.P.E.C. policies to a decision as to whether or not to buy an electric fire. Traditionally however, all facets of energy economics have been firmly grounded in the operation of the marketplace, (and in national politics), with little thought to a future beyond the timescale of conventional financial accounting.

Largely since the 'energy crisis' of 1973 however, (though there had been mutterings for many years previously), a new set of 'energy economics' fields has arisen. These initially set energy aside from 'the marketplace' as such, and treated it simply as a resource in its own right, generally to be viewed over a long time horizon. Yet from this resource based starting point, most of these approaches eventually arrive at some form of monetary analysis, usually based on a hypothetical future, through which to justify their often moralistic, resource based initial stance.

Thus a dichotomy exists between these two basic standpoints, resource based and market based, and their differences arise, not just on matters of detail, but in their initial assumptions and terms of reference.

This section will argue that the duality of thinking on energy economics is not confined to a trend towards 'doom-laden prophesy' on global resource depletion, but is, for whatever reason, filtering down to the attitudes of individuals in society. Many of these individuals will be those with money to spend, and their terms of reference may no longer be confined to present day monetary economics, but may embrace some of the resource based thinking per-se, which, though it may become reflected in the market place of the future, lies outside todays conventional economics.

As such thinking relates to individuals who may only make up a small minority of any rural community, it may not be relevant to most rural people, but since such individuals may have a powerful influence over land and capital, their decisions are likely to affect rural areas considerably.

2.3.2. Energy Economics in the Context of Changing Attitudes-

2.3.2.1. Introduction-

In the wake of late 1960's idealism, and the subsequent economic and energy crises of the 1970's, whole new approaches to many issues have arisen, characterised by an, often naive, 'moral' or idealistic approach, rather than a purely economic or overtly self-interested one. Examples of such movements might be; peace movements, environmental pressure groups, Third World concern (the latest and most dramatic expression of which has revolved around the famine in the Sahel), 'Green' parties, vegetarianism, 'prophet of doom' type global forecasts, interest in renewable energy, alternative forms of medical treatment, and a whole range of 'alternative lifestyles'. Such movements are linked together, not by their importance, which is highly varied, or their validity, which is often questionable, but by their common break with conventional monetary economics and national politics as main motive forces. All these movements claim a sort of morality as their justification, and most share a refusal to discount the long term future in the way that is conventionally done in straightforward monetary economics.

2.3.2.2. New and Conventional Economics in a Post-Industrial Society-

Much has been written postulating the idea of a 'post-industrial' society under one guise or another (35), suggesting the ways in which such a society might develop. Earlier attempts were largely doom laden forecasts of the consequences of unchecked western materialism and industrialisation, though latterly they have attempted to structure alternative futures and an alternative economy.

Perhaps contrary to popular belief, these works do not align themselves with the traditional left wing, nor indeed do they have any conventional political affiliations (if anything, their view of the individual in society is a self-interested, somewhat capitalist one). Nor are they all united by a general abnegation of the ideals of economic growth.

What does unite them is the adoption of a longer timescale than that of conventional economics, not only in looking at the future, but also in drawing lessons from the past, leading to the conclusion that present day lifestyles are not inevitable and cannot be extrapolated into the future, but that they result from certain specific events in the past, notably those events connected with the industrial revolution. Thus industrial society is seen only as a development phase (much as capitalism was to Marx), which even now is passing, to be replaced by something else. Often this 'something else' is characterised by; a 'self-sufficient' lifestyle in the broadest sense, including a move towards rurality, economic pluralism and a more informal employment economy, the erosion of nuclear forms of family and replacement by extended families or non blood-related groupings, a smaller scale of development more 'appropriate' to small communities, a concern with the 'environment' and 'ecology', and a general humanitarian type of morality, usually concerned with lessening the gap between 'north and south'. All of them also share the break with conventional economic thinking, particularly a dislike for extrapolating economic trends, though most, under criticism for naive idealism, have tried to construct a kind of monetary economics around their ideas to lend them credence.

The influence of these general economic thinkers has been compounded by the work of people such as Schumacher (36), whose philosophical brand of economics have been backed up by the 'alternative technology' movement, which has developed various products as concrete expressions of the validity of the new economics. The growing interest in the technology of renewable energy, as it has spread from small numbers of 'eco-freaks' to large engineering firms and multinationals, is another expression of this movement.

The concept of a 'post-industrial' society has received much attention in recent years, and as a general idea it would seem to be beyond question, yet the form which such a society might take is in considerable doubt. It is suggested that one of its facets will be a partial departure by many people from conventional economic thinking, in the name of some kind of morality, with decision making based on somewhat different criteria. This is a view that is at least partially endorsed by the resulting scenario of the Delphi survey.

Table 2.4. suggests how this might affect thinking on energy matters, by offering a series of opposite poles in the way people consider issues, with most views falling somewhere along a line between the two poles. Some of the terms used in table 2.4. are rather emotive and difficult to define, but they represent broad thinking patterns rather than hard science, and in as much as they remain ill-defined in the minds of their adherents, do not require close definition.

Table 2.4. Changing Priorities in Issue Definition.

Issue	'Alternative' Viewpoint	Conventional Viewpoint
Global Economics	New Economics	Conventional
	post industrial often emotive	extrapolations
	Resource based	Market based
	low or no growth 'Green politics'	exponential growth existing parties
National energy	Low energy plan (Leach (37))	Conventional energy scenarios (DOE/Watt (38))
Small scale energy econ.	Energy Analysis	Conventional Economics
Lifestyles	Ecological (pressure groups vegetarianism, low energy consumpt., rural inmigrants etc.)	Economic (materialist)
Individual	'Alternative energy' (renewables; solar panels, wind, woodburning) Possible positive effect of time on money	Cheapest energy source, outlay quickly discounted over time.

The above hardly represents a comprehensive review of the 'alternative economics' movements, but is merely intended to point out the similarities between many such individuals and groups, albeit that they may differ in many ways as well. It is suggested that the validity of these new ways of thinking is largely irrelevant for our purposes, and that the mere fact of their profusion, and the diffusion of interest in them throughout society, might make many of their prophesies self-fulfilling.

If enough people have enough interest in any of the propositions of the 'alternative economics', and choose to adopt lifestyles coincident with the suggestions of such movements, then decision making in some quarters wil need to move partially away from the traditional marketplace and take other factors into account, to reflect the changing values of individuals.

As in other areas, for instance architecture, economics are by no means an individual's only concern, so this might come to be more and more true of other investment, such as investment in means of providing energy.

2.3.2.3. World Energy - The Market Versus The Resource-

A key element in much of the alternative economic thinking is the energy resource. As a major input into society energy is seen, not exclusively as a commodity subject to the laws of supply and demand, but as a finite resource which, unlike other materials, is inevitably being progressively lost from the earth. The abundance of solar energy in its various forms has led to many attempts to tap this low concentration energy for use in more highly concentrated applications, but it is basically the depletion of fossil fuel resources that has led to a departure from purely economic thinking on energy by such workers as Foley, Chapman and the Club of Rome (39). These individuals have replaced the market with the dwindling resource as the main focus of concern.

The resource depletion approach also gains credence from the pure sciences, particularly the laws of thermodynamics, as interpreted by Soddy (40) and others. Their views support the idea of energy resources as fundamentally different from other resources in their ability to be depleted.

Central to these arguments is the traditionally assumed linear relationship between energy use and economic growth, and most of the resource based forecasts either argue that growth should be restricted and replaced by stability, or nil growth, or that the linear relationship can be departed from to allow economic growth in an atmosphere of static or decreasing energy use.

These views on the fossil and nuclear energy resource have created much interest in renewable energy sources, and the new developments of what is essentialy age-old technology to harness wind and water power in particular. Solar design has also given new impetus to old ideas of passive solar building design, with post-war industrial modernity giving way to traditional forms and great concern over energy use.

Thus a growing number of people see the resource based approach as being 'appropriate' and 'ecological' for two reasons. Firstly, a relevance to the future is perceived, with a need to conserve energy for future generations and soften our impact on the environment; and secondly, these approaches often seem relevant to the past, using technology which allows possibilities for nostalgia in an age of reflection.

2.3.2.4. U.K. Energy Models-

In the past ten years there has been something of a departure in some quarters from conventional economic analysis in energy forecasting. Some largely extrapolative forecasts have adopted a 'scenario' approach, postulating a wide spectrum of long term possibilities for energy development (41). More importantly, others have taken a rather 'utopian' approach, and manipulated the future to demonstrate extremes, such as the possibilities for energy saving, and developing a 'low energy society'. (42)

The Department of Energy's (D.O.E) 7 scenarios (43) do take account of resource deletion, and contain scenarios with low economic growth, and low growth in energy use, but they do not allow for a break with the traditional one to one relationship between energy use and G.N.P. They are built around macro-scale forecasts, and concentrate on generating capacity as a measure of the potential use of energy. Therefore, even in their low energy use scenarios, by concentrating on the generation side, rather than the use side of the equation, they are basically energy use maximisation strategies.

Leach, on the other hand (44), is able to break the connection between G.N.P. and energy use, by concentrating, not on energy production, but on energy use. This becomes basically an energy minimisation strategy. Leach's work looked at the energy use of all sectors in society, such as Domestic, Transport, Industrial sectors etc., and suggested ways in which, whilst still allowing for the relatively high economic growth suggested in some of the D.O.E. scenarios, energy use could be stabilised or reduced.

For instance, in the agricultural sector Leach shows that, in spite of agricultural energy use having dropped in the middle 70's, more can be saved by relatively simple measures, such as electronic control of building fuel use and machinery, and night insulation of greenhouses, allowing for a 30% saving, a quite conservative proportion of the potential, over a 34 year lead time.

Similarly, a change in technology, as well as simple saving strategies, is able to save 35% of energy use in the food and drink industries, and this without changing the nature of the product in any way, such as by reducing packaging.

The net result of this is that, taking high growth projections of up to 3%, and further growth in such high energy factors as car ownership, fuel use, though rising a little up to 1990, falls thereafter to get below the 1976 figure again by 2020. The low growth projections still allow for a high of 2.5% growth, and a G.D.P. more than doubling by 2025, yet with energy use 22% below the 1976 figure.

By building a hypothetical economy from the bottom up, rather than assuming long-term links between energy and the economy, potential savings are shown which make D.O.E. low energy scenarios look like strategies for getting rid of fuel.

Although Leach's suggested future is a manufactured one, and is not put forward as the most likely course of action, such 'prophesies' might become self-fulfilling. If there is enough concern over energy use, and this concern is backed up by such 'feasibility studies', then there is sufficient reason to suppose that the future might bring more and more moves towards energy use minimisation on the part of individuals, and if such sentiment is powerful enough, it might transcend monetary economics in some cases, and intelligent energy saving might become an end in itself.

The above scenarios are further discussed in greater detail in section 3.1. which looks at wider futures than those for renewable energy projects.

2.3.2.5. The Effect of Resource Thinking on Project Economics-

Various attempts have been made to bring concern over energy from the resource point of view into the realms of individual project planning and economics. These attempts can be broadly grouped under the heading Energy Analysis.

Originally developed to trace flows of energy through natural ecosystems, the aim of energy analysis, for our purpose, is to calculate the energy inputs required for any project, (which could be anything from the construction and lifetime operation of a nuclear power plant, to the expansion of output from a farm). In this process the monetary unit of accounting is replaced by some energy unit, such as Megajoules, Kilocalories or Kilowatt hours. Net energy analysis is a variant of energy analysis which goes a stage further, and assesses the amount of energy remaining for consumer use after the energy costs of finding, extracting, upgrading and delivering the fuel have been paid.(45)

The methodology raises energy *per se* to a level of great importance and, in its purest form, allows energy to take precedence over all monetary economics and the value of human labour. Often it is intended to be used in tandem with monetary methods, to provide a simple guide for decision makers as to the energy characteristics of projects. Of course this still leaves the problem of how to compare the two evaluations, with their different units of accounting, but if used a lot, energy analysis is likely to increase the perceived importance of energy production and use in many spheres of life. As it is largely concerned with the resource, energy analysis is generally concerned with the use of 'stock' rather than 'flow' resources, and thus direct solar energy use can be omitted as a cost.

The methodology of energy analysis aims to produce a set of energy requirements for all commodities produced and used, as well as energy use outside the direct commodity production. Its principal techniques are; process analysis, statistical analysis and input-output analysis.

Process analysis involves the identification of the network of processes involved in the production of goods, the analysis of each process to determine its set of inputs, and the assignment of an energy value to each input. These energy inputs can then be summed to give a total energy cost for the project.

Statistical analysis apportions energy cost per unit of output by using published statistics to build up total energy cost as a factor of the various different inputs.

Input-output analysis uses an input-output table to calculate the list and quantity of commodities required to produce any given good. Monetary terms must be replaced by primary energy terms in the tables to present a true energy analysis.

Whatever method is used, energy analysis mirrors Leach's approach, building up a picture of energy use from the bottom up, using a breakdown of constituent parts, and makes a break between monetary and energy terms. If any notice is taken of it in decision making, it is likely to increase the perceived importance of energy as a constituent of any project.

Yet the apparent purity of the energy analysis approach, in terms of its ability to gauge energy inputs objectively, is not as great as it first appears. By removing money as the unit of accounting, one has removed not only the illogicalities, in energy terms, of monetary values, but also the means of gauging the relative usefulness, and therefore value, of different energy sources.

The monetary values of the market are perhaps better able to allow for the fact that a kilowatt hour of electricity, for instance, is more valuable than the equivalent kilowatt hour of coal, or a kilowatt hour of waste power station heat. There are obviously many things that can be done with electricity that cannot be done with a slightly warmed bucket of water. Monetary market values presumably make some allowance for this, whilst energy analysis values do not. Several methods have been considered for dealing with this problem, including separating all types of fuels, and making no attempt to aggregate them, so that a project would be described as having used 1 tonne of coal, 1/2 a tonne of oil and 1000KWh of electricity, for instance. But moves of this nature make a nonsense of what transferability there is between fuels, and make project comparison impossible.

Another problem which makes energy analysis less objective than it might be, is the need to put limits on how far back one goes in apportioning energy costs. For instance, one might include the energy costs of producing and transporting cement, and the energy used in running the cement mixer, but does one include the energy used in making the cement mixer and the shovel, or even the energy used in making the tools needed to manufacture a cement mixer? Similarly, is one bound to have statistics on use of energy in overseas industries to trace back the 'energy content' of imported goods.

Whilst the monetary unit of accounting naturally gives an informal value to every facet of production in this way, to apportion energy values is much more difficult, and this means that various artificial limits must be set on the extent of the analysis.

Thus energy analysis as a discipline has many faults which should be recognised, and cannot give a sufficient value to needs such as human labour, yet whilst being useless as a single decision making tool, it may have considerable relevance when used in tandem with monetary analysis, to anyone with an interest in the energy resource and its conservation. The use of any analysis of this kind is likely to lead in the future to a greater importance being placed on energy in projects, which is in turn likely to be reflected in the monetary value system of the future.

2.3.2.6. A Partial Move Away From Profit Maximising by Individuals-

It has always been the case that some individuals' priorities are not entirely profit maximising, even if it is only those individuals who can afford such a luxury. The question is whether the numbers of such people are likely to increase, and if so, what form their detachment from pure economics is likely to take. Certainly factors other than economics have played an important part in society in the past. The medieval church, for instance, whilst a very efficient self-supporting means of extracting money from the population, hardly seems to have provided a very useful economic service in return. Where wealthy landowners were prepared to support monasteries, at huge expense, the only service they were buying was peace of mind. By the same token, if the 'religion' of the future is 'conservation', 'back to nature', 'spaceship earth', then the wealthy landowner may well wish to invest in wind generators and solar panels, not necessarily for economic reasons, but to purchase the same peace of mind.

Although it is possible that 'appropriateness' and concern for the future is only a short term 'fad', prevalent amongst a small minority, it is equally possible that this is likely to be the shape of a 'post-industrial' future, in which energy, along with food, is likely to have a value not initially based on market economics.

The following sections exemplify this dual approach by presenting some simplified economic and energy analyses of various different energy schemes. Projects are in the main fairly small, whilst concentration on renewables reflects the concern with resources, all net energy produced can in effect be treated as an addition to the resource.

The specific nature of the projects considered means that the ability to generalise to wider rural areas is limited, yet these projects cover the whole range of the rural energy resource considered in section 2.2., and exemplify the kinds of ways in which this resource might be utilised, whilst itemising the necessary imports of energy into the rural agricultural/domestic system.

2.3.3. Assessment of Projects-

2.3.3.1. Wind Energy Projects-

Although solar water heating has had perhaps the greatest impact of all the renewables in recent years in small scale projects by individuals, it is wind energy that has perhaps most captured the imagination as an 'environmentally conscious' means towards 'self sufficiency' and the use of free resources. It is also a particularly suitable renewable for northerly latitudes, where solar power may be of more limited use, and has received much interest in the academic world, despite constant claims that not enough money is available for research.

Practical projects might range from small windchargers, charging batteries for use with electric fences on hill farms and estates, (perhaps, when all is said and done, one of the most viable uses for the resource), to multi-megawatt generators linked to the local network electricity supply, of which a few already exist, primarily in the U.S.A. and Scandinavia, whilst a 3 megawatt machine on Orkney is due for commissioning in 1987. The recent Energy Act, allowing the sale of power by private generators to individuals as well as the electricity boards, bringing Britain into line with many other western countries in this matter, has assisted greatly in allowing the larger scale type of application.

Where supplementary grid power is the aim, a wind turbine can stand alone; where grid power is not available, the wind generator is likely to be run in conjunction with a diesel generator, which can compensate for fluctuations in wind energy. The wind machine can either be supplementary, and of lower peak output than the diesel, or the diesel can be supplementary, and just able to produce enough power to compensate for total lack of wind. Lipman suggests that in the latter situation around 40% of diesel fuel can be saved by the wind turbine (46).

Storage is always the problem with electricity, and if expensive grid connection is not viable, and diesel generation to smooth out fluctuations does not exist, then turbines producing too much power for expensive battery storage generally employ heated water as the storage medium, since when used in storage heaters or coupled to a boiler, fluctuations in output are not so important.

Yet the real economics of wind generator installation and use are hard to separate from rather optimistic manufacturers literature, and the equally optimistic suggestions of some enthusiastic, and not always objective academics. For instance Musgrove (10) suggests that medium sized wind machines of around 50kW capacity have a capital cost of about £125/m2 swept area at 1982 prices, whilst Lipman et.al. (46), suggest capital costs of around £200/m2 swept area at 1983 prices. Once site costs are added to manufacturing costs, Lipman's figure rises to £400/m2 swept area. Musgrove omits to mention site costs and yet tries to create the impression that all costs have been considered. The above figures translate to around £400/kW installed capacity in Musgroves estimation, £2350/kW for the Lipman figures.

Differences are accentuated even more when unit costs per kilowatt produced are considered, since operational and maintenance costs must be considered, discount rates for capital decided, and systems for utilising the energy produced purchased. For instance, Lipman and Musgrove (1981) (48) state that a computer model achieved an optimum cost per kilowatt hour for electricity from a 10kW generator using diesel and battery storage was 48.6p at 1981 prices, whilst Musgrove (1983), states that <u>average</u> costs of electricity, discounted over time, from a 50kW generator, are 2.15p/kWh. Admittedly these generators vary in size, but both papers state a more or less constant figure for cost per kW over a wide range of generator sizes. Some of this difference is undoubtedly caused by the difference between manufacturers literature and field experience, and the difference between prototype application and production line machines, yet it still remains difficult to arrive at figures in which one can have any confidence.

It must be said in this connection however, that the speed of development of this new industry means that there is a great amount of genuine uncertainty about average pricing, and the difference economically between R and D machines and those now in production may be great, and that costs should come down given increases in production, and indeed may have come down already since the above figures became available. The extent of such likely price drops is however unknown.

Looking at individual projects is no more illuminating, since the typically scant economic detail available invariably contains a crucial gap or two which prevent real comparison with alternatives.

For instance, a scheme on Fair Isle integrated a 55kW wind turbine and a 50kW diesel in the winter months, the wind turbine and a 20kW diesel set in the summer, with an original requirement for diesel generated electricity of 40,000kWh/annum (49). (Most such projects are in extremely isolated communities, reflecting not only the suitability of the wind regime, but also the dubious economics, since mainland production is very unlikely to compete economically with National Grid production, despite Musgrove's claims).

No costings are given for the project, but after the wind generator installation, 37,000kWh of diesel generated energy was used, and 93,000kWh of wind generated electricity per annum. Therefore, whatever the economics, the recipients of the power appear to be able to do considerably more with the electricity than they could before, and if they actually wanted to use this additional energy, this probably amounted to a considerable improvement in lifestyle. Most of the additional electricity is used for heating on a cheaper tariff, whilst some is accounted for by the longer hours for which power is available. It is not clear what the cost of the wind generator was, what savings are produced, if any, over the continuous running of the diesel to produce this larger amount of electricity, or whether using wind power for heating is an economic and welcome substitute for the use of peat.

Whilst the economics may be unobtainable, the energetics of such projects, particularly when they are experimental, may be a nonsense. For instance, on the Fair Isle project, component failures in the first year of operation twice necessitated the use of a Sikorsky helicopter, loaned by British Airways, which was flown to the site from Sumburgh to lift the generator on and off the tower. The energy consumption involved in this makes a mockery of the idea of saving fossil fuels.

A similar installation on Lundy Island (50) used, in 100 days of operation, 6303 kWh of diesel, and 45514 kWh of useful windpower, cutting diesel use to a minimum by employing wind power for heat. Here however, each kilowatt produced does not have equal value, for with the island mostly depopulated in winter, the only use for the cheap electricity available then is for basic building fabric heating, and since only low temperature differences are needed for this, much of the energy produced over the winter, when most is available, may be useless.

Using Lipman's figure of £2350/kW capacity, this suggests a cost of £117,500 for the 50 kW machine. Using a discount rate of 5% over a lifetime of 20 years (giving an annual charge rate of 8%) and Musgrove's perhaps rather low figure of 2% for operation and maintenance, 10% of capital must be earned each year, or £11,750.

With wind produced electricity per annum at 166,000 kWh, this would require 41,080 litres of diesel (assuming that the present diesel engine could generate this much electricity), at 18p per litre, including for the high costs of transport. This is equal to a saving of £8216, considerably less than wind machine costs, suggesting that the wind project is not a viable option, even over 20 years and at a low discount rate of 5%. Only by the removal of the time value of money can it become economically valid, even in this high energy cost situation. Additionally, although running the diesel at a much higher rate might occasion higher maintenance costs, there is no guarantee that much of the energy produced by the wind turbine (at the rate of 7p/kWh) might not be completely useless, whilst the rough costing above takes no account of investment, in storage heaters for instance, which must be made by the users.

Perhaps the North of Scotland Hydro-Electric Board (51), with experience in costing schemes for power generation, and no particular reason to exaggerate the advantages of wind, are better able to make valid assessments of cost, and their large 250kW machine on Burgar Hill, Orkney has some costings available.

The Board reckon that the generator has a straight payback time of 20 years, using no discount rate for the time value of money, and only a small figure allowed for maintenance, allowing a saving in the fuel bill of £282,000/annum. This kind of pay-back time would be unacceptable on economic grounds in most cases, particularly since the unproven nature of the hardware is likely to limit its life considerably. Of course if the cost of acquiring new diesel generators was set against the wind generator capital cost, the figures might change somewhat, but since the two must normally be run in conjunction, there is rarely a saving to be made in these situations by the employment of wind power.

Whilst economic analyses are made difficult by the ambiguity of the available information, energetic analyses are equally difficult, due to the lack of data on the energy cost of capital, in spite of the fact that such data might be able to justify the choice of wind power much better than economic analyses.

A rough estimate can be made however, of the energy costs of capital. Chapman (52) has calculated the energy costs per £ value of different commodities (1974 prices), and although wind turbines do not figure in the list, other large engineering projects vary from around 30 to around 170 kWh/£ value, whilst the construction industry has a figure of around 35kWh/£. Although a wind turbine is more akin to engineering than to construction, its fuel use per £ in manufacture is probably fairly low, since much of the cost of such low volume production is involved in low energy areas of research and development and human labour.

Taking a construction industry figure of 35kWh/£, updated to 1983 prices to 13kWh/£, the Burgar Hill turbine, with a total cost of £5.6 million, would have an energy cost of capital of 72,800 MWh, a pay-back period of just under 7 years. This, in theory, means that if the total energy of the Burgar Hill windmill was employed in building another similar machine, the first 7 years of its life would be totally dedicated to the task. A plan to exploit energy from the wind on a nationally significant scale would therefore take a long time before it became a producer, rather than a consumer, of fossil fuels. So although free energy is generated from the wind, and a net gain is experienced, this gain is not as clear cut as might be thought.

For the Lundy Island turbine the equivalent figures would be a capital energy cost of 1410MWh, and a pay-back period of 12 years. For Fair Isle an energy cost of 1400MWh with a pay-back period of 15 years. None of these figures include any energy cost of operation and maintenance.

Energy pay-back periods such as these are considerably longer than for most simple energy saving measures that can be employed, though in the long term it might be possible for wind machine construction energy to come from other wind machines, and for a large system of such installations to be self-supporting and to make an eventual net contribution without consuming fossil fuels.

One scheme where such an arrangement is already working successfully, is in the small, battery charging wind generators on the Scoraig Peninsula in the North West Highlands of Scotland (53). Here the total capital cost of installations is £350, plus £100 for batteries, with the cost of a maintenance contract set at £50/annum. Total energy production is estimated at 300kWh/annum per machine. At a 5% discount rate over a 20 year life (which may be over long for this type of machine), costs are £28/annum excluding maintenance costs, £78/annum including maintenance, though it may be that maintenance costs are inflated due to an unwillingness on the part of the manufacturer to take on guaranteed contracts. Including maintenance, costs are 25.7p/kWh, excluding maintenance they are 9.2p/kWh.

Yet even at these inflated costs per kilowatt, the wind generators can compete better than the generating board in this particular setting, despite the latter's offer of a vastly subsidised connection fee of £490/household, with a guaranteed usage of 4000kWh/annum at 4.7p/kWh. The reason for this is that, unlike the Fair Isle project for instance, where the addition of a wind generator created considerable amounts of additional energy, a use for which had to be found whether it was wanted or not, Scoraig inhabitants perceive a high value in the first few kilowatts used, and a rapidly decreasing marginal value in subsequent amounts.

In the Scoraig case, mains connection would create the need to use much more electricity to make the scheme pay, whereas the inhabitants, frugal users of electricity by habit, with free peat available for heat, do not perceive the need to increase their consumption in this way. So it may well be different attitudes of mind, rather than pure economics, that determine the best scheme for a particular situation. Energy values differ not only between types of fuel, but within the same fuel, depending on the structure of demand, which may be very different from one place to another.

An attitude of mind such as that displayed by the inhabitants of Scoraig is closely linked to the desire for energy conservation for altruistic, as well as selfish reasons, and their windmills appear to perform much better energetically than they do economically.

The machines are constructed almost entirely of recycled scrap parts, for instance old Jeep dynamos and wheel bearings, so that it is reasonable to say that their energy cost is only their scrap value, since their costs have been paid for over their previous useful life, and there is now no competing use for them other than to be melted down as scrap. The total weight of the generator and the tower is around 75kg, and whilst finished steel consumes 13200kWh/tonne in its manufacture (54), from this must be deducted the energy needed to turn scrap into usable metals, giving a final figure of 10,000kWh/tonne, or 750kWh for materials. Human labour plays a large part, but in energy terms this is inconsequential, whilst all energy in manufacture of the turbine is provided as a free resource by wind machines already on site.

Thus even if an additional 250kWh is added for labour and transport, the total of 1000kWh represents a pay-back time of just over three years. When maintenance costs are added at the same proportion of 3kWh/£ value, this rises to nearer 7 years, but the energy content, as well as the monetary cost of maintenance seems somewhat inflated.

So in spite of the seemingly poor economics, the energetics are better than for all other schemes, and these machines are extremely well suited to the situation, given the purchasers' apparent attitudes to the minimisation of electricity use.

Although no figures are available on the energy cost of capital for wind resource utilisation, and the above figures are necessarily sketchy, they do give an idea of the orders of magnitude of energy requirements, and a look at the energetics of wind power gives something of an insight into the real value of using a 'free resource'. At least however, wind power can make some net contribution to resources, whilst fossil fuel burning will always reduce the resource, even though monetary and energy pay-back times have to drop before most wind projects become viable.

As demonstrated by the Scoraig wind turbines, it is the attitude of mind of the individual, and the value he puts on energy resource conservation, that largely determines the validity of many of these projects.

2.3.3.2. Active Solar Energy Projects-

Active solar energy projects are likely to fall broadly into 2 categories, photovoltaic projects and solar water heating. For the most part, photovoltaic (P.V.) cells are prohibitively expensive, optimistic figures put the cost of a kilowatt of useful energy at 60 to 80 pence (55), even for very sunny climates. They also appear not to be, so far at least, net contributors of energy, since it generally takes as much energy to manufacture the cells as they can produce in their lifetimes. If they can become much cheaper however, their use as clean, low maintenance producers of high grade energy, with little environmental impact on the small scale, could be great. It seems unlikely that they will ever achieve any great importance in Britain however, since, unlike solar water heating panels, they only operate efficiently in direct sunlight.

Presently viable uses for photovoltaics are for situations where small amounts of good quality energy are required, and a value is put on this energy which, per kWh, is very high. For instance, in parts of the Third World, PV cells charging batteries have been used to run televisions in remote areas providing, for instance, education which would otherwise have been very expensive or unobtainable. Photovoltaic refrigerators for vaccines is another useful area (56). But although very useful in these situations, there is still no gain to be had energetically or in terms of conventional economics.

When the Delphi panel were questioned on the future of photovoltaics (Section 3.4.), all but one of the panelists felt that, though likely to be of increasing importance in the world in general, they will have little application in northern latitudes such as the U.K. However, the dissenting panelist was of the very strong opinion that photovoltaics would be of great importance in the U.K.

By and large however, it would seem that water heating by solar panels, without the requirement for direct solar incidence as in PV cells, can be rather better applied to northern climates, and with the energy produced being rather higher per unit cost, they might sometimes prove economic.

Figures for the energy cost of construction for solar panels have been produced, and are reproduced in Table 2.5, though these are meant for application in the rather more favourable climate of Italy. This shows a real energy return rising for systems up to 60% solar, thereafter falling dramatically. However, whilst these figures are based on the useful energy produced by the panels, they also only take account of the useful energy used in their manufacture, making no allowance for what waste there may be in, for instance, converting fossil fuels to electricity; the picture may be very different if these energy losses are considered. Taken at face value however, these figures give a minimum pay-back period of 13 years without discounting through time.

Table 2.5. Capital Energy Costs of Solar Systems-

% solar energy compared to total energy requirement	M2 collector area	Useful energy produced (GJ/yr)	Energy in construction (GJ/yr)	net annual energy produced (GJ/yr)	Payback time (based on 20 yr life)
20					
40	5	1.98	1.35	0.63	13.6
60	10	3.96	2.57	1.39	13.0
80	16	5.94	4.32	1.62	14.5
100	28	7.92	7.56	0.36	19.1
	60	9.9	16.2	-6.30	infinite

An Irish study of 8 domestic hot water solar installations (57) suggested that a 5m2 system could produce up to 50% of average household hot water requirements, with a pay-back period of 10 to 13 years. However this study used a discount rate of 14%, but a fuel inflation rate of 25%, putting a large positive value on the time value of fuel.

Even with no discount at all for the time value of money, the best system used in the Irish experiment has a pay-back time of 23.4 years, rather longer than the scheme's expected life, and is not viable economically. Although the system used to get this result did experience problems which may not apply in other cases, it was the best of 8 tested, and a normal domestic installation is unlikely to perform better. When maintenance costs are included at the rate of 2% of capital costs per annum, straight, undiscounted payback times rise to 43 years.

At 7500kWh for the energy in construction of such a system however, with again 2% of capital energy requirement for maintenance, the payback period is only 5 years, making the energetics much better than the economics. Yet the pay-back period is in reality likely to be much longer, for the figures for the Irish system are for total energy produced, and make no assessment of how much of this energy is useful, whilst the figure for energy use in construction does not include inevitable wastage. Were 30% of the energy produced wasted, and 30% of the energy in construction wasted, then the energy pay-back period would be 11 years.

The inaccuracy of these figures produces a critical variation, but at worst the system performs twice as well energetically as it does economically, and if it were to be installed, it would be for reasons of energy saving per se, and not for saving money.

More or less the same sort of economics seems to apply to larger schemes, in agriculture for instance, though in seasonal applications the lack of continuous use may be prohibitive.

An example of such a use for solar energy is in crop drying, a function which is seasonally, rather than diurnally cyclic. A 'solar barn' constructed near Edinburgh for experimental purposes (58), included 160m2 of solar plate collecting area, heating ambient air for inclusion with the air in an electrically heated fan. Under experimental conditions 20 tonnes of hay and 75 tonnes of barley were dried, at an energy saving over an equivalent system without the solar panels, of 4600kWh/annum, which apparently was using the system to its full potential.

No economic figures were provided, but this system may well be much cheaper per m2 of collector area than a water heating system. Using the figures put forward in Table 2.5 for energy in construction suggests an energy cost of construction of 43.2 GJ/annum over the lifetime of the installation, as compared to an energy gain of 16.54GJ/annum. Yet as well as a lower capital energy cost, the system has the benefit that the barley had a slightly higher digestibility and lower final moisture content than in the non solar system.

It is also possible that greater use of the system may be made in non experimental conditions, but the seasonal nature of this installation is always going to restrict all year round operation, unless some other use can be found for the heat at other times, such as domestic space heating or animal house heating, both of which would of course incur additional costs.

Yet all these additional benefits would need to increase the system efficiency by a factor of nearly 3 before a net energy gain would be experienced, which suggests that only on grounds of pure energy saving, rather than economics, could the installation of such a system ever be justified.

Thus capital costs appear to make these solar systems unattractive economically, and not even such great exploiters of 'free' resources as might be supposed, and it is towards reducing these capital energy costs that we must look if any renewables are to be viable.

2.3.3.3. Passive Solar Design-

Of all the means of utilising renewables, passive solar design is probably the least spoken of and certainly the most used. Simple measures like south facing glazing are standard practice in architecture, and many traditional architectural forms have evolved to make the best use of insulation, heat stores and the available solar energy. Although these traditional forms may be more concerned with cooling, or stabilising diurnal temperature ranges further south, in northern latitudes maximum use must generally be made of the sun for heating, at least for a large part of the year.

Post-war architecture, in a climate of perceived limitless energy supply, largely ignored the needs of energy conservation, but with rising fuel prices these are once more a priority. Yet today's building is more often than not concerned solely with the conservation of artificial energy sources pumped into them, whereas passive solar design is concerned more with making positive use of available solar energy.

Such features as Trombe walls, conservatories and solar skins can trap useful solar energy, whilst storage, for instance by means of dense rock stores, can ensure the distribution of this energy as and when it is required.

In one study involving the construction of single bedroom, two storey flats (59), the buildings employ a glazed porch, a roof mounted solar collector with electric fan distribution, double glazing and a large rock store. These flats are compared to similar, hypothetical buildings which come up to the (now quite exacting) standards of the building regulations, but have no additional insulation or solar technology. At design temperatures with a maximum of 20 deg. C, falling to 14 deg. C in some rooms at night, the solar flats were able to save some 3.6kWh/day,(1314 kWh/annum)

In terms of energy costs, the energy in construction of a brick built three bedroomed semi-detached house is around 1300kWh/m2 gross floor area, a figure which should be generally applicable to most traditional building on a small scale. The energy requirement in construction of these flats is therefore 56,862kWh for the non-solar flats, i.e. the solar gain achieved is around 2.2% of the capital energy in building, 37% more than discounted annual construction energy costs.

If the additional energy cost in construction of the solar flats is taken to be proportional to the additional floor area required for the rock store and the sunporch, or 25% additional area, the energy requirement for the construction of this would be 15,600 kWh, with a payback time for energy of 11.8 years. In fact the pay-back time is likely to be even longer than this, since the additional work on the solar flats includes some high energy components, such as glass and metals. Additionally, no maintenance costs have been taken into consideration in the analysis.

Yet the difference between passive solar architecture and the other energy sources discussed here lies in the design life. Wind machines characteristically have an arbitrary and quite unproven design life of 20 years, whereas it is quite reasonable to assume a life of three times that long in the case of a building using largely traditional materials. If an individual is prepared to invest in the future of energy then design solutions relying on the passive utilisation of solar energy may be quite valid.

Perhaps contrary to expectations, passive solar design may have a larger effect at more northerly latitudes than in the south. The longer heating season in the north means that a larger proportion of available solar energy can be utilised, particularly since the heating season extends to months when daylight hours are longer. This means that design solutions involving passive solar heating should by no means be excluded due to latitude.

Passive and passive/active solar architecture can also be employed usefully in agriculture. Indeed in its simplest form the ordinary greenhouse utilises technology to maximise available solar energy in a fairly efficient manner.

One means of utilising passive solar energy in a more efficient and productive manner is to link greenhouses to animal houses. A French study (60), suggests a double glazed greenhouse producing Lemma Minor as vegetable protein for feeding to ducks being raised in an attached building. Animal faeces is used as a fertilizer directly, whilst the greenhouse is used as a solar collector to provide heat for the birds via a rock store. A similar American scheme (61), with a greenhouse attached to a pig unit, additionally utilises carbon dioxide, a by-product of fuel alcohol production, to increase greenhouse yields.

Results of this study are difficult to summarise in simple energy saving terms, since the system is incomparable with 'non-solar' systems, but between 60 and 70% 'self-sufficiency' in energy terms (not including feed requirement) is claimed. This does not necessarily represent the saving however, since casual gains would also apply to both simple greenhouses and ordinary animal houses, giving them also a, presumably lower, 'self-sufficiency percentage'.

This scheme tends to highlight the difficulty of comparison between 'passive solar' and 'non-solar' developments. Not only is there the basic difficulty that all schemes, both agricultural and domestic, rely on the passive acceptance of solar energy to some extent (unless they are to operate at absolute zero), but the question of what is useful energy arises when the choice of schemes is large, and not just a question of replacing the fossil fuels used at present.

Battery poultry production, for instance, typically operates at an output/input ratio of about 0.1, i.e. ten times as much energy is put into the system as is retrieved in the form of food. This is an appalling figure in terms of other farming types, even if it is recognised that protein production, and not food energy production, is the main aim. Broiler production compares poorly with, say, wheat production, the former producing one kg of protein for every 80kWh of energy input, the latter 1kg of protein for every 11kWh. Thus even if the top figure of 70% self-sufficiency for the above scheme is assumed, and no casual heat gains are assumed for ordinary poultry production, and no account is taken of the additional energy needed for construction, 24kWh are needed to produce 1kg of protein, more than twice the energy needed for protein production through wheat growing.

Of course the real situation is rather more complex than this. Crop production requires much high quality land, whilst poultry production requires almost no land in itself, yet it would be difficult to advise someone interested solely in energy efficiency that such passive solar schemes represented the best investment.

All passive solar schemes represent grades along a line, rather than absolutes. It would be easy to compare, for instance, a house with a Trombe wall, rock store and quadruple glazing, with a poorly built, draughty house with no insulation, and conclude that passive solar design is highly energy efficient, but a similar comparison with say, an ordinary new house with double glazing, proper heating control and loft insulation may not present such a positive picture. Passive solar design is essentially different from the other sources discussed here, in as much as a wind machine, for example, is just that, a single function device which one either installs or does not install, with the one purpose of saving energy. A house employing passive solar design, however, is a development which would exist whether or not it included a Trombe wall, and has functions other than energy saving. The effort that can be gone to to employ solar techniques is infinitely variable, and often consists of a balance of insulation to prevent heat loss, together with lack of insulation in some parts to allow heat gain. As such there is no base point or common criterion against which to compare schemes, and whereas a wind machine represents a straight saving of so many litres of oil, a house uses energy, and the efficiency with which it does so can only be measured against that of another actual house.

Certain general principles can be stated however. It is likely that the first few kWh can be saved for very little energy expenditure, and that the marginal energy cost of successive savings is likely to increase. Thus draught proofing, loft insulation and double glazing are likely to have small, but increasing energy pay-back times, whilst a Trombe wall and rock store may have a prohibitively long pay-back time. Simple procedures like house aspect and adjustment of the glazing area may actually have nil or even negative energy pay-back times, and represent one of the truly free uses for additional solar radiation.

2.3.3.4. Biofuels-

Although biofuel energy, mainly from woodburning, still remains important in fulfilling domestic energy needs in many Third World countries, it now makes up only a small proportion of world energy demand (62).

Yet in spite of the huge amounts of fossil fuels now consumed, total annual world biomass production remains ten times the total world annual energy requirement, whilst at any one time the world standing biomass has about the same energy content as all the worlds proven reserves of fossil fuels. British performance compares unfavourably with these figures, since total annual biomass production is only around 30% of annual energy needs (61).

Added to this massive availability is the relatively high concentration of biomass energy which, though it cannot compare in this with fossil fuels, is much better than most other renewables, the ease of storage of this form of chemical energy and the low technology needed to harvest and tap it.

Given these facts one would expect biofuel energy to be much in use and competing well on energetics and economics grounds with fossil fuels. The fact that it does not do so is largely a product of the different intrinsic values of different energy types. In the same way that electricity is a much more useful and valuable energy source than warm water, in terms of the work that it can perform, so biological energy sources will always have a greater value per kWh when used for food than when used for domestic heating for example. Biomass energy in the form of trees may also have a much greater value as a material than as an energy source. Due to the lack of comparability between these different uses, simple energy analyses are inadequate in decision making. In general however, energy is likely to prove less valuable than other biomass products, particularly food, if only because biomass is not the only source of energy, and only very marginal land is likely to prove economic for the growing of energy crops in the foreseeable future.

There remain however two different types of situation in which biofuels may be economic; situations where no other productive use can be found for a material which already exists, largely in the form of waste products, and situations where use of part of the resource as a fuel does not adversely affect its main function.

The latter case includes the management of existing woodland, whose main function may perhaps be ecological, and shelter belts, where excess production can be harvested as fuel. The former case includes animal waste, domestic and industrial refuse, cropping wastes and forestry wastes, together with small amounts of seasonal 'catch crops'. Yet even with these wastes alternative uses may also exist.

In terms of energy conversion, aside from simple burning, which though efficient does not allow the flexibility of oil or gas, anaerobic digestion can be carried out to produce methane, plant matter high in sugar or glucose can be fermented to produce ethanol, wood can be subjected to pyrolysis, (heating in the absence of oxygen to around 800 deg.C to produce gas and solid carbon,) and wood can be burnt slowly to produce charcoal, a highly inefficient process, but resulting in a high grade of fuel.

Fermentation requires a good quality feedstock, and can produce fuel suitable for automotive use, and whilst it has received much attention in countries such as Brazil, where the fuel needs of the whole country could potentially be produced on only 4% of the land area (63), and mixed alcohol and gasoline fuel is in common use, biomass is unlikely ever to be of enough importance in this country to require the production of such a high quality fuel, or to be able to command good arable land. There remain plenty of low grade uses for biomass in the U.K. without going to considerable expense to upgrade fuel. More or less the same applies to pyrolysis, which, though efficient and needing only lower quality biomass, is unlikely to compete with straight woodburning because of the technology involved.

Even direct burning techniques can involve a variety of quite sophisticated technologies, particularly when carried out on a large scale. Fluidised bed combustion can be employed for greater efficiency, whilst whole tree chip power plants and district heating plants have been developed in the U.S.A., Finland and Sweden, again in areas where land supply is not a problem, and virgin forest is still being used as feedstock (64).

In economic terms, great benefits are claimed for burning wood. One study suggests that, at 1980 prices, electricity cost 3.4p/kWh, fuel oil 1.4p/kWh, coal 0.79p/kWh, wood 0.63p/kWh and natural gas 0.56p/kWh (65). Adjusting the figure for electricity to account for primary fuel consumption in its generation gives a figure of around 1.36p/kWh, cheaper than fuel oil, but still much more expensive than wood.

Yet these figures are rather misleading, in as much as solid fuel burning appliances, particularly in the home, are often very inefficient, as demonstrated by the local energy use survey (section 7), and the price of wood is very much subject to local availability. Wood requires a large amount of storage space and often, when the cheaper sources are used, much preparation and additional cutting is needed before the fuel can be used. Present use of wood for fuel is restricted to around 10,000 families in Scotland, 1% of the population (66).

For the most part, energy analyses of the use of timber for fuel are favourable, though due to the many different ways of harvesting, reliable figures are difficult to come by. For instance, forest thinnings must be harvested carefully and relatively slowly, and are likely to require considerable amounts of energy. The same would apply to the management of woodland and shelter belts, whilst material normally left in place, such as tree roots, may need highly energy intensive equipment for their harvesting. On the other hand, sawmill waste may require little or no additional energy that cannot be accounted for in the manufacture of the main product.

Yet even if a very high figure is assumed for the energy requirement, equivalent to the energy needed to produce timber building components for the average house, a favourable analysis is achieved. Building components average at around 1095kWh/tonne, as compared to an energy content of 4700kWh/tonne. An ordinary domestic stove of 6kW peak capacity uses up to 4 tonnes of fuel a year, whilst its capital energy cost is around 4000kWh (67). Operating at 73% efficiency (68), 4 tonnes of wood produce 13700kWh/annum of useful heat, at an energy cost of 4380kWh there is a net energy product of 9320kWh, which would pay for the capital energy requirement in under 6 months. Burning efficiency would have to drop below 25% before the energy gained dropped below the energy cost, which is quite possible in the poor domestic situation, but it is highly probable that energy costs are in reality much less than recorded here.

As the necessary technology increases in complexity however, the energy analysis becomes rather less favourable. Clausen and Gaddy (69) present an energy analysis of a methane producing system using cropping wastes. In their words: "The biomass utilised consisted of locally harvested grasses, unsuitable for animal feed". (One wonders what justification there is for growing grasses unsuitable even for animal feed, this must surely represent an opportunity cost for alternative uses for the land.)

They state that annual production from the plant is 253GJ, whilst the energy requirement is only 63GJ, leaving net energy produced at 190GJ. Yet the energy requirements only include building heat, agitation, biomass grinding and lighting, with no capital energy need or energy requirement in growing and harvesting the feedstock. A monetary costing is included for the installation however, which comes to £20400 at 1982 prices, for materials only. The break down of these materials allows an energy analysis based on the energy requirement of similar materials.

The building required has a gross floor area of 168m2, or twice the size of a house requiring 100,000 kWh in its construction, yet due to the basic nature of the building, the 100,000kWh figure will be used. The engineering components are assessed in the same way as for wind machines, adjusted back to 1982 values this gives 15kWh/£ value, a total of 270,000kWh for the engineering components, and a grand total of 370,000kWh, not including the cost of labour and building plant, or the cost of the central heating system needed to utilise the gas produced. A low figure of 50kWh/tonne is assumed for the energy needed in the production of the feedstock, one twentieth of the figure used in the wood burning example, and at an incredible 40 tonnes of feedstock per day, is 730,000kWh/annum.

The total energy running cost is therefore 747,451kWh/annum, as compared to 70,276kWh produced, so the scheme is a complete non-starter as an energy producer, and in fact consumes ten times as much energy as it produces!

Admittedly the figure for energy needed to produce the feedstock is arbitrary, but this would need to come down to around 5kWh/tonne for the cost of harvesting and transport, and the opportunity cost of the land, before the scheme approached being viable in energy terms. Such a low figure for energy input is not even achieved in the most 'energy efficient' forms of agriculture in the world, which rely entirely on human labour and 'slash and burn' techniques, with no inputs to the soil at all. If the feedstock really was an inevitable waste product, for which there was no possible alternative use, and energy costs are treated as nil, then the net energy production of 52,825kWh/annum would take 7 years to 'pay off' the capital energy content, without any discounting. Anomalies like this scheme can only hope to exist by impressing with technology. One would certainly be much better off simply burning the plant matter, however inefficient the process might be.

A more hopeful feedstock for methane production is animal wastes, where direct burning may not be a viable solution. Yet energy analyses of such schemes depend heavily on the energy cost of the feedstock, i.e. the collection cost, which can be small in intensive farming situations, and the opportunity cost of the loss of fertiliser value.

There are various reports on the fertiliser value of the waste solid after methane production, but little consistency amongst them. Some researchers have suggested that the value of animal waste as fertiliser after anaerobic digestion is enhanced, others say the effluent has little fertiliser value (70). Stafford et al. (71), suggest that "effluent from digested animal dung retains much of its fertiliser value, but with greatly reduced odour and biological oxygen demand", they do not say just how much fertiliser value is retained however. Since energy has been extracted from the dung, the energy remaining to be used as fertiliser must also have been lowered, though it is possible that its utility might have increased due to chemical changes making release to the soil easier. In the absence of reliable information it is difficult to make recommendations, but if fertiliser value is lost then one is merely changing the use of an equivalent amount of energy by producing methane, so there is no real net energy gain; whilst if all the fertiliser value is retained, the energy analysis for this feedstock is likely to be quite favourable, in spite of the high capital cost involved per kilowatt of capacity.

In summary, it is the energy cost of the fuel that is important in biofuel technology assessment, since there is not, or should not be, such a thing as absolute waste, and this cost is likely to vary in every case. However for the foreseeable future it is likely that 'waste' feedstock such as animal dung, straw, forest thinnings and timber from the management of woodland and shelter belts and sawmill waste, are likely to prove the most viable forms, whilst where dry biomass is available, combustion is likely to be the best means of utilising it.

Unlike for most renewables, the means of releasing energy from biofuels is contained in most homes, and high technology investments in small-scale projects are not likely to be viable.

2.3.3.5. Water Power-

Conventional hydro power, utilising gravity and stored rainwater, is the only form of water power which will be discussed here, since wave and tidal power are, of necessity, really limited to large, capital intensive projects, and must be confined to only certain specific rural areas, without the ability to apply them in all or most rural environments.

Hydro-electric power has the advantage of being able to use highly concentrated energy sources very efficiently, (compared to hydro power, solar panels are rather like trying to utilise the pressure of rain on a roof to provide energy), and has the most highly developed and proven technology of all the renewables. However it has the disadvantage of needing a specific suitable site, very many of which have already been exploited.

Present U.K. public utility hydro-power capacity is 1.3 GW, or just under 2% of the total electricity generating capacity, though the necessarily sporadic nature of hydro generation means that actual energy produced will be rather less than this. Taking Scotland for instance, or just the Scottish Highlands, as a region within the grid system, hydro power may be of great importance, whilst in Norway for example, (and, under very different circumstances, in several Third World countries), hydro power can provide all the electricity needs.

Yet because of the highly developed state of hydro-electric power generation, the potential for additional large scale generation is quite small, and future development is likely to be restricted largely to small schemes, perhaps utilising the sites of some of the 20,000 water mills that once operated in Britain (72).

Using all possible available waterpower could push up generation to 4GW, but it is impracticable to use most of this, and indeed it would be undesirable that all rivers and streams in Britain should be used for this purpose. Many of the original sites in England and Wales are in lowland areas, using small heads, and many have silted up completely or are otherwise in a bad condition

(73). Yet many of these old sites do have potential for hydro-power development today.

More than any other renewable, hydro-power is site dependant, and generalisations about costs are very difficult to make. Yet the most economic sites are generally those where there is an existing dam or weir, and where a water mill used to operate. The type of installation depends on site conditions, flow rate and head, as well as the power requirement, and the installation can either interact with the grid supply, now perhaps also supplying energy back to the grid, or stand alone or with diesel or other generation. The Atomic Energy Research Establishment (A.E.R.E.) and the University of Salford (74), have assessed various small hydro projects of different types, and discounting energy production over time and taking into account operaton and maintenance, at 5% discount, pay-back times vary from 4 to 40 years, and average 16.5 years.

Very long pay-back times tend to be associated with sites where the water authority will not allow full use of the available water, and insist on a large continous flow escaping, and 'run-of-river' schemes employing cross-flow turbines under conditions of low head. The size of scheme does not seem to have any direct bearing on the pay-back time, as calculated using electricity board buying rates for electricity from private individuals, and smaller schemes can be cheap when D.I.Y. labour is used.

Three schemes are assessed here, A, a small scheme producing cheap electricity from a high head, B, a small, rather expensive run-of-river scheme, and C, a large scheme producing very cheap electricity by means of a centrifugal pump.

Scheme A has an installed capacity of 14kW, on a 30m head, with an annual output of 49MWh, its capital cost is £11220, but a rather low value is put on the electricity produced, giving a long pay-back period of 15 years. Using an energy cost of capital of 16kWh/£ value, at 1982 prices this gives an energy cost of 180MWh, or under 4 years energy production.

Scheme B cost £24,000, giving an energy content of 384,000kWh for capital, for a rated capacity of only 7.5kW, but a relatively high annual output of 36MWh, giving an energy pay-back time of 11 years for this cross-flow turbine with an economic pay-back time of 25 years at the high energy price of 5p/kWh.

Scheme C cost £63,000 for an installed capacity of 35kW and an annual production of 700MWh. Capital energy cost is 1,008 MWh, giving a pay-back time of only a year and a half, compared to a monetary pay-back time of 4 years.

All of these schemes are based on sites with old disused facilities, and since energy wastage due to excess production has not been taken into account, the great divergence between the projects is almost entirely a function of site suitability.

Where an individual has a suitable site, hydro-power can be the best, and perhaps least disruptive of the renewables, but it is a lack of such suitable sites that is likely to prove the problem. Probably the best sites, not discussed above, are those where the whole technology for harnessing water generated electricity already exists, but has been abandoned. Often abandonment has occurred quite recently, due to 1950's and 60's cheap energy from the grid, such as on one estate in Lumsden, Aberdeenshire (75), which still has the generating and distribution system. If such obvious chances of cheap development are ignored, it takes a very determined and interested individual to carry through development at the more usual, poorer site.

2.3.4. Summary of the Use of Renewables Projects-

In summary, the few schemes in each of the categories discussed above are highly varied in their energetics and economics characteristics, and the major feature is how few of the options are actually economic.

The schemes which appear to be economic in their own way at present are, the small battery charging wind machines at Scoraig, large scale hydro-power at good sites with large heads, low technology forms of passive solar design, and wood and straw burning, when no better use can be found for the land or the biomass.

Rather more projects display reasonable performance when pure energetics are the aim, and aside from the above mentioned economic schemes, wind machines such as at Burgar Hill (i.e. quite large scale ones), some solar water heating systems, many passive solar design projects, and most hydro schemes would seem to provide rational means of development if pure energy saving is a priority above economics.

The schemes which perform best appear to have in common either a concentrated fuel source, such as wood or hydro power, which can easily be tapped, or relatively cheap and simple technology, such as wood burning in domestic stoves, rather than digestion to produce methane for example, or small wind machines built from scrap parts rather than expensively engineered new designs.

Often the energetics of projects only appear favourable in perfect situations however, one major unforseen piece of maintenance which uses considerable amounts of energy, such as the use of a helicopter for maintenance on the Fair Isle wind energy project, can change these figures around considerably, and make a nonsense of the decision on energetic, as well as economic grounds.

Anyone wishing to invest in renewable energy projects must also be prepared to accept long pay-back times, often even in pure energy terms, and must only require a small return for their money, high figures for the time value of money are likely to lead to negative decisions on investment in renewables. Pay-back times may be more acceptable however when the life of the project is expected to be long, particularly in buildings, where people may be prepared to invest in a longer term future.

Finally, it is important to remember that the value of a kWh of energy, even in the same form, is not always the same, and that the marginal value of each subsequent kWh tends to decrease. It is the speed of decrease in value with every additional kWh acquired that will often determine what kind of project to invest in, or indeed whether to invest in renewable sources of energy at all.

Sources of renewables are considered by both the Delphi survey in section 3 and the local survey in section 8, and lessons on their applicability are included as recommendations. Thus the technology necessary to fulfil any potential for rural energy autonomy has been shown to exist, albeit not always in a particularly economic or efficient form.

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3. RURAL ENERGY FUTURES-

3.1. Developing a Rural Future Scenario by Reference to Existing Global and National Forecasts-

3.1.1. Introduction-

3.1.1.1. Rural Energy and the Future-

An assessment of patterns for the future must be an essential part of any research which is intended to have any practical application, and is not a purely retrospective look at a subject. In order to be able to assess how far the current potential for a greater degree of rural energy autonomy is likely to change in the future, it was decided to initiate a 'Delphi' method survey of global, national and local energy futures, (sections 3.2 to 3.5). This survey runs parallel to the local surveys reported in sections 5 to 8, whilst sections 9 and 10 draw these two approaches together, finally concluding on the extent of the potential for a greater degree of rural energy autonomy.

As a lead up to the 'Delphi' study, in order to arrive at a viable initial scenario for application in a postal survey, this section presents a review of currently available literature on future forecasts, both general and energy based, at the global and national level.

Though obviously an integral part of the 'world system', rural energy demand and usage, particularly in the urbanised developed countries, rarely figures as a discrete variable in systems approaches to the world such as the future model. Yet its small place in the global structure does not preclude it from interacting as a variable in the real world, and thus a variety of possibilities for the future will generate a variety of scenarios for rural energy.

Due to the complexity of the world system a confinement to purely energy matters will not be adequate, and therefore a variety of global and national, general and energy based future models will be considered, with a view to constructing a series of possible futures for energy use in the rural areas, against which to measure presently available research and technology.

Although 'futurology' has become a large and complex specialism in recent years, and the detailed construction of possible futures from scratch is beyond the scope of the present research, it is hoped that a review of existing forecasting methodology and data can throw some light on the models, and enable rational choices to be made from a welter of different scenarios.

3.1.1.2. The Study of Existing Future Models-

The literature study of future models starts from a broad base and attempts to progressively narrow down the range of forecasting literature, partly by consideration of the objectivity and motives of the forecasters.

Section 3.1.2. looks at global future models, identifies a number of works for consideration, and discusses the difficulties of future modelling normally cited, the element of qualitative bias in the models, and common assumptions which serve to make many of the methodologies far from scientifically accurate. It then proceeds to narrow down the range of models to be considered.

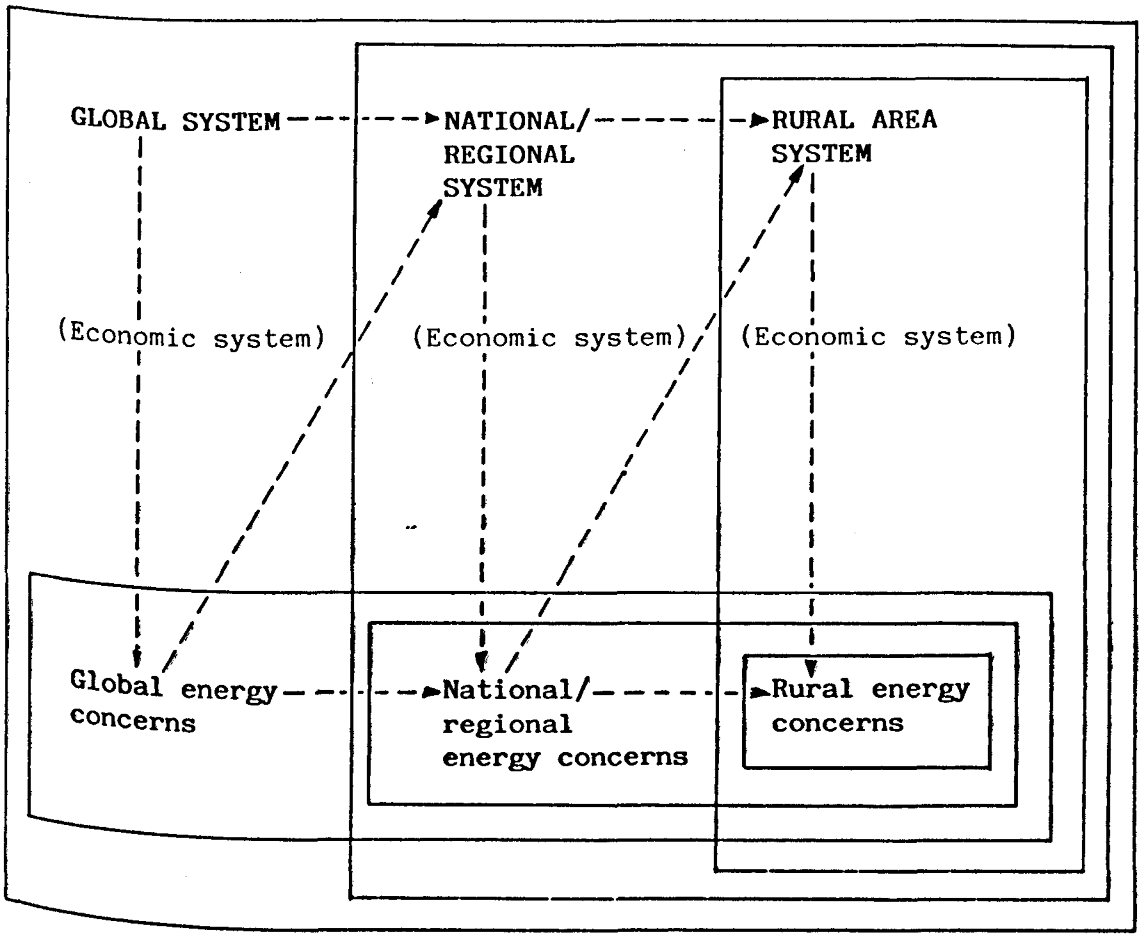
Section 3.1.3. begins to concentrate on the energy model, and energy as a variable within models, discussing the range and validity of variable choice and the advantages and limitations of the multiple scenario approach. Using a further reduced set of models, section 3.1.4. attempts to build an informal model for rural energy use by selective adaptation of existing models, whilst section 3.1.5. to 3.1.7. produces a scenario for input into the first round of the 'Delphi' process.

3.1.1.3. Working Towards a Relevance to Rural Energy Usage-

In spite of the broad nature of this section, it must be noted that only where global futures interact with rural energy matters are they relevant. Having said this, however, it is evident that the number of real interactions is so large that almost all the concerns of the broad global system can be said to have some spin off, which, directly or indirectly, affects rural areas, and thus rural energy use. Thus global energy futures affect rural energy, but also other factors in rural life, whilst global futures in general affect rural life and therefore rural energy use. A simplified interaction system, with energy as a subset of the whole system, appears as figure 3.1., and demonstrates the potential complexity of the situation.

No particular variable can be omitted from the global model in evaluating the future of rural energy, and thus some of the more general and simple models are not likely to be useful, where they omit considerations of items which, peripheral though they may be to total world futures, are essential to the study of rural energy. Thus a model which fails to consider the split of future energy use by fuel type, in favour of sweeping concerns of world population or economic growth, can have little relevance to the specific study of rural energy, except as a leader to the further development of futures.

Figure 3.1 SUBSETS AND INTERACTIONS IN THE GLOBAL SYSTEM.



So the first constraint on the future models is that they should have a specific enough data level to predict particular energy resource uses.

3.1.2. Models and Motives in Global Future Projection-

3.1.2.1. The Problems of Forecasting-

The problems implicit in attempting to forecast any facet of a future world are manifold, and many of them are all but unavoidable. Thus the fact that single individuals, through political activity of a violent or passive nature, can change the course of history, may quickly make the most rigorous and best considered forecasts look rather silly.

Indeed the whole spectrum of political relationships is one of difficulty, and an area often avoided by modellers of the future, who characteristically ignore the political element except where considering their own preferred strategy for the world, when they replace the complexities of modern international relations with a kind of benificent political/economic policy at a global level.

Those authors who do tackle the subject of political futures, such as in Hall's attempt to map out a future Europe from an entirely political standpoint, find themselves unable to come to a consensus about any issue in the world dominated by personalities and subjective judgement (1). Yet purely resource based forecasts have little validity if not supported by some assessment of future policy measures, even if policy is assumed to be an entirely rationally controlled variable.

Furthermore, non-political single events may have major effects on policy, and on world futures, yet remain unpredictable. For instance, a single major accident involving a nuclear power plant might have huge worldwide effects on the development of nuclear energy programmes (2). Similarly, technological change, often considered by forecasters as though it were a continuum, is in reality a series of large or small jumps, and very rarely a properly forecastable item.

Another problem arising with variables which are at least potentially forecastable, can be the mechanistic extrapolation of recent trends, often following biological rules of growth which are not necessarily applicable to societies having a degree of control over their operation. Often this extrapolation follows an exponential growth followed by collapse path, a Malthusian view of the world which, whilst useful in stressing dangers, has little substance in the reality of development. Thus Foley (3) quotes Professor Jevons' quite valid 1913 prediction of British coal output, showing it to rise continually to a peak in the year 2101, thereafter falling rapidly as the resource size constraint was reached. In fact coal production has never yet passed its 1913 peak, and Jevons' reliance on recent historical trends, as well as his lack of consideration of technological innovation, contributed to his downfall.

The narrow approach to extrapolating recent trends way into the future remains a fault of many forecasts today, and one to which there is at least a potential answer. If Jevons had, instead of only considering coal production in recent years, carried his historical view further back, and considered the rise and fall in use of the previous major fuel resource, wood, he might have gained a more accurate picture of the way in which resource depletion tends to operate.

The actual world model is a summation of every resource, and of every action taken with those resources, and as such sets up a number of possibilities for variation which is all but infinite. Thus any manageable world model for forecasting must amount to a gross over-simplification, and achieving the optimum model is not so much a case of considering as many variables as possible, as of producing a number of variables which reflect the scope of world activity, whilst keeping the number of interactions to a manageable size. Many models have tended to err on the side of too many variables, thus precluding their proper interaction and the inclusion of sufficient feed-back mechanisms, whilst making the model and its results too complex for rational consideration by decision makers.

3.1.2.2. The Models Under Consideration-

Table 3.1. sets out the models considered broadly in terms of type.

Table 3.1. Listing of Models Considered-

AUTHOR/TITLE	*METHODOLOGY*	*VARIABLES*
GENERAL GLOBAL MODELS .		
FREEMAN, World Futures	Critical assessment of other forecasts and qualitative decision making by resource/ /sector, world split into developed/underdeveloped.	Energy, resources technology, population GNP other models (4)
BARNEY, Global 2000	US bias, aimed at environmental projections by adaptation of Federal agency data	Pop, GNP, climate technology, food, energy non-fuel minerals. (5)
MEADOWS, limits to Growth	Early computer model, unrealistic whole world based, simple weightings 'prophet of doom' type forecast.	food, energy , non- -fuel minerals,pop., GNP, pollution.(6)
LEONTIEF, UN, Future of the World Economy	Sophisticated computer model, world in 15 regions, 45 economic sectors, linked by import/export, aid, capital transfer etc. mainly aimed at the environment	Complex economic indicatos, pollution pop., resources (7)
KAHN, The Year 2000	Unqualified optimism through simple indicators. High value on technical change, little consideration of resource base, classical justification for capitalism.	GNP, population food, technical change. (8)
EHRLICH, Population, Resources and Environment	Simple extrapolation to the resource limit, imminent collapse, developed v under-developed, advocate of 'Triage'.	Pop., food, resource base, GNP (9)
DUMONT, Utopia or Else	Qualitative study with simple variables, world as one system no technical advance, stability reached through 'organic' control.	Non-quantitative (10)

SCHUMACHER, Small is Beautiful	*Qualitative, severe growth limitations,but not through collapse, alternative technological route*	*Non-quantitative (11)*
HEILBRONNER, An Enquiry into the Human Prospect	Simple extrapolation leads to collapse, world as one system simple quantitative.	Resource base, GNP pop., food. (12)
MESAROVIC, Mankind at the Turning point	Advanced version of Meadows, more considered, still leads to world collapse, several world regions considered	Economic, food, pop., resources, pollution (13)
HERRERA, Catastrophe or New Society	Later, complex computer model, end result= world collapse, emphasis on regions, trade etc., catastrophe economic rather than resource or population induced.	Many economic, pop., food, trade, political. (14)
MODRZHINSKAYA, The Future Of Society, and KOSOLAPOV, Mankind and the Year 2000	Russian writers employing simple extraploation and political constraints, resource constraints ignored in anticipation of technical change.	Resources, energy, GNP. political constraint. (15)
NATIONAL/REGIONAL GENERAL MODELS-		
HALL, Europe 2000	Qualitative scenarios through political variables, building views of the future in terms of alternative power blocks	Political and social change. (16)
GLOBAL ENERGY MODELS-		
WAES, Energy Supply to the Year 2000	Computer supply and demand models by nation, integrated by economic function, wide range of scenarios using official national data	Policy, GNP, replacement fuel energy price oil discovery. (17)

NATIONAL RESEARCH COUNCIL, Alternative Energy Demand Futures to 2010	*American biassed integrated 40 sector model by economic activity interaction by input-output and econometric methods, 4 scenarios produced.*	*Energy price, GNP. economic indicators by sector (18)*
FOLEY, The Energy Question	*Qualitative, non-scenario approach with broad conclusions about scarcity*	Other models, the range of projection technique. (19)
WEC, World Energy Resources 1985-2020	Economic indicators by fuel source limited to fuel considerations, by region and developed/UDCs.	fuel price, resources GNP, technology. (20)
FORD FOUNDATION, Energy The Next 20 Years	Justification for free market capitalism no scenarios, discussive on a wide list of separate topics.	Largely economic and resource based (21)
MONTBRIAL, Energy, the Countdown	Unstructured, qualitative approach by political event/situation, collapse when oil runs out	Economic, resource political. (22)

NATIONAL/REGIONAL ENERGY MODELS-

LEACH, a Low Energy strategy For The U.K.	Middle of the road simple energy strategy used as starting point for demonstrating energy saving ability initially used exaggerated U.K. Government figures.	GNP, energy demand resource type conservation measures (23)
WATT CTTEE/ DEPT. OF ENERGY SCENARIOS	Series of 7 scenarios based on econ. growth, policy decisions, energy cost largely energy only base.	GNP, energy prices policy decision technology (24)

3.1.2.3. The Range of Results in Future Prediction-

From section 3.1.2.2. one can begin to see how huge is the range and variety of models and model results. Furthermore, models of a similar kind, making broadly similar assumptions, can interpret results in totally different ways, (e.g. Kahn and Heilbronner (25)), whilst models which take entirely different routes, using different kinds of data, may come to broadly similar conclusions (e.g. Dumont and Leach (26)). This is not only a result of different quantitative assumptions, but of subjective judgements deliberately made from limited data to prove a point, be it an honest attempt to shock people into action to solve the problems described, or an undeclared bias to the authors own ends.

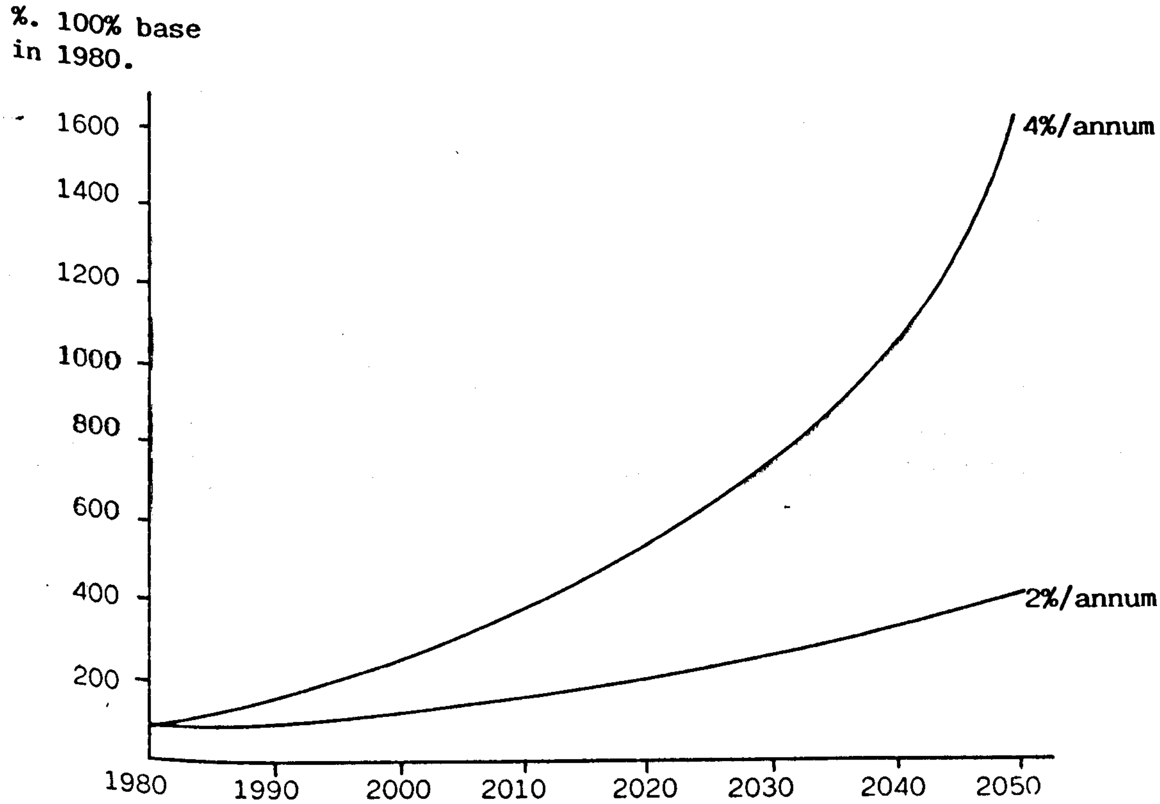
Thus, even when dealing with such factors as population trends, a relatively simple item to forecast due to the long time period which tends to elapse prior to major trends taking effect, there arise very major differences both in projected rates and ceilings to growth, between Forrester's maximum ceiling of 4 billion (27), and Kahn's of 50 billion (28). To take another example, some look no further than oil as the primary fuel source, and predict collapse before the turn of the century, whilst others, again notably Kahn, are confident of fossil fuel supplies for the next few hundred years, followed by technological advance to support energy usage at many times the present level indefinately.

Leach (29) sees growth in GNP as being compatible with nil increase in energy consumption, whilst others see energy use as being inextricably linked to GNP, and predict a two to four times increase in energy use by the turn of the century.

One problem in trying to rationalise these differences lies in the nature of the figures used, and in the nature of exponential growth. Forecasters are able to appear quite justified in their choice of values through the difficulties of assessing the difference in, for example, valid growth level predictions between 2 and 4 % per annum in GNP, or beteen linear and exponential growth forms. Using such annual increases, marginal differences at year 1 can become huge by year 50. Figure 3.2. illustrates this problem, and shows how an initial 2% difference in energy demand becomes a 400% difference by 2050, whilst cumulative figures and the fixing of the resource base can allow these discrepancies to become still greater. Thus it is that a 1 or 2% difference in estimated growth rates, and a single technological innovation, can alter views of a future world beyond recognition.

Thus it is difficult to choose between the minutae of forecast figure differences without a considerable amount of statistical analysis, which in itself is no guarantee of a greater level of success than has been achieved by any previous forecaster. One way round this problem is to look, rather than specifically at the

Figure 3.2. DIFFERENCES IN ENERGY DEMAND PROJECTIONS ACHIEVED BY A 2% VARIATION IN ANNUAL GROWTH RATES



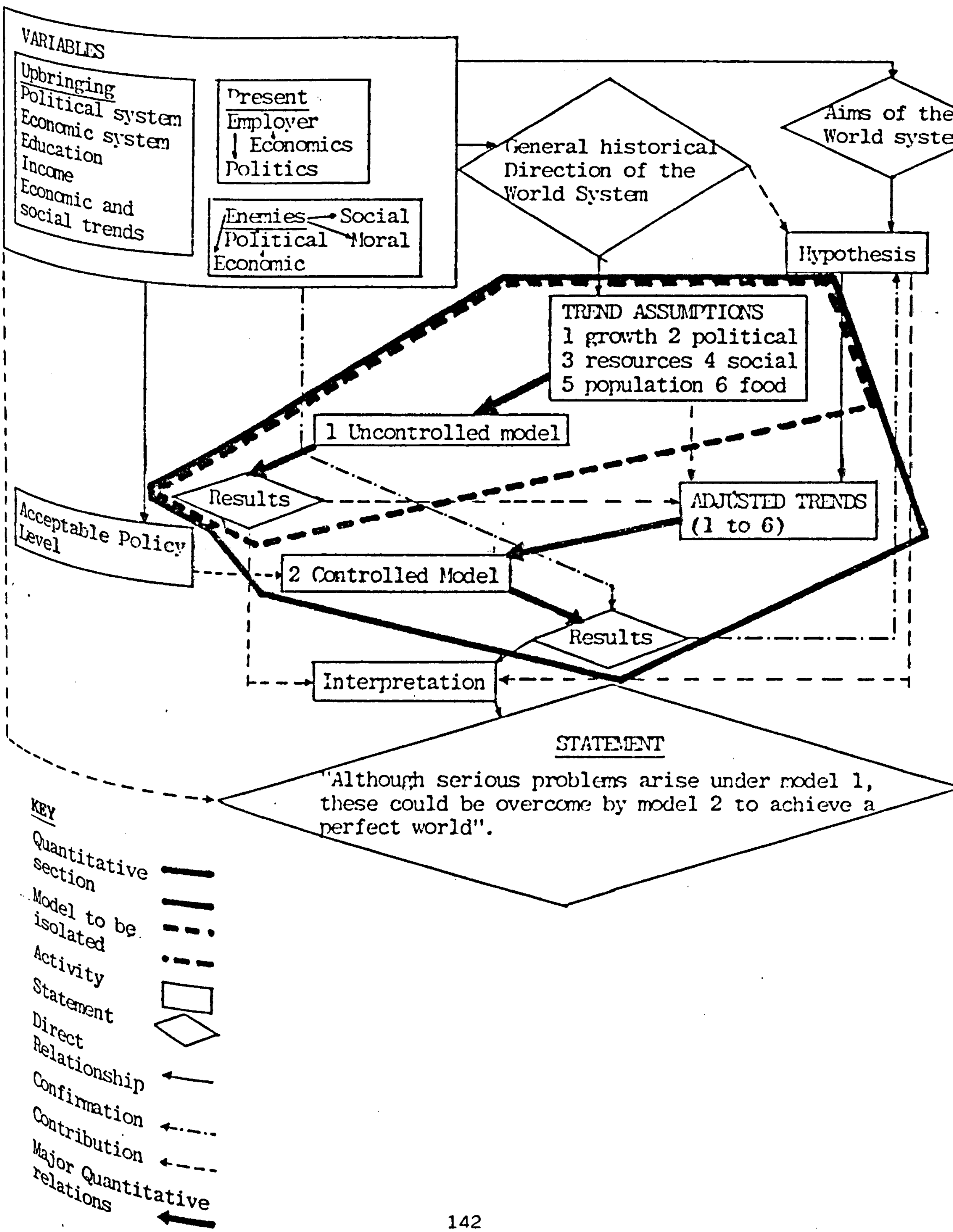
figures and the models, at the thoughts and motives of the forecasters.

3.1.2.4. Quantitative Bias Arising Through the Forecasters Qualitative Analysis of Trends-

Figure 3.3. presents a perhaps over-cynical view of the future forecaster's modelling process, claiming it to be at least partly a function of his perception of past trends and his desired goals. For instance, it is possible to argue that simply the historical period in which the forecaster formulated his political ideology and his general view of the historical direction of the world system in general, can alter his entire perception of world futures. Thus, someone with most of his or her learning period in post-war Britain or America, up to the mid 1970's, may see overall historical trends as being exponential in nature, whilst someone with a memory of the depression of the 1930's, or for the future, perhaps the early 1980's, will naturally hold a very different view of the natural direction of change.

Both upbringing and present circumstances will change the forecasters view of the model and of the end product, sometimes quite obviously, as in the case of Kahn (30) or the Russian authors (31). Yet it is only where such subjective judgements act as inputs to the quantitative sector of figure 3.3. that difficulties

Figure 3.3. A PSYCHOLOGICAL MODEL OF MODELLERS OF THE FUTURE



arise through this process, and it is towards the minimisation of such crossovers that we should look in trying to achieve an acceptable model for energy forecasting. Another problem exists where, as often happens, the quantitative element of the model is split into two halves, an uncontrolled model demonstrating natural state trends, and a controlled model demonstrating the effects of the forecasters preferred policy options. Quite apart from when this difference is obscured, and one is not certain which element one is dealing with, the uncontrolled model is likely to be skewed onto the opposite side of the range of possibilities to the preferred model, as in the case of Leach (32), in order to demonstrate extremes and how to solve them. In this case neither model, nor any averaged middle road, is likely to present a picture of the real world adequate to the purpose. It is necessary to isolate the real state of the world model from all the subjective judgements and ulterior motives that surround it.

Unfortunately, such a process cannot be carried out by seeking obvious political bias, or merely amending the forecasts that seem to stray too far from the norm, for in certain cases bias may be unintentional and universal throughout the model, and becomes very difficult to isolate.

3.1.2.5. Common Assumptions Which Cause Bias, Exponential Projection and Economic Growth-

Economic growth is one area where, to some extent, all the modellers are agreed, for they all see gross national, or gross world, product increasing exponentially into the future, albeit that some see the trend being followed by economic collapse. Yet, as shown in Figure 3.4., only the most optimistic of assumptions could achieve the 6% growth rate suggested by some forecasters, whilst the 'average low' figure of 3.5% also seems like a high estimate when compared to past trends. The problem seems to be that everyone has a motive for wanting to raise economic growth projections to a maximum.

Official government estimates are widely known to err on the optimistic side, as is only natural in an organisation trying to create confidence in its own prospects. Optimistic technocratic forecasters such as Kahn, in their efforts to show that spin-off effects from the developed world will help to stimulate third world growth, and therefore to justify western policies, also tend to maximise economic growth, in order to minimise the time period necessary to achieve a reasonable standard of living in the poorer countries. (Even at a growth rate of 6%, it would take until 2050 for Asia to reach an average of $2000 per capita, and this, under Kahn's scenarios, would require a developed world growth rate considerably higher). Even the less optimistic

Figure 3.4. PAST U.K. GROSS DOMESTIC PRODUCT AND FORECASTS OF ECONOMIC GROWTH (33)

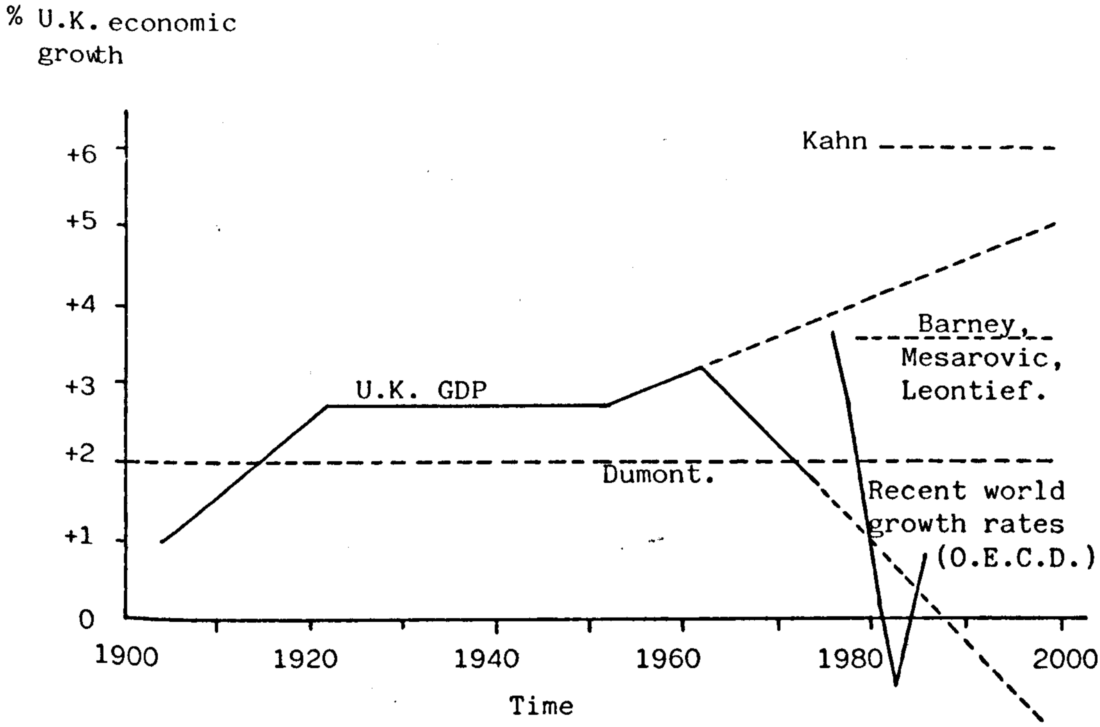
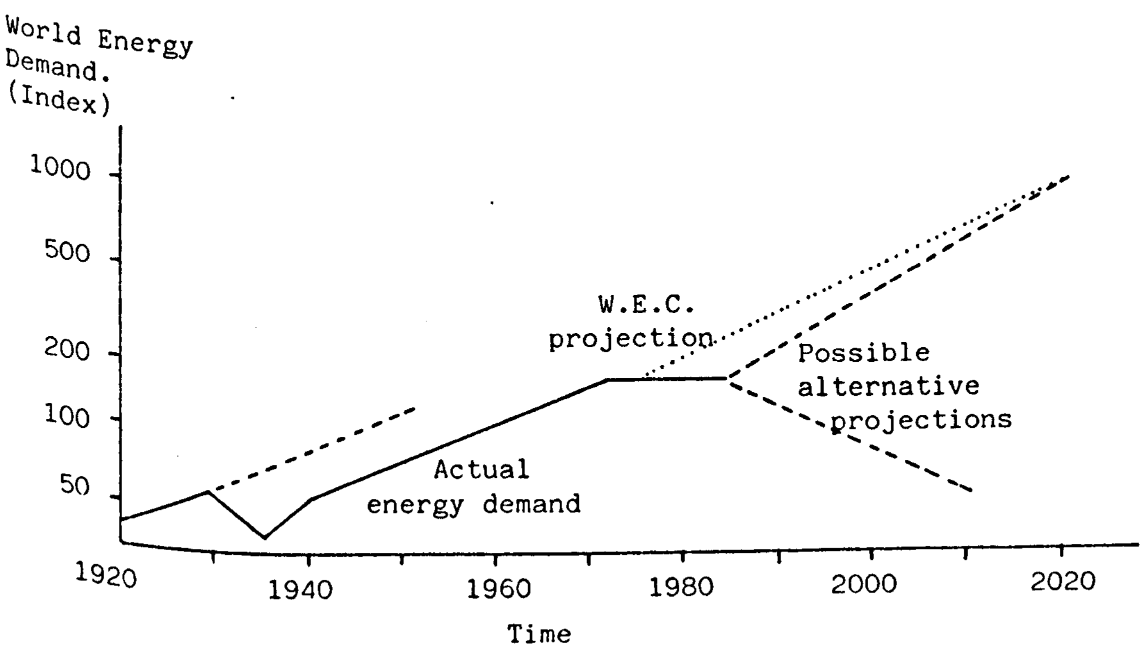


Figure 3.5. WORLD ENERGY DEMAND, AFTER W.E.C. ALTERNATIVE PROJECTIONS (34)



forecasters, those harbingers of doom who predict eventual collapse of the world system, assume quite high levels for economic growth, for in order to show the collapse state being reached as early as possible, and thus to increase people's feeling of imminent danger, it is in their interest to demonstrate a naturally high growth rate, whether it exists or not in reality. Thus in the case of economic growth, estimates must be carefully reviewed before being accepted.

Though perhaps the most extreme case, economic growth forecasting demonstrates a more general tendency amongst forecasters, an eagerness to accelerate the process of history to make a point about it, such as the imminence of the collapse state, the adaptability of the technology,or the policy measures necessary to reach equilibrium.

One further example of the dubious extrapolation of trends is illustrated in Figure 3.5., in which the forecasters take a view of historical trends which seems in reality to be an extrapolation of some 35 years of unusual growth taken at random. Now whilst the conclusions are by no means invalidated, (the exponential growth trend certainly being one possibility), it would be quite possible to argue, on the same evidence, that world energy use follows a cyclical pattern, and a crash is to be expected. In the 5 years since this study was carried out, the forecasters choosing to ignore the levelling off of energy consumption in the mid 1970's has already considerably increased the growth rate needed to achieve their 2020 figure for energy consumption. Any forecaster making a similar extrapolation in 1930, ignoring the demand downturn current at the time, would have arrived at a 1983 energy consumption some 3 times that which is actually the case.

Two lessons arise from this example, the obvious need for caution in choosing models, and the need to consider historical perspectives properly, rather than ignoring any fluctuations brought about by one-off events in a bid to preserve objectivity.

3.1.2.6. Minimising Subjective Bias by Choice of Modellers-

From what has been said so far it would seem that the process of minimising the connections between qualitative and quantitative sectors of the model tends to be a case of choosing on the low growth side of the spectrum, since most forecasters have a tendency towards high growth predictions. Yet where part of the aim is to provide for eventualities, it is not necessary to rigidly follow an objective middle line, but merely to demonstrate the possibility of a certain course. Thus a certain level of ulterior motive is acceptable in a model where one is generating high and low possibilities through scenarios. One should merely try to ensure that the forecasts used are not just trying to make a point, that high forecasts are not just the maximum that can be squeezed out of the available figures, and that low forecasts do not rely on an unrealistic level of control over the system.

Therefore, whilst one might be wholly in agreement with the exhortation to conserve implicit within Leach's modelling, neither the exaggerated high growth 'natural state' model, nor the extreme policy controlled model, can be taken as considered attempts to predict real futures.

The same can be said of both the 'prophet of doom' forecasts, and the forecasts placing particularly high confidence in technical changes.

As has been stated, political factors can be of considerable importance, and it is worth bearing in mind the non-quantitative work of such forecasters as Hall (35), in building an informal framework. Economic indicators are generally adapted from national figures as the baseline data, so in spite of their potential inaccuracies these are perhaps the most suitable sources.

The models which pass these tests of reasonable objectivity, and which try to forecast more or less 'natural state' futures, and are thus worthy of further consideration are in terms of general models; Freeman's review of forecasting methodology, Hall's politico/economic approach, Leontief's U.N. computer model and Barney's recent study for the US President; in terms of global energy forecasts, the W.E.C., W.A.E.S. and National Research Council studies; and for the U.K. national energy forecasts, the D.O.E./Watt committee scenarios.

Due to political bias, attempting to mould the future on paper to forecasters own ends, or the treatment of the world as too simple a single system, the other forecasts mentioned in Table 3.1. are all excluded.

3.1.3. Towards an Energy Model-

3.1.3.1. Energy Models and Energy Within Models-

One of the major problems arising in many of the models considered is a tendency to see major variables as direct indicators of societal successes. Thus, as well as using economic growth, population growth and energy usage as variables in building up a future world picture on a macro scale, forecasters tend to see such factors as sustainable growth as advantageous in themselves. Though at its worst in the simplest global models, those which take a regional view of the world also fail to take account of income differential levels and social change. In this way forecasting methodology reinforces past national scale development attempts and all the failures and inequalities which they have sometimes induced. For instance, Freeman's discussion of the gap of inequality between developed and developing countries, though egalitarian in intent, cannot go further into society than the national scale (36). A sidė effect of this is the general lack of appreciation of the way growth works within countries. Thus a high percentage growth rate can be attributed to the less developed countries, with the precedent of early industrialising Europe, without considering the extent of the exploitative element, drawing on weaker economies to ones own ends.

When dealing with energy models a further short-sightedness arises, a tendency to omit even the macro-scale variables and concentrate only on the rate of energy use and the resource base. Thus models must be chosen which admit to the possibility of fluctuations in energy use which are not wholly dependant on a 1/1 relationship with GNP, such as through technological innovation, pricing structures and conservation effects.

Some energy models amount more or less to general global models in which energy is the unknown quantity to be found, in the same way as others, such as Barney (37), are working towards environmental knowledge. Yet in some of these models, such as the WAES study (38), the non-energy world is viewed too simply, as merely a function of economic growth.

Thus a general global or regional model must be used to make 'state of the world' assumptions, before focussing down on the energy question, and their inputs (whether or not they are variables, in the sense that they are varied from one scenario to the other,) must be assessed to evaluate the worth of the model.

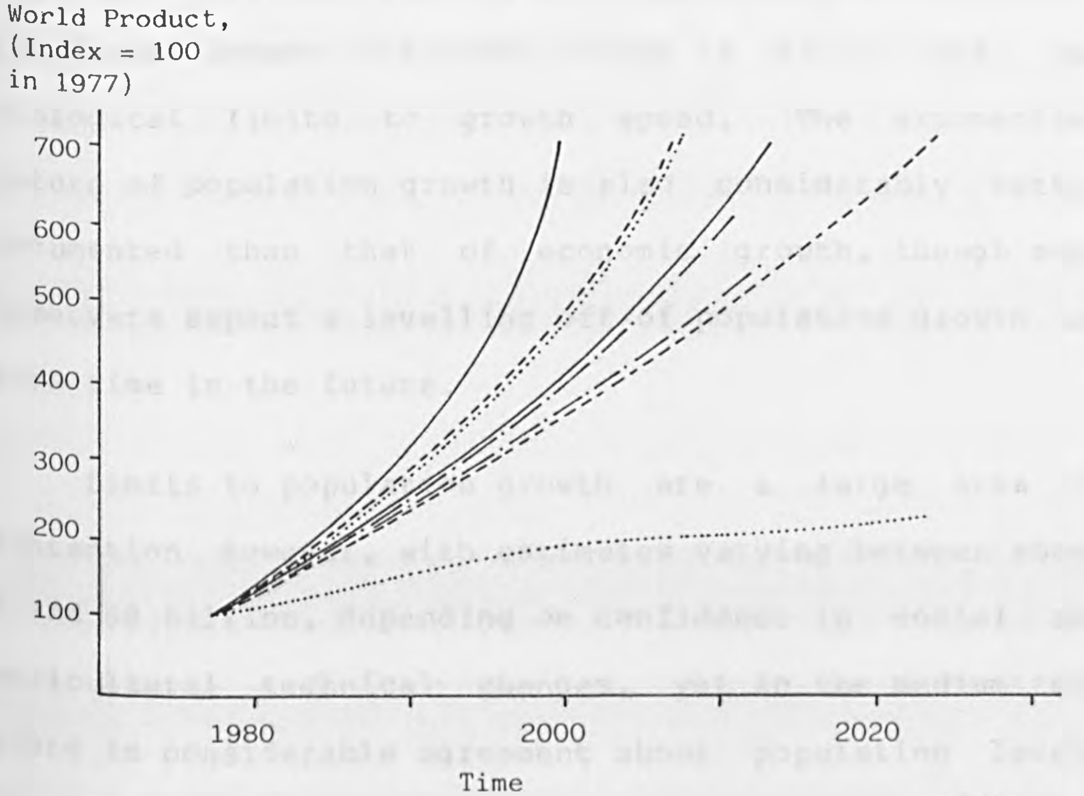
3.1.3.2. The Characteristics of Variables-

Economic growth is a variable used in all of the forecasts, and often, as in the WAES study, used as the sole direct indicator of energy usage, under a direct linear relationship. The tendency to exaggerate growth rates has been considered already, but the general historical picture of the variable is one of an extremely difficult to forecast, wildly fluctuating, but in general growing world and regional economy.

The approximate range of growth rates for the models considered is shown in Figure 3.6.

A wide variety of forecasts exists to the year 2000, and the range widens still further after this date. The only forecast which sees growth as not necessarily being an exponential function is the DOE (40) lowest estimate. This model also approximates, at its highest level, to the maxima envisaged by others, with the exception of Leontief (41), and DOE (40) forecasts therefore seem to provide a useful measure of economic growth.

Figure 3.6. WORLD GROSS NATIONAL PRODUCT PROJECTIONS FOR DIFFERENT MODELS (39)



KEY

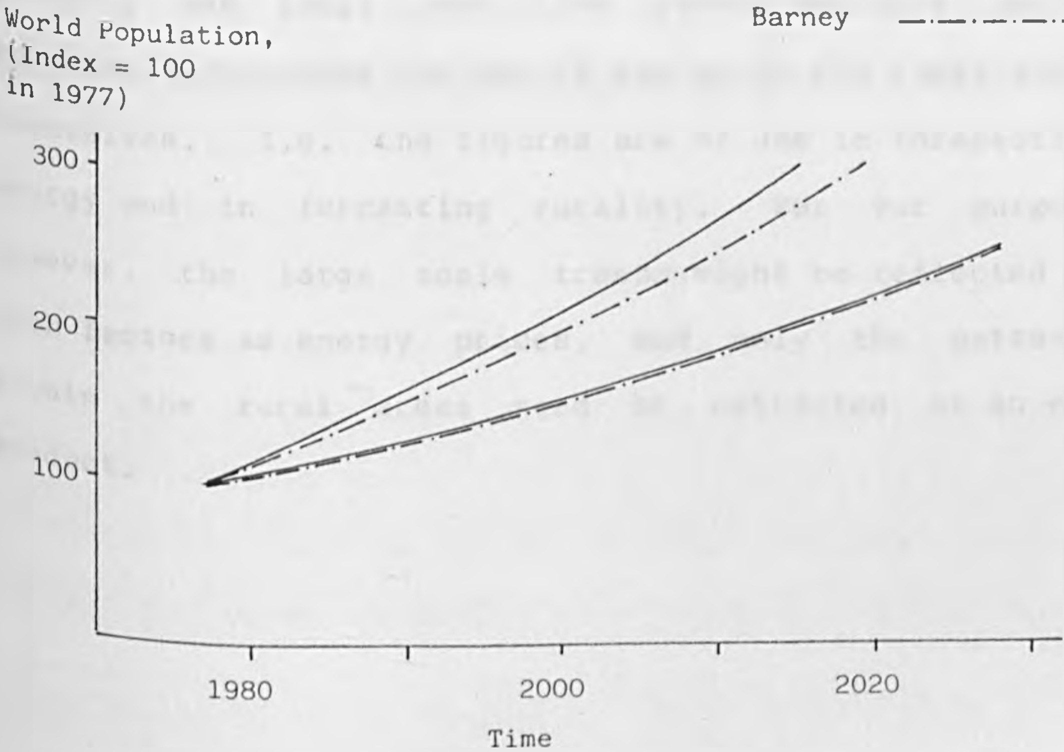
Leontief ————

W.A.E.S. - - - - - -

D.O.E. ....

Barney —·—·—·—

Figure 3.7. POPULATION PROJECTIONS UNDER DIFFERENT MODELS (42)



Population forecasts are about the most certain of all the variables for the next generation or so, due to the future impact of present trends in birth rate, and biological limits to growth speed. The exponential nature of population growth is also considerably better documented than that of economic growth, though most observers expect a levelling off of population growth at some time in the future.

Limits to population growth are a large area of contention however, with estimates varying between about 4 and 50 billion, depending on confidence in social and agricultural technical changes, yet in the medium term there is considerable agreement about population levels into the next century.

Population has a twofold influence on the rural energy model, with worldwide and major regional trends influencing the economy generally and the energy supply pattern, and local population growth and distribution patterns influencing the use of energy in the rural areas themselves. I.e. the figures are of use in forecasting energy and in forcasting rurality. For our purpose however, the large scale trends might be reflected in such factors as energy prices, and only the patterns within the rural areas need be extracted as an end product.

As an existing, rather than a purely future factor, the energy resource base seems at first sight to be readily measurable as a variable, yet in reality it causes more problems than does forecasting future energy usage. Estimates vary as to the length of time for which reserves can support society, from thirty years to infinity, and the length of this period is inextricably linked to technological change.

Although presently recoverable reserves can be more or less agreed upon, these figures are more or less unconnected to the range of forecasts for ultimately recoverable reserves. One can expect a pattern of steadily decreasing reserves, accelerating as demand increases, periodically bolstered up by technical advances brought about by the imminent depletion of current reserves. Figure 3.8. gives a notional picture of the way in which such a process is likely to operate.

The technical optimists would hope to keep presently usable reserves at least constant over time, whilst the pessimists see little scope for technical change. In reality the grounds for pessimism seem to be quite strong. Foley quotes Chauncey Starr (44) as estimating that it takes around 50 years to move from the use of one energy source to another, yet goes on to remark that such a figure is based on the time taken to transfer from wood to coal, and from coal to oil. These changes involved moving to technologically more simple, efficient and flexible sources, rather than to more complex, higher

Figure 3.8. NOTIONAL INTERACTION OF ENERGY RESERVES, TECHNICAL CHANGE AND DEMAND (43)

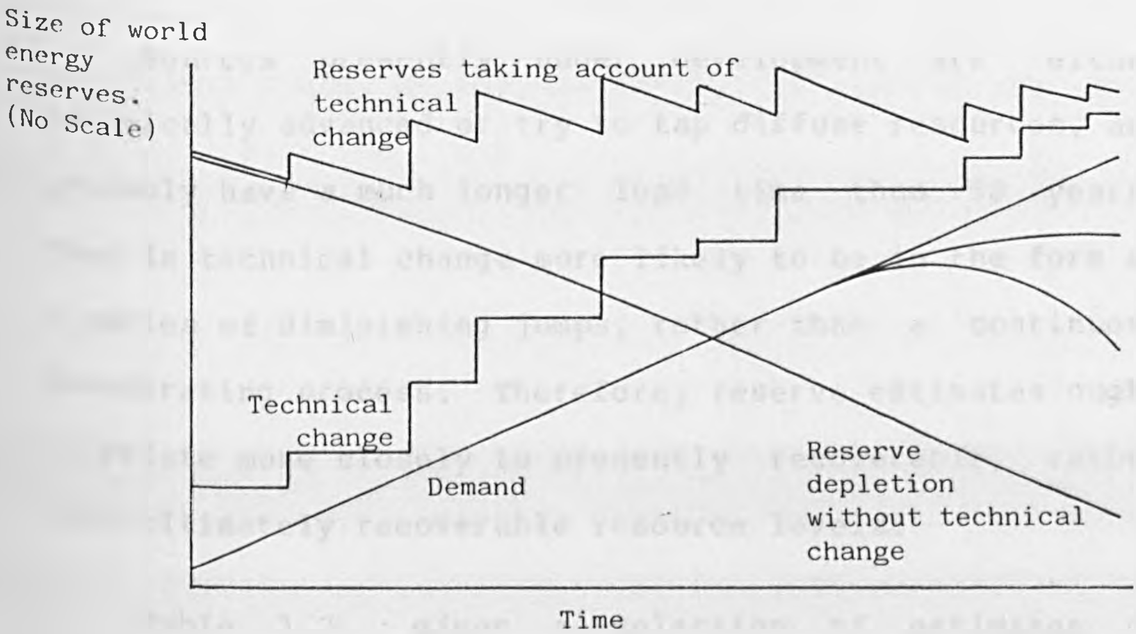
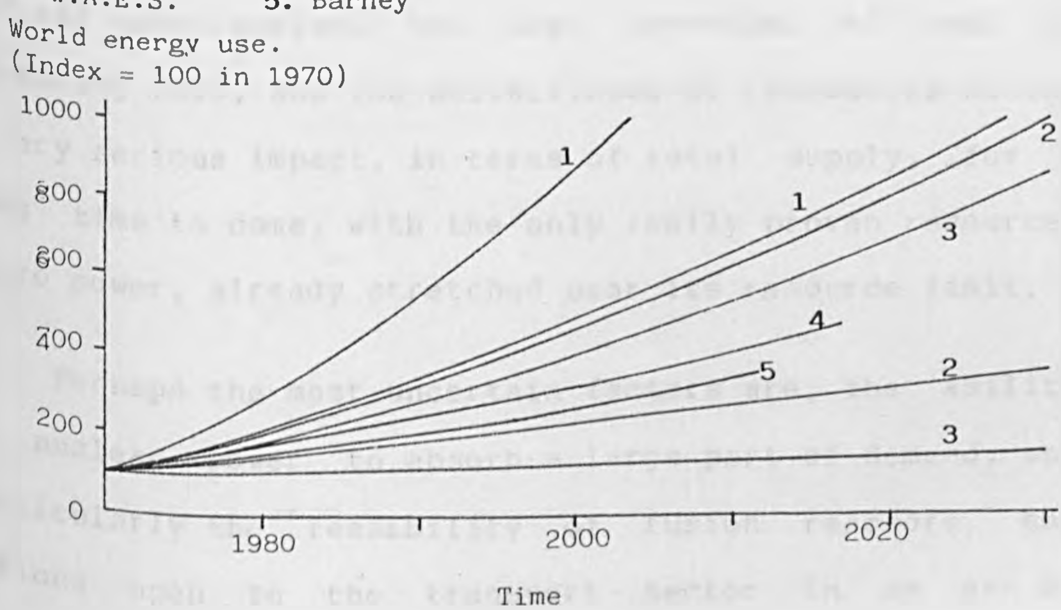


Figure 3.9. PROJECTIONS OF WORLD ENERGY USAGE (49)

KEY

1. W.E.C. 2. Freeman 3. N.R.C.

4. W.A.E.S. 5. Barney



technologies, lessened efficiency and less flexible conversion processes, which is likely to be the case in the next resource transfer.

Sources presently under development are either technically advanced or try to tap diffuse resources, and probably have a much longer lead time than 50 years. Thus is technical change more likely to be in the form of a series of diminishing jumps, rather than a continuous accelerating process. Therefore, reserve estimates ought to relate more closely to presently recoverable, rather than ultimately recoverable resource levels.

Table 3.2. gives a selection of estimates of reserves of different fuel types, and shows the great gap, except perhaps in conventional oil and gas, between presently recoverable and possible reserves. This is particularly the case with renewable sources and nuclear power, where total reserve figures are almost useless, and technical change is the leading factor. Factors which are little disputed however, are the imminent need for oil substitution, the high potential of coal in achieving this, and the unlikelihood of renewables making a very serious impact, in terms of total supply, for a long time to come, with the only really proven resource, hydro power, already stretched near its resource limit.

Perhaps the most uncertain factors are, the ability of nuclear power to absorb a large part of demand, and particularly the feasibility of fusion reactors, the options open to the transport sector in an era of declining oil reserves, and the potential of renewables in solving specific, smaller energy needs, particularly in the rural areas. Any future which sees continually increasing oil prices and a greater reliance on electrical energy at end use level, is likely to come somewhere near the truth.

The non-fuel mineral resource base is a similar complex, if perhaps more measurably finite one. Resources are less directly comparable, in that they each fulfil different functions and are not, by and large, transferable, yet growth depends on their continued availability and the technical innovation needed to tap and use them.

Table 3.2. Estimates of World Fuel Reserves- (45)
(Billion Tonnes Coal Equivalent)

FUEL	AUTHOR	ULTIMATELY RECOVERABLE	PRESENTLY RECOVERABLE
Coal	WAES	1327	737
	Freeman	5600-7700	1000
	WEC	10000	640
Natural Gas	WAES	2100	-
	Freeman	200-1500	200
	WEC	280	-
Oil	WAES	987	-
	Freeman	300-2760	300-375
	WEC	450-600	250-300
Nuclear	WAES	infinite	11-23/annum 2000
	Freeman	infinite	80-100/annum 2000
Oil sand, Shale, Heavy Oil	WAES	230	53
	Freeman	1200	-
	WEC	450	-
Hydro	WAES	2.52/annum by 2000	1.26/annum 1980
	WEC	3.07/annum ultimate	-
Solar	WAES	750000	0.0025/annum

When treating energy use rate as a variable,few people have seriously challenged a more or less 1/1 relationship of energy use to GNP, yet as pointed out by Leach (46), this is by no means a necessary relationship, since technical change in an era of tightening constraints on energy supply might well work in the direction of greater conservation of resources. Most observers see energy use as increasing some two or three times by the end of the century, with the exception of the WEC study (47), which has a maximum increase of 7 times, and the NRC (48) model, which envisages a no growth scenario at the lower end.

In view of the post oil crisis trend towards stabilisation of energy use under economic constraints and policy pressures, bringing energy use into the political spectrum; and seeing no reason for a revision of this situation, in spite of oil price fluctuations, until a replacement for oil is found, low growth scenarios for energy use seem to be the most likely.

There is certainly a large amount of slack which could be taken up in the system in the industrialised countries, conserving energy and allowing economic growth without energy use growth, yet in underdeveloped countries with a low energy use and a high reliance on non-commercial fuel sources already stretched to their limits, development is almost certain to mean greater energy use. Unless these countries are driven to making considerable use of renewable resources at an intermediate technology level by continued high international energy prices, energy use will be pushed up.

However, with 83% of present energy usage in the developed countries, large percentage increases would be needed in Less Developed Countries to change the world picture a great deal.

Thus a look at 'natural state conditions' shows a likely stabilisation in energy use, whilst preferred policy options show the need for a large increase in supply to facilitate third world development. Yet optimism about third world growth rates cannot be very high, and the stabilisation scenario seems much more likely until such a time as capital formation has progressed far enough to allow demand increases. Therefore the most likely scenario seems to be for a two or less times increase in world energy demand by the year 2000, with perhaps an acceleration after this date depending on technical advances. Recent use stabilisation probably now extends this doubling time to around 2008, with a 1.6 times increase of 1980 levels by 2000. The extreme extrapolations of the 'doom-mongers' and the technical optimists seem to have little foundation, whilst political forces, faced with the prospect of cumulative energy uses expanding towards the resource limit, are likely to have a strong impact on use levels.

Turning to policy variables, Hall (50), deals with future scenarios entirely from the standpoint of political divisions, treating the world as a series of power blocks and assessing the possible changes in the political/economic system, then looking deeper into society at the extent and possible future direction of possible change from a planning/social science viewpoint. Although such an approach is a very useful one, few have employed it, perhaps due to the difficulty of generating mathematical projections from such a qualitative starting point. Much of the discussion of policy and structural variables is in terms of desirable options for the creation of a stable world system for the distant future, and is too subject to the manipulation of the forecaster to systematically analyse possible futures.

Other models include simple expressions of individual policies as variables, rather than as an organisational whole. Thus the DOE scenarios include energy price, energy conservation effects, premium on self-sufficiency and extent of nuclear power programme decided upon as variables. This is a useful way of including policy matters, even if they do not amount to a rigorous appraisal of possibilities. It is necessary to consider policy options in the broadest sense before deciding to concentrate on single limited variables, though these variables may be sufficient in the end where they are the major influences on the pattern of energy usage within a country.

Aside from technical change, (a major underlying variable behind resource size and energy use, which has already been discussed,) other possible factors may be included as variables, though they may strictly be seen as existing only as a part of some larger factor. Freeman's conception of the gap of inequality between rich and poor countries is as a variable in itself, and to a large extent, it is the discussion of the operation and likely future extent of this gap which leads to his scenarios. This is an approach which admits sensitivity to an egalitarian ideal, yet it need have no particular relevance as a variable in discussing the more specific subject of energy within a developed world rural context.

Certain forecasters, notably Meadows (51), have considered environmental pollution as a variable on the macro scale, with a simple inverse relationship between pollution levels and such factors as population and economic growth. On the basis of historical trends this seems to have no real basis in fact, takes no account of technical change, and tries to draw direct, tangible conclusions about the effects of pollution from data which, for the most part, is unquantified and relatively intangible. Pollution is a more useful factor to consider as the end point of the model, such as in Barney's Global 2000 study, where conclusions can be drawn about likely pollution levels. Trying to create feedbacks where pollution has a direct effect on other variables is far more difficult to substantiate.

A major variable considered in most studies is the production of food, which may be seen as constrained by inputs, or as a finite resource, yet is in reality a combination of the two. Agriculture is particularly important due to the absolute necessity of food, the scarce nature of the resource, and its importance in the rural areas. It is this variable which places the upper limits on population growth, and tends to vary between direct extrapolation of past production trends, and conservative assessments of land availability and productivity.

Obviously agriculture has wide implications for the use of energy in the rural areas, and is likely to grow in importance in the future, with tightening constraints on food availability and its growing role as a political weapon. One factor which is unclear however, is the balance which is likely to emerge between increasing food production and energy use in agriculture. Whether the future direction will be towards energy self-sufficiency within agricultural systems, or increasing energy inputs and an integrated agricultural/industrial system remains an imponderable. Yet in either case, higher energy costs are likely to lead towards the desirability of some level of energy conservation within agriculture, whether or not production losses can be tolerated as a result.

3.1.3.3. The Scenario Approach-

Various of the forecasters under consideration, notably Freeman, Hall and the DOE (52), have selected a number of scenarios for consideration, without simplifying these into a 'state of the world' scenario and a 'preferred policy scenario. The main problem with this scenario approach lies in selecting views of the world from the extremely high number that can be generated from a relatively small number of variables. Hall achieves this by the assumption of various major 'modes of operation' for a European system, thereby virtually assuming outcomes before operating the model.

virtually assuming outcomes before operating the model. The DOE scenarios, on the other hand, assume a set of 9 'state of the world' variables, and have a constant set of demographic assumptions.

Yet in choosing their 7 scenarios only 3 variables are changed, world economic growth, world energy price and policy options. There is little rigorous methodology in the choice of scenarios, apart from in the low and high growth and trends continued scenarios, which take a useful look at maximum, minimum and median growth conditions.

Freeman, on the other hand, exhausts all the possibilities involved in changing only 2 variables from high to low, economic growth and equality of distribution. His preferred scenario, high growth and equal distribution, is then split into 5 levels of energy use, from a 'USA2000' level to a 'high conservation' level. Such a method of scenario choice perhaps shows greater methodology than the DOE approach, yet the latter is better able to isolate more specific factors and test their application on the whole system.

The NRC study also uses a scenario approach, and integrates 40 sectors of energy usage into a complex matrix, coming up with 4 scenarios based on real energy prices, from a considerable drop to a quadrupling by 2010. Thus a connection between price and demand is established, against which to measure technical and energy use changes. This is also a useful approach, but one which is unable to really predict energy use from the state of the world, merely setting energy use levels and describing how constraints would be carried through in practice.

Thus each approach has its advantages, yet a coalition of them all is not possible without increasing complexity many times over. A more formal adaptation of the advantages of these models can lend a more balanced approach than mechanistic adoption of one of them.

Generally speaking, it is acceptable to choose high, low and central strategies for one major variable to distinguish scenarios, whilst incorporating other factors more informally as necessary within these scenarios.

3.1.4. Formulating a model-

The scenario based systems which remain are widely diverse in nature, initial assumptions, methodology and variables. For an energy model which is applicable to the U.K. situation and is quantitative and specific enough to be useful, the DOE/Watt Committee scenarios provide the best base from which to work. Using this base, comparisons can be made with each of the other models, Hall, Freeman and the NRC, in order to assess the validity of, and adjust, the DOE model.

3.1.4.1. The Political/Organisational Framework; Hall's View of Europe 2000, and the DOE Scenarios-

Hall's selective look at alternative futures for Europe encompasses 5 broad strategies: a more or less trends continued view of a suppressed Europe between 2 power blocks, the emergence of a unified Europe as a third power block, the further split into discrete nations with little or no European unity, a regional view of Europe with peripheral areas breaking away, and the split of eastern Europe from the USSR power block.

The DOE scenarios all assume the trends continued view, with a bias towards a Europe of individual nations, particularly with regard to their self-sufficiency scenario. Such a view is probably not inaccurate in terms of inputs and outputs from the UK system, but in terms of technological innovation and the use of resources it is an over-simplistic one. Thus energy conservation effects, nuclear programme energy prospects from alternative sources and the depletion of coal due to export might all be expected to be higher than in the DOE scenarios.

In terms of rural, and particularly agricultural variables, which are not included by the DOE at all, Hall's regional approach is of considerable interest, since present policy in such matters as the Integrated Development Programme for the Western Isles has already assumed a regional stance. Thus it is possible that an increasingly regional view of a central versus a peripheral Europe might have a strong influence on the future pattern of the rural areas.

3.1.4.2. Growth and Equality Scenarios; Freeman's Approach to Gaps in World Development-

Freeman's scenarios are rather more politically expressed than those of the DOE, and span a wider range. Thus they were able to envisage the recent drop in world fuel prices where others did not. The DOE consideration of energy prices takes the place of a more rigorous study of resource depletion, and presents an adequate alternative for present purposes. Freeman's technique of comparing individual periods of history with future patterns, to achieve historical precedent for trends is a useful one, particularly for the consideration of the future development of third world countries, a factor which, however, is only important here where it exerts an influence on the developed world. DOE variables can be adjusted to take account of these effects by an informal comparison with Freeman's figures.

3.1.4.3. The Sectoral Approach to the Use of Energy; The NRC Scenarios-

The NRC approach allows a lot of separate inputs for separate sectors of the economy, something which the DOE model cannot do. Of particular interest is the agricultural sector, where the energy inputs can be seen to arise from various sectors of the economy. Yet in spite of the usefulness of such figures, the multipliers by which they are calculated are of dubious accuracy and should not be treated as mathematical certainties. The NRC scenarios also consider in more detail the implications of scenarios for the use of energy, and energy conservation in different sectors, thus attempting to trace the effects of technological innovation and diffusion for different scenarios.

With a lower end estimate of 2% GNP increase/annum, the NRC forecasters take a more pessimistic view of growth, and a 2% figure taken as the world, (rather than developed countries) figure, would seem fairly realistic. The probability of low growth is taken account of in the scenarios developed by this research by adjusting the DOE short term figure downwards by 1.5% to reflect recent recession levels.

3.1.4.4. The Choice of Scenarios-

It is appropriate to limit the number of scenarios considered for ease of perception to 3, broadly speaking a low, middle and high growth path, with relevant policy assumptions and other criteria being incorporated through variables, and other DOE scenarios being incorporated informally within these three to reflect a broader range of futures.

Two major variables are added to the DOE list to assist in the prediction of rural area characteristics, agricultural conditions and rural demographic structures. These are variables in the true sense, in that they do not necessarily follow from the other conditions described, but merely reflect a high likelihood. By the adjustment of variables, an amended picture is produced which is adapted from the DOE descriptive rendering of scenarios. Effects which have made themselves known since the initial preparation of the DOE study are also included by adjustment of variables, and presentation is largely non-quantative to give a broad picture of possible future rural conditions. Table3.3. gives a description of these scenarios in terms of the values of the variables involved.

Table 3.3. THREE SCENARIOS TO 2025. (Adapted from D.O.E. forecasts)

(53)

	'0' TRENDS CONTINUED	'1' LOW GROWTH	'6' HIGH GROWTH
U.K. Economic growth.	Low growth to 1990, to 1.5% on recent trends. 1990-2000 3% 2000-2010 2.5% 2010-2025 2%	Self sufficiency, nuclear limit, low growth to 1990, to 1.5% on recent trends. 1.5% 1% 0.5%	High energy cost, Europe of regions, resource ceiling, low growth to 1990 to 3% on recent trends 4% 3.5% 2% low to reflect resource ceiling.
World economic growth	to 1990 2.5% 1990-2000 4% 2000-2010 3.5% 2010-2025 3%	1.5% 2.5% 2% 1.5%	4.5% 5% 5% 3.5%
World energy price	Slow rise to 1990's, then faster	Lower than scenario '0'	Doubling soon, faster than scenario '0'
UK energy price compared to world	As at present	High	As at present
Energy conservation	Present trends slowly continue	High priority for low tech. conservation	Above present, high tech level
Self sufficiency desired	Present policy	Very high	Present UK policy, shift to European self sufficiency
Nuclear plant	Max. 50-60 GW by 2000	Low, 20-25 GW by 22000, little after.	Max. 100GW by 2000
Alternative energy sources	Present trends of development	Low tech. but dev. encouraged by nuclear limits	Present trends, increase after 2000 through resource ceiling, high tech.
Coal production	Present plans	Well above present	Present plans, later more with resource ceiling and export
Rural demographic assumptions	Continued depop. and change in rural urban fringe	Rural workforce rationalised to agricultural, reverse of gentrification	Policies support rural structure, slight growth, tourism, retirement and suburbanisation strong
Agricultural conditions	Emphasis on better areas and energy intensive	Low tech, high employment due to lack of other opportunities, increased ploughing of marginal land	Large farms, high mechanisation with energy efficiency, marginal areas under extensive methods.

3.1.5. The Scenarios Developed for the Study-

3.1.5.1. The 'Trends Continued' View-

The basic divergences from the DOE view in this scenario are; lower initial economic growth, continued depopulation of peripheral areas and the suburbanisation of the rural-urban fringe, and greater emphasis in agriculture on more productive areas, with continued amalgamation of farms and mechanisation.

Economic growth rises by 1990 to 3%, then slowly falls in the U.K., with world growth remaining somewhat higher. Increasing oil shortages, after the present artificial 'gluts', would result in rising prices. With coal production rising to 150 million tonnes then stabilising, existing technologies are sufficient for its extraction and use. Oil retains its importance for a long time to come, due to enhanced extraction rates, whilst all the renewables do not amount to more than 40 million tonnes coal equivalent by the year 2000, mainly made up of wave power and solar heat, with wave power late in making an appearance due to recent government halting of the development programme. Real advances in nuclear power are not achieved, due to the inability to develop fusion power in the foreseeable future.

In terms of conversion, combined heat and power plants are likely to make a considerable impact in areas of steady local demand, with district heating gaining in importance after 2000. These are factors which take rural areas further away from the cheapest and most readily available fuel source, yet the increases in gas prices and resort to synthetic natural gas (SNG) tends to balance out this isolation effect as many urban households return to electricity

A 20 to 25% saving in energy use is achieved by conservation by 2025, particularly through improvements in buildings, the small scale nature of which is of some advantage to the rural areas. With existing transport patterns, technology has reduced average fuel consumption by a further 10% by the turn of the century, though electric vehicles and other fuels are unlikely to have made an impact, and with oil prices rising faster than those for other fuels, rural areas are likely to suffer most. Localised rural impacts are likely to be felt with the reduction in importance of oil and the withdrawal from existing North Sea sites, whilst new coal development will require land, as will shifts to other areas in search of oil.

3.1.5.2. The Low Growth View-

The basic differences between this scenario and the DOE version are; lower economic growth to 1990; higher energy conservation effects due to nuclear limits, but generally operating at a lower technical level; a higher premium on self-sufficiency; a nuclear plant building programme central between 'low growth' and 'limits on nuclear' scenarios; slightly higher use of renewable sources at the present technology level; higher coal production; the reverse of suburbanisation and gentrification, with further reduction of the rural population to a more purely agricultural one; and a low technology, self-sufficient approach to agriculture coming to the fore, with a reversal of present trends towards larger farm sizes.

Though world energy prices do not rise very fast, government measures keep up the price of UK energy to encourage conservation, whilst indigenous resources, particularly coal, are exploited more easily with the reduction of workforce consequent on the recession. Oil extraction extends well into the next century on a self-sufficient basis in spite of the limits on nuclear power.

Combined heat and power, and district heating schemes are encouraged to the detriment of the rural areas, whilst electricity has a low priority against other sources, and the continuation of oil use is of some advantage to the rural resident with a high need for energy for transport. SNG from coal is a high priority, but coal itself regains prominence in the rural areas. Existing energy use patterns broadly continue, but with a high conservation effect and end use efficiencies, and later a strong move to replace hydrocarbons quickly enough to avoid imports.

Renewable sources have a high priority. The effects of changes in the siting of oil based activities in the rural areas would be much slower than for other scenarios. Conservation could save some 30% of all energy use by 2025, with a high conservation level in buildings and a 15-20% reduction in fuel use for transport by 2000, albeit still all based on oil as the fuel source.

A base level of population is reached in the rural areas, as agricultural depopulation is halted or reversed, but support facilities and other rural activities such as tourism decline. Many rural areas keep up food production at a low technical level due to lack of alternative income sources, whilst there is a switch to less energy intensive methods in less isolated rural communities. Rural land requirements increase for coal production and the development of renewables such as wind, which could become a viable 'export' and a source of income and employment in isolated areas. A corresponding decrease in the requirement for land for oil related activities is felt.

3.1.5.3. The High Growth View-

The major differences between the DOE scenario and this version are; lower economic growth to 1990; a faster rise in energy price due to world conditions before 1990; slightly higher conservation effects at a higher technological level; present expectations as to UK self-sufficiency, but a shift to a more European viewpoint; a higher reliance on renewable energy sources due to resource pressure by 2000, and a similar move towards coal supply increases. Successful national and European policies place a higher priority on peripheral rural areas, and these are able to achieve growth as marginal areas come under agricultural production, and immigration of the urban dweller into rural areas near towns continues.

Energy price rise is rapid, and tends to rise very quickly initially, then to fall more in line with scenario increases, before rising again as the resource ceilings are reached before substitutes for oil can properly take over. Coal increases in importance to nearly 200 million tonnes/annum, whilst oil recovery techniques are advanced. Nuclear plant building also increases. The percentage contribution of electricity increases, whilst combined heat and power plants and district heating are introduced in selected areas of favourable economic conditions.

Some high technology, large scale renewable energy developments come into effect, often being sited in rural areas, though with an end use in urban areas, whilst the market for small renewables hardware in rural areas increases.

Nearly all new electric power plants are nuclear, with the increase in coal production largely being put to more low grade end uses. Conservation gains save up to 25% of total energy use, again mainly in buildings and transport, with the introduction of more electric vehicles, particularly in urban areas. Agriculture gains increasing importance as a branch of industry in the better producing areas, whilst marginal areas are of low economic importance, but come under efficient extensive production. Peripheral rural communities are propped up by central influence, and experience slight growth in small industries and such factors as tourism. Land pressure increases for all forms of urban development and for fuel extraction, particularly for coalfields and nuclear power plants.

3.1.6. Scenario Effects on the Rural Areas-

As has been explained earlier, energy scenarios exert a two fold influence on the rural areas, firstly by changes in energy use patterns directly affecting rural energy use, and secondly by indirect effects, with national energy use affecting the structure and function of the rural areas as a whole. Table 3.4. interprets the three scenarios, chosen basically in terms of economic growth variables, but with a large amount of variation in other variables, and describes the effects on rural communities, economies and energy use which they appear to generate.

Table 3.4. CHANGES IN RURAL CHARACTERISTICS IMPLIED BY THE SCENARIOS. (54)

CHARACTERISTIC	TRENDS CONTINUED	LOW GROWTH	HIGH GROWTH
GENERAL			
Policy and public priority on rural areas	*Low, increasingly leisure based, with periphery depopulating, low priority for marginal areas as economic units.*	*High, due to decline of industry, lower pop. but enforced economic feasibility of allareas but the most outlying*	*High, policy response, low economic importance of the periphery, but high leisure and conservation pressure. Relatively high pop.*
Agricultural form	Emphasis on better areas, decline of the periphery, increasing farm size and mechanisation	High priority for periphery and for agriculture in general, but low tech. solutions and a halt to increasing farm sizes, lower energy use, high employment	Marginal farming areas supported uneconomically, Extensive cultivation, larger farms and greater mechanisation, but high emphasis on energy conservation
Demographic form	Continued depop. and replacement by tourism and suburbanisation	Consolidation of the local community and the withdrawal of the middle classes, poor conditions, but a basic level agricultural workforcein more isolated conditions.	Successful policy to keep population in the rural areas, improved infrastructure and continuing in-migration for retirement etc.
Settlement form	Minor spread in villages near cities, periphery collapses, eventual withdrawal to larger villages	Cease of urban spread and a move to small villages in the periphery with low communication level and low infrastructure	Growth, outlying and suburban, some emphasis on rural employment in light industries creates new centres, support of smaller settlements
Rural industrial form	Decline of service industries in rural areas, some energy based development, some high tech, growing near cities.	Little industry in countryside, all support facilities withdraw to towns	Spread of small industry in rural areas, crafts in the periphery, high value/weight high tech around cities. Oil, coal, nuclear, renewables spread in rural areas
Land pressure, general	Continuing pressure on rural-urban land	Low land pressure	Pressure on marginal land for agriculture, rural-urban development, high environmental pressure, small settlements expand
Land pressure, energy related	Coal, nuclear and oil pressure, environmental problems of old oil development	Some pressure for renewables for rural generation etc. coal field pressure, low pressure for new oil, some biofuels.	High pressure for new oil, coal and nuclear. Environmental problems of old oil devs. after 2000 pressure for renewables

Advantages over urban areas compared to present	*Some building conservation effects*	*Continued oil use for transport, high cons. effects for buildings and transport, decline in urban standards allow rural areas to become economic, conservation in agriculture.*	*Higher % electricity use, later influence of renewables favours rural areas, agric. approaches an industrial form, larger rural communities have more economies of scale*
Disadvantages compared to urban areas at present	*Low importance of renewables in rural areas. CHP and district heating takes urban areas ahead. Low transport conservation effects*	*CHP and district heat in urban areas not available rurally. Low % electricity, high priority on SNG, low economies of scale, increase in real transport prices and in rural transport needs.*	*High oil price for transport, some CHP and district heat. Electric vehicles have high urban bias for shorter distances*
Agricultural sector energy use	Increasing mechanisation on present technology, low emphasis on outlying regions and on conservation	Energy input decreases without much more energy efficiency, low tech solutions	High conservation but high tech. solutions and increased mechanisation, even in the periphery
Domestic sector energy use	Medium conservation effect with continuing retrofit system at low-tech level, some technical advances	High emphasis on retrofit, low tech solutions, little opportunity to combine with other sectors. High emphasis on small-scale self sufficiency through renewables	Opportunity for combination of conservation with other sectors, high tech., level not so applicable rurally
Transportation sector energy use	Continued reliance on private cars and running down of public transport, compensated for by greater efficiencies, sharing etc.	Decreased importance of private cars, worse public transport, but lower energy use or sharing schemes	Private car emphasis reduced only where an alternative available, increased public transport at high efficiencies
Rural industrial sector	Few rural industries, low efficiency and present energy source	Few rural industries, low tech. with efficient energy use	Low energy industries and crafts at high efficiency, high electricity use
Technological level	Median technology in all sectors	Low tech. in all sectors, emphasis in agric. on energy input/output ratios	High tech. in all sectors, domestic sector shows least technical change
Main shifts in energy	Oil continues, coal main replacement, nuclear secondary	Oil continues, coal a cheap replacement, renewables in rural areas, on small scale, self sufficient basis	Oil loses prominence, nuclear main replacement, plus coal, large scale renewables in rural areas serve the towns

The result is an assessment of rural future possibilities, in which the high growth scenario as presented, assuming a high emphasis on supporting the periphery with central funding, is the only one likely to iron out many of the present problems of the rural areas. On the other hand, the low growth scenario, albeit harsh on rural population levels, is the only one likely to preserve a locally employed community without outside support. Thus the low growth mode, whilst unable to improve absolute conditions in rural areas, does shift the rural-urban bias in favour of the former, and allows a real economic self-sufficiency for rural communities. In higher growth situations the potential for rural areas as contributors to society is low, except where a part of that high growth is ploughed back into them.

Certain features are common to all scenarios, such as the probability of the increasing importance of large scale conservation effects operating on energy use in such fields as combined heat and power plants and district heating schemes, both of which legislate against rural areas. Another common feature is the increasing importance of agriculture in some form, tending to support the rural areas in general, albeit that in some cases the advantage is not felt in the remoter, more marginal areas. Also common throughout the scenarios is the relatively low confidence in the ability of renewable resources to go far towards meeting national needs, though of course their application to individual, small-scale rural needs can be of great importance.

3.1.7. Moving Towards a Single Scenario for Application in a Delphi Survey-

Any study of futures has tended to conclude that the range of possibilities is limitless, and that it has made many arbitrary decisions as to its direction in the building up of pictures of the future. Scenarios cannot hope to be comprehensive, and neither can the model itself, whilst many functions are omitted. The present non-mathematical approach to adjusting an existing set of scenarios cannot claim to be scientifically objective, but it hopefully gives a reasonably readily absorbed picture of the range of possibilities for rural areas and their energy use.

The task in designing the Delphi survey scenario (section 3.2), was to turn these multi-directional futures into a uni-directional one for comment by panelists. This involved adaptation of the low growth scenario, and the addition of more detail than has previously been the case, some of which was not necessarily consistent, but designed to provoke responses from panelists. Thus the first round of the Delphi survey contained various elements of the other two scenarios listed above, with the conferencing process being relied on to sort the scenario into a single most likely future.

3.2. The Evolution of a 'Delphi Methodology-

3.2.1. Introduction-

It was proposed that 'grass-roots' level research into the potential for energy integration between agriculture and the rural domestic sector, should be supplemented and further developed by a parallel 'Delphi' type methodology, taking advantage of the expertise and opinions of a range of 'experts' in the different fields which touch on aspects of the subject. It is the function of the following section to explore the characteristics of Delphi, and to synthesise a specific methodology for use in generating workable, consensus based futures within the framework of the project.

Descriptive and philosophical discussion on the nature of Delphi is followed by an exploration of the available methodology, together wih a clear statement of the hypothesis which it is hoped to be able to test.

3.2.2. 'Delphi' in Brief-

Despite the mystique suggested by the 'oracle' reference in the name 'the Delphi Method', the technique is in essence no more than a series of methodologies for 'long-range conferencing', utilizing the opinions of 'experts' and others in a more or less structured format, usually to achieve a consensus from an initially wide range of views on a given subject.

Perhaps partly due to the implications of the name, and partly due to original and subsequent predominant uses, Delphi has become associated with forecasting, more particularly with technological forecasting, but although of course there must be an element of the forecast in any social science research, this element is by no means a necessary function or limitation of the method.

The origins of Delphi lie in the perhaps rather sinister area of the application of ....

> ..."Expert opinion to the selection, from the point of view of a Soviet strategic planner, of an optimal U.S. industrial target system, and to the estimation of the number of 'A-bombs required to reduce the munitions output by a prescribed amount".

...which was the avowed intention of the first example of the method, 'Project Delphi', by the Rand Corporation in the 1950's. (55)

Since this rather grandiose starting point, after a suitable lapse of time between the study and any public access to such sensitive material, the Delphi method has been expanded and applied in many fields, more latterly in the social sciences, though generally in attempts to find answers to quite specific problems which may not fit neatly within an individual specialism. A notable gap in the literature, though an understandable one in view of the vast complexity involved, is any attempt to employ Delphi in the production or refinement of generalised future models of the type which have proliferated since it's inception, in spite of practitioners' identification of the method both with forecasting and with the ability to make wide generalisations (56).

Delphi is basically no more than a method for structuring a group communication process, so that it is effective in allowing a group of individuals, as a whole, to deal with a complex problem. A further characteristic, which distinguishes the method from a simple conference or series of correspondences, is the existence of a monitor, or monitor group, whose function ought to be rather more than that of recording, or 'minute taking', but should structure and interpret the communication process to produce, with reasonable confidence levels, results to a specific inquiry

Two basic modes can be said to exist in 'Delphi' both for methodology and intent. Methodology may be either conventional, a 'pencil and paper' exercise, usually carried out by post over a considerable amount of time, or real time, a less fully developed method in which the group communication process is almost conversational, in as much as interactions are short and occur rapidly, yet in which a highly structured element is introduced in the form of a computer programme for the immediate aggregation and processing of individual rounds of the survey for resubmission to the participants. Intent is likely to differ in as much as an inquiry might either be looking for an eventual consensus view on a problem, or might serve the function of a kind of pilot probe into the number of diverging views and ideas available,(as well as the number of differing types of concern under a particular heading), though in reality the former type must also pass through this stage, and is merely a more complete version than the latter.

The nature of Delphi is more than just a one-off communication, a questionnaire which elicits existing opinion, it is specifically an interaction process, requiring of necessity more than one round of views and opinions, together with feed-back after each full round, and the belief that it will be beneficial to employ the opinions of more than just a very few, perhaps like-minded individuals, in a group which could not easily or adequately sit around a table in discussion (57).

It is suggested that the choice of 'Delphi' over other methods of inquiry in any particular case, relies on the problem under research having one or more of the following characteristics....

> 1. Precise analytical techniques do not exist, so that subjective judgements on a collecive basis may be useful.
>
> 2. Individuals needed for such a broad complex problem have no great history of communication, and come from diverse backgrounds and various specialisms.
>
> 3. More individuals are needed than can cooperate properly in a face to face exchange.
>
> 4. Time and cost makes group meeting infeasible.

5. Face to face meetings might be increased in efficiency by supplemental group communication processes.

6. Disagreements amongst individuals are very severe or politically sensitive, so that a high degree of anonymity is required.

7. Validity of results can be increased by avoiding domination by the strongest personalities or the largest groups. (58)

Thus it can be seen that, far from representing a single specific technique aimed at a specific goal, Delphi is merely a broad type of interactive process, and as such there are few rules to be rigidly adhered to, or laid down procedures which must be followed, but the individual problem demands the careful formulation of an individual, appropriate methodology to deal with it, once the decision to use Delphi has been taken.

3.2.3. A Philosophical Basis for Delphi Within the Social Sciences-

It must be said that at first sight Delphi fits rather uncomfortably beside both traditional views of scientific reasoning, and moral/ethical bases for the social sciences of the latter half of the 20th century. However, a deeper investigation shows both hypothetical objectors to be in the wrong, as long as Delphi subjects and methodologies are carefully formulated.

Using the opinions of 'experts' as an alternative to scientific inquiry seems like rather a backward step, perhaps reverting to a time before the advent of social science, or in a more modern context, foreboding the takeover of many functions in society by the technocrat. However, if Delphi is seen as merely being an alternative to a conference, that is, an organised gathering ground for pieces of other people's scientific inquiry, and an adjunct to, rather than a replacement for, empirical research, then it can be justified in the same way as any other normal communication process.

Nevertheless, it is still necessary to ensure that the subject of the Delphi is a valid one, and particularly that it is not open to more direct research, or the 'elitist' criticism holds good. For instance, it would be counter productive to inquire in a Delphi, (except perhaps for reasons of studying the biasses and illusions of the panelists themselves), as to what experts believe to be the opinions of the populace, when tried and tested techniques for the direct assessment of such data already exist. Suffice it to say that the term 'expert', say on rural matters, might well include the small farmer, the estate worker, and perhaps even the occasional tourist. The criticism of elitism is a potentially serious one, and one which must be carefully guarded against.

Delphi is a method of inquiry likely to be mistrusted by empirical scientific researchers, for within the actual method itself there is little or no actual empirical content; neither can statistical inferences be drawn about the data collected, (though statistical projections can be modified using the results of the Delphi), for there is no randomness in the choice of panel members, and no particular group in society that they can be said to represent, so that opinions cannot be averaged, and the process remains merely an ideas forum unless consensus can be reached. Yet even the consensus situation is of dubious scientific validity, for the mere fact of agreement between parties initially of several different persuasions (though not all possible ones), does not constitute the classical conception of the scientific testing of an idea. Even were all possible points of view to be sampled, general agreement may bring one no nearer to the truth than arbitrarily choosing one of several viewpoints.

Yet the philosophical basis for a strictly empirical science which finds (some might say 'creates'), absolute truths through flawless and incontrovertible testing procedures is at best shaky. Most inquiry systems must recognise lack of certainty and the shifting nature of a truth which is subject to refinement, and sometimes complete changes of direction. Thus Popper's development of Critical Rationalism postulates that....

> "....Knowledge evolves through a sequence of conjectures and refutations, of tentative solutions to problems, checked by searching and uncompromising tests....in the eyes of Critical Rationalism our knowledge is not securely founded, being freely aired rather than staidly grounded....What matters....is whether the conjectures under debate are right, not whether there are reasons to suppose that they are. If

> a conjecture weathers all the objections one can raise against it, then there is no reason to suppose that it is not right. Nor....is there any reason not to suppose that it is right....And being right....is quite good enough....Rarely, of course, do we know that we are right, but we do'nt need to know it if we are. (59)

Against a background such as this, the suggested objections to Delphi on the part of the empirical scientist become inconsequential. Delphi takes an initial view of the 'truth' of a situation from a monitor group, assimilates as many alternative views of truth as can reasonably be gathered, and invites participants to throw all the criticisms they can muster against the monitors' and each other's views of truth. Those views which survive such a bombardment and which are eventually agreed upon may, as long as the methodology itself stands up to criticism, reasonably be considered to represent 'truth', until some other inquiry, by a similar approach of new ideas standing up to criticism, refutes them. Other inquiry systems in the annals of philosophical thought can also be used to justify research of the type that is implicit in a Delphi survey. (60)

Under the philosophy of Critical Rationalism, truth becomes a creation rather than a discovery, and the creative structured discussion inherrent in a Delphi a rational means towards creating it.

In terms of intent, Delphi methodology may be aimed at achieving any of the following....

Ensuring that all possible options are

considered.
Estimating the impact of a particular option.
Estimating the acceptability of an option. (61)

...though in reality a well constructed Delphi, with a wide enough panel selection, might hope to achieve all of these results in the order represented here.

So the philosophical justification for the method is clear enough, and it remains to be seen how methodology can be adapted to the circumstances of the present project to create a valid research procedure.

3.2.4. The Practical Nature of Delphi-

As has already been mentioned, the name 'Delphi' presupposes an oracle-like method of forecasting, which the method certainly is not. Conversely, since Delphi is not a single, predictive method, but merely a set of types of information gathering procedure, criticisms that it is "no good at predicting the future" are invalid, in as much as each individual survey is as good or as bad as the design of its methodology allows.

Much of the available experience in Delphi to date has occurred in a business setting, and has been concerned either with intra or inter-organisational study of trends and desirable courses of action. For instance Enzer (61), describes a Delphi survey designed to predict specific advances in plastics technology over a 15 year period. Others have concentrated down further, and used Delphi as a means of criticising and amending individual company policy and organisation, without the need to expose individual participants to the fear of the wrath of their superiors.

Aside from business uses, the other main area of Delphi utilisation has been in policy formulation. The inception of this kind of Delphi in 1969 (63), introduced several changes in the traditional form. In most policy Delphis, it no longer becomes possible to select a homogenous group of 'experts' who have a knowledge of the whole field of inquiry. On the contrary, though the expert may be able to contribute some quantifiable estimation of a particular effect, no-one is expert in the whole field, and all are merely advocates of a particular viewpoint.

Consensus cannot arise so easily given such a form, and the complexity of issues to be discussed, but if it arises at all it does so out of a deliberately wide range of strongly opposing views. Also there can be no sense in which a decision maker has the panel formulating his decision for him, they merely put forward their eventual view or views for consideration. Given such a purpose, consensus may not be a primary aim, and in some cases may even be actively discouraged by the monitor, in order to maximise the number of opposing views arising.

Many Delphis of this type have dealt with specific proposals and the issues arising from them, such as inner city ring-road schemes. Others have concentrated on wider, but still geographically located issues, such as transportation plans for a major city, or the likely future pollution effects around the shores of the Great Lakes. (64) In a wider context still, studies such as the U.S. National Drug Abuse Policy Delphi take the method into a more amorphous sphere where the choice of 'experts' is still wider, and the issues under discussion highly varied.

Perhaps the widest concept to be subjected to a Delphi to date is the idea of forecasting, from the whole range of issues of concern to society, those issues which will be of most public concern for the medium and long-term future. For instance, again in the U.S., a Delphi entitled "An Experimental Public Affairs Forecast" was carried out in the early '70s, involving a panel of some 70 people from many areas of public affairs withthe objective of identifying an ordered list of national priorities and areas of major concern for the 1980's. Though admirable in its broad conception and attempt to tackle issues which are difficult to forecast, and indeed even difficult to identify, such an exercise obviously invites criticism as to the validity of the method, since the issues being forecast are merely "what ordinary people will think about", and the abandonment of any attempt to assess this data directly, perhaps by surveying the young and extrapolating to a future date, opens up the study to the criticism of 'elitism' outlined above. Therefore the present research attempts to restrict matters to those that cannot easily be elicited directly from people at random. Information which can be thus aquired is the subject of the local surveys.

Although such studies give an idea of the range, and potential broadness, of the issues which may be discussed under a Delphi survey, it remains notable that issues tend to be formulated in relatively narrow ways, and that some restrictions are imposed on panelists including in their analysis the whole range of human activity which might be encompassed in a generalised future model. It is this problem of how far to restrict discussion, and how many imponderables can be introduced into a workable model, that creates the major issue for formulating a specific hypothesis and methodology for the present project. Imbuing a complex problem with a high degree of 'straighforwardness' is both a difficult and desirable skill and, if taken too far, a potential danger in conducting a Delphi survey.

In a policy Delphi which is concerned with forecasting, it is important to recognise that even a collection of experts drawn from every aspect of a particular problem does not constitute expertise on the problem as an entity, that is, the whole tends to be greater than and different to the sum of the parts. In addition, problems may be encountered through different people, irrespective of differences of opinion on matters of policy and their own specialism, viewing the future in different ways. It is certainly true that all individuals discount importance to a certain extent wih time; thus no one conceives a problem as being of the same magnitude if it is forseen as occurring in 100 years time, compared to problems which are encountered today. The difficulty lies in identifying the individual's discount rate per annum of the future importance of certain problems.

Thus it is suggested that such an effect can be equalised by a process of 'projecting panelists into the future', rather than asking them to forecast. That is, setting up an imaginary present, to be temporarily inhabited by participants, thus creating a perhaps slightly fanciful situation inwhich individuals can be expected to react by freeing their minds, to a certain extent, from present, pedantic concerns, to create a larger and more imaginative structure of ideas for the future.

This again emphasises the creative, as opposed to the purely analytical, nature of the most productive Delphis, and suggests routes towards a methodology to be applied in the context of the present project.

3.2.5. The Justification for a Delphi Methodology in Studying Rural Energy Futures-

Section 3.2.3 used the concept of critical rationalism to justify the Delphi methodology per se, and the same arguments apply to the use of the technique in the present project. More specifically however, it is the basic interdisciplinary nature of the project which provides the rationale for the use of a Delphi survey.

The essential nature of this project is integrative, between both different sectors of society and different functions within these sectors, it having the specific function of cutting across the boundaries of individual specialisms, to the end of perceiving a total picture. Covering all the kinds of information needed requires the amalgamation of more specialists than normally communicate adequately together, and more individuals than can productively discuss an issue by more informal means.

Therefore Delphi, as described above, is plainly a good method of studying future integration potential in rural energy; whether it is the best or the only method is for discussion here.

Most of the data involved concerning the present situation, such as present energy use and attitudinal data, is available through direct survey in a relatively hard form. Data on the capabilities, for now and in the future, of some of the technology available, such as renewables hardware, may be available in the literature, but some form of communication with specialists may be the most useful method of acquiring answers to certain specific enquiries as to the applicability of hardware to specific situations, though Delphi would not be the only means of acquiring such information.

It is in the realm of predicting the future, first globally and nationally, then within this sphere rurally, and within the rural future predicting the future of energy use and the potential for inter-sectoral integration, that Delphi comes into its own.

Hard data is obviously not available on the future, and the welter of available forecasts are both often contradictory and not specifically applied to the problem at hand. An alternative to Delphi in drawing together the various strands of knowledge needed, might be the subjective adjustment of forecasts in the literature to the rural energy situation, (as has indeed been carried out in section 3.1. as a preliminary to the Delphi process), coupled to literature study, data collection and individual enquiry as to the present rural situation. But in this context the use of a Delphi methodology has the function of introducing method, and a degree of scientific analysis, (under the framework suggested by critical rationalism), which would be absent in a purely subjective literature survey. Aside from the direct building of an alternative model, which would have no particular prospect of being any more accurate than previous models, and would still require consultation with experts on certain aspects, Delphi seems to provide one of the only opportunities for drawing together hard data and subjective judgement in some meaningful way for carrying out the project.

Not only is Delphi a useful method in terms of the optimum way of achieving specified aims, but the very fact that it has not been used in this context before makes it of value, both in terms of producing new perspectives on the field, and as a spin-off effect, possibly providing panelists themselves with useful new perspectives and contacts in different specialisms, and allowing them to participate in an interdisciplinary communication which takes them outside of the restrictions of their own field.

Where changes are likely to occur, not just as economic trends, but as basic alterations in forms of society and ways of thinking, then Delphi becomes a less pedantic and potentially more sensitive method than subjective model construction, in as much as the range of people concerned ought to be able to create a wide range of alternatives for consideration, based on changes in most aspects of society.

Thus as an adjunct to and development of the hard data collection and literature review side of the project, Delphi provides a useful means of achieving a creative and scientifically valid integration, with the aim of forecasting elements of rural energy which rely on many other factors in society for their determination.

3.2.6. The Delphi Methodology Used in the Research-

3.2.6.1. Introduction-

Although there are few hard and fast rules as to Delphi methodology and format, various suggestions can be made as to the correct way of going about design. The essentially multi-stage nature of the process necessitates careful processing and structured interaction beween participants, and methods for achieving this are discussed below under the headings; panel choice, approach and questionnaire design, organising interaction, interpretation, and communication of results.

3.2.6.2. Panel Choice-

The construction of a panel can take various forms. In such areas as technological forecasting it may consist merely in the identification of all available experts within a specialism, whereas options are more varied in the wider, policy type Delphi. Interdisciplinary panels might be chosen to give any weighting to experts in particular categories, forming a single panel or, as suggested by Ludlow (65), several panels receiving different information and being asked to contribute in different ways, depending on their specialism, (a method which, though perhaps of practical value, rather goes against the interactive philosophy of the process).

Scheele (66), suggests that three types of panelist exist, the stakeholders, who are likely to be directly affected by policy decision, the experts, who have experience and knowledge in specific parts of the field, and the facilitators, who have skills in organising, clarifying and suggesting thought, as well as perhaps individuals who might offer a different and perhaps contentious global overview. The balance of the panel between these various groups ought to vary, suggests Scheele, depending on the nature of the problem (although interdisciplinary problems are likely to require a preponderance of experts, due to the number of specialisms involved). For instance, where the opinions are clear but the direction of action is not, then stakeholders might predominate, where it is clear who must act but not how, experts predominate, whilst facilitators might increase with the problem's complexity. However, the balance of the panel ought not to be of ultimate importance, since statistical procedures have been shown not to work in the Delphi context, and minority opinion may be just as valid as that of the majority.

Panels might be chosen by an individual, a monitor group, or by a small panel created for this purpose, but however they are selected, the important thing is that the option chosen should be the correct one for obtaining the type of result which is required, and generating the most productive discussion.

It is probably advisable to keep anonymity intact as regards individual responses, to avoid certain members of the panel predominating, though of course it must be obvious to the monitor who is responsible for certain comments and ideas. 'One dimensionality' is suggested by Scheele as a problem of too narrow a panel, though it is also likely that certain panelists will not behave as expected, perhaps not aligning themselves with their allotted group, and thinking from a different perspective than expected. This has its advantages from the point of view of creating more ideas,but can also be a problem, in as much as a panelist chosen, say, for expertise in rural sociology, who chooses to expound on the state of renewables technology, though his ideas may be interesting, his status as an expert is limited in this case, and the exercise becomes a sort of public opinion poll of academics.

Obviously it is necessary to avoid all of the above stereotypic forms of interaction, and to select panelists carefully to ensure that the desired type of communication is achieved, and discussion, whatever its end result, at least provides a balance in dealing with issues which are thought to be appropriate.

3.2.6.3. Approach and Questionnaire Design-

It is important in designing the survey, and particularly the initial round, not only to be able to generate some response from panelists, (which is a considerable problem, since no-one likes 'questionnaires', an image to be avoided in survey design, and academics and other 'experts', perhaps more than other categories of people, are likely to ignore such correspondence as they do not feel to be worthwhile), but also to ensure a quality response of the type required. There is little of a general nature to be said of questionnaire design, except the obvious statement that it should not appear too much like a questionnaire, that participants should not feel either patronised or bored, and that material should make it clear, without appearing to dictate, what kind of response is desired. Although the anonymity of panelists and their comments should be preserved, an initial list of participants, if reasonably impressive, might persuade individuals of the value of the exercise.

In terms of content, Scheele suggests either putting forward a 'reality construct' based on specifics, to focus the mind onto a real-life situation and stimulate thought on it, then later generalising from the results of the specific, yet imaginary situation; or creating highly hypothetical and 'fanciful' situations to force panelists to think differently or laterally, and allow those of very different persuasions about the real world to begin to collaborate. In either case the discussion works from the specific case to greater generalisations, and whilst this is not the only option, it would appear to contain certain considerable advantages. Although this approach brings with it the difficulty of extracting generalisable propositions from specific instances, it is probably better than trying to indulge in 'abstract speculation' and hoping to generate useful results.

Whilst problem-solving directly is better done at the specific level, there can be no harm in exploring the extent of ideas by creating generalisations of the 'what if' nature, such as....

> "What other circumstances do you know or can you imagine might prevail, and for each of these would the propositions (given or created) be valid". (67)

This might be asked of a particular situation to ascertain its ability to be generalised, to try and make panelists think more widely, and to criticise specific propositions.

The design of the survey ought to be concerned with exploring the issues at stake under the following broad and flexible heads....

> ....1.Formulating issues, which ones should be under consideration and how should they be stated.

2. Exposing options, what are the real policy options available?

3. Finding out panelists initial position on the issues, which ones do everybody agree on, which are unimportant, and which generate the most disagreement?

4. Exploring and obtaining the reasons for disagreement, what are the underlying assumptions being used by panelists?

5. Evaluating the underlying reasons, how good are each of the arguments?

6. Re-evaluating the options based on the views of the underlying 'evidence', and its relevance to each position taken. (68)

Under such a framework 5 or 6 rounds could easily be generated, but in practice this can be reduced to, say, three, by devoting some time to formulating the issues before the first round, suggesting initial options whilst allowing panelists to add to the list, and asking both for positions and underlying assumptions in the first round.

Thus, although no hard and fast rules have been laid down, some of the dangers, and advisable courses of action, in designing a Delphi survey, become apparent, and the design of a specific methodology can proceed from this point.

3.2.6.4. Organising Interaction-

In a situation where individuals are being asked to participate in a survey due to their supposed unique expertise, there is an obvious danger of alienation if any tendency is shown to ignore the responses of a panelist, however trite they may be. Conversely, the inclusion in feedback of too many irrelevant responses can make the process quite meaningless through the loss of central lines of thought and the cluttering up of the survey with trivia. Treading the line between these two extremes provides a psychological difficulty to add to the difficulties of providing scientifically valid and useful results.

Detail must be paid attention to, both for useful small-scale ideas, and to allow each panelist to feel that at least one of his comments has been used in feedback. However the most important function is to provide feed-back of overall movements and other macro-scale observations, such as best reflect what is going on and the types of result desired. Aside from mere feedback, and the highlighting of convergences and divergences, new ideas and leading suggestions can be introduced at any stage, as well as anomalies and ambiguous factors to draw people away from particularly narrow lines of reasoning. Constraints can also be stipulated if necessary to focus discussion in the right areas.

3.2.6.5. Interpretation and Communication of Results-

Complete records of eventual responses are likely to be difficult to use constructively due to their size and the number of irrelevant items, so that interpretation and paring down must start early on, if the overall 'reality' that has been produced is to be captured in the results.

It is also valuable to communicate results to panelists, not merely during the stages of the Delphi, but also at the end results stage, to further encourage feelings of involvement, and in the hope that such results might be of some interest, or even use, to the participants.

3.2.6.6. Conclusions On Principles of Methodology-

Figure 3.10. presents a suggested flow diagram of the way in which the Delphi methodology is likely to develop. Whilst it gives no details of such things as questionnaire form and the like, it tries to show the outline of methodology as discussed above, and provide guidelines as to the actual design in section 3.2.8.

Much of the information given in this section has been concerned with very broad guidelines for the design of Delphis, but it is not until the specifics of what precisely is required from the survey have been worked out that such broad guidelines can be translated into the specifics of questionnaire design.

3.2.7. Formulating the Issues-

The basic hypothesis for the research, as generated in previous sections, is that there exists considerable potential for a greater degree of rural energy autonomy, especially through the medium of increasing integration between agricultural/forestry and domestic sectors. The hypothesis is based on the desirability of moves in that direction, given the likelihood of a low growth future, with continuing movement of new classes into the countryside, the withdrawal of the state from many areas of its past concern, and the growth of the 'household economy'.

Testing of this hypothesis involves the choice of rural areas, not designed to cover the whole spectrum of what can be defined as 'rurality', but concentrating on areas that are 'indisputably rural', thus omitting many of the more urban functions of some areas and focussing on the basics of rurality, with the hope of being able to extrapolate to other areas later.

Within this framework of inquiry, there are three areas to which a Delphi panel might be able to contribute usefully; the criticism and amendment of suggested futures to produce a more scientifically valid assessment of likelihoods; the contribution, criticism and refinement of ideas designed to increase rural energy autonomy; and, perhaps to a lesser extent, the criticism of the whole research methodology itself.

The first round of the survey ought to be able to amalgamate the two major functions to some extent, and speed the process along somewhat by leading suggestions and some form of listing of the possibilities. This involves both a full list of possible energy saving and integration ideas, with ranking systems for an assessment of their likelihood and desirability, and the postulation, in quite detailed terms, of a future model for criticism. The suggestion that diagramatic extensions of the method into catastrophe theory should be carried out was dropped due to the danger of putting off panelists by adding too many alternative scenarios to an already bulky questionnaire.

Subsequent rounds should make use of the feedback to open up new ideas to criticism, terminating in a consensus based 'most likely future', and a list of the most useful possibilities for energy autonomy, together with an assessment of total potential and the policy measures needed to achieve it.

Obviously, the panel needed for such a survey must be an interdisciplinary one, the choice of which is discussed in the next section.

3.2.8. Designing a Delphi Survey-

3.2.8.1. The Choice of a Panel-

Since the study looks in detail, to some extent, at all aspects of rural areas, the panel needs to be able to cover a lot of different specialisms in order to be comprehensive, and since it is broad economic futures which are at stake, the broad-based social scientist must be included to capture the total view, and particularly to criticise total futures.

Panelists, for the sake of argument, can be divided into five broad categories; rural specialists, energy specialists, rural 'generalists', energy 'generalists', and 'others'.

Within the category of rural specialists ought to be chosen forestry experts and agriculturalists, (with the greater emphasis on the latter), and perhaps certain people with practical expertise in rural policy, such as housing. Agriculturalists, the largest segment of this group, should not be merely academics, (chosen for their knowledge of a wide range of different agricultures, but should include, perhaps, those with responsibility for running a large estate, and for balance, perhaps some smaller farmers. It would also be advantageous to include agricultural policy makers, such as individuals from the Ministry of Agriculture, Fisheries and Food (M.A.F.F.), Department of Agriculture and Fisheries Scotland (D.A.F.S.), and those involved with the Common Agricultural Policy (C.A.P.).

Others in this grouping include ground workers for the H.I.D.B. on their cooperatives programme perhaps, and those responsible for administering the Western Isles I.D.P.

Whether there really are many branches of energy specialism which are particular to rural areas is debatable, yet the assumption is generally made that they should include renewables technology experts above all other. To some extent this is probably valid, and representatives were chosen from each of the energy sources wind, hydro, biomass and biogas, passive, active and photovoltaic solar systems. Experts in other fields included representatives of the North of Scotland Hydro Electric Board (N.S.H.E.B.), the National Coal Board (now British Coal) and the like, and academics in other areas of energy. Additionally, those with expertise on the energy use side, particularly in buildings, but also as regards other conventional technology, were included.

The category rural generalists included rural sociologists, economists and planners, both academics and practitioners in the field, particularly those who have some concern with futures. The choice was made bearing in mind the desire for variety and originality of thinking, in precedence over the eminence of the individual. Strong regional differences were likely to exist in this section, so that care was taken to reflect the correct balance, by choosing most panelists for having a background in the less favoured areas of Britain, but with one or two having knowledge in other areas. (including the Third World).

The energy generalist category consisted of energy planners and writers of different persuasions, from different parts of the world, and energy forecasters, who are likely to exhibit an extremely wide range of opinion. Since, outside the specifically rural sphere, countless energy experts could be identified with different outlooks and foci of interest, the criteria for choice here were broadmindedness, far-sightedness (in terms of willingness to look to the future, rather than the tendency to get it right), and width of field.

The nondescript term 'others', hides two groups in particular of great importance, those whose own field fits in closely with the totality of the present project, the social scientists who have studied energy use and energy futures in rural areas, and the generalist future forecasters who have not concentrated specifically on rural areas, but who have studied economic and social futures on a national and global scale.

It was not thought to be appropriate to include those other rural experts, the ordinary inhabitants of the areas, on the Delphi panel, but a comparison of their responses with those of the 'experts' might be interesting, if carried out in the context of the local level survey.

The number of broad specialisms listed in the above 5 categories amounts to some 35 different fields. Multiplying this number by a suitable amount to achieve a balance over each of these fields would involve a panel of unmanageable proportions, whilst allowing for a certain drop-out rate would increase this size even more. Therefore, the choice of panelists must rely on their broadness and ability to fit into more than one category.

Optimum numbers for a survey of this kind are different to gauge, but being able to process replies and give meaningful feedback from each participant probably reduces the effective number to about 50, in spite of the broad range of fields covered. This number was thought to need expanding by some 100 percent to cover for non-response, and to ensure that all specialisms were still represented in a reduced number of responses.

Lists of first, second and third round panelists are included in Appendix 2.

3.2.8.2. Survey Round One-

The first round of the survey presentation can conveniently be split into three main sections; an explanation of its contents and intent, a fairly detailed future model, and a list of issues designed to stimulate thinking on energy integration.

An opening letter made clear the purpose of the research, including the major hypothesis, the persons involved, sponsorship, the current stage of the project, the general purpose of Delphi, the reasons for its use in this particular case, the exact methodology being used, the make-up of the panel (with a full list of names appended), and a statement of the contents of round one and how the panelist should deal with it.

Next, a suggested future was mapped out in full, postulating long-term low growth with low employment, a new egocentric capitalism with a return to a 'survival' mentality, the withdrawal of the state from many of its past concerns, coupled to the growth of a 'household economy', and in rural areas, particularly with the growth of information technology, an increasing number of non-rural incomers to more and more remote areas.

This forecast was then opened up to criticism by itemising each of its elements and asking for assessments of probabilities against some timescale, as well as asking for alternative suggestions and general comments on other likely futures under particular categories.

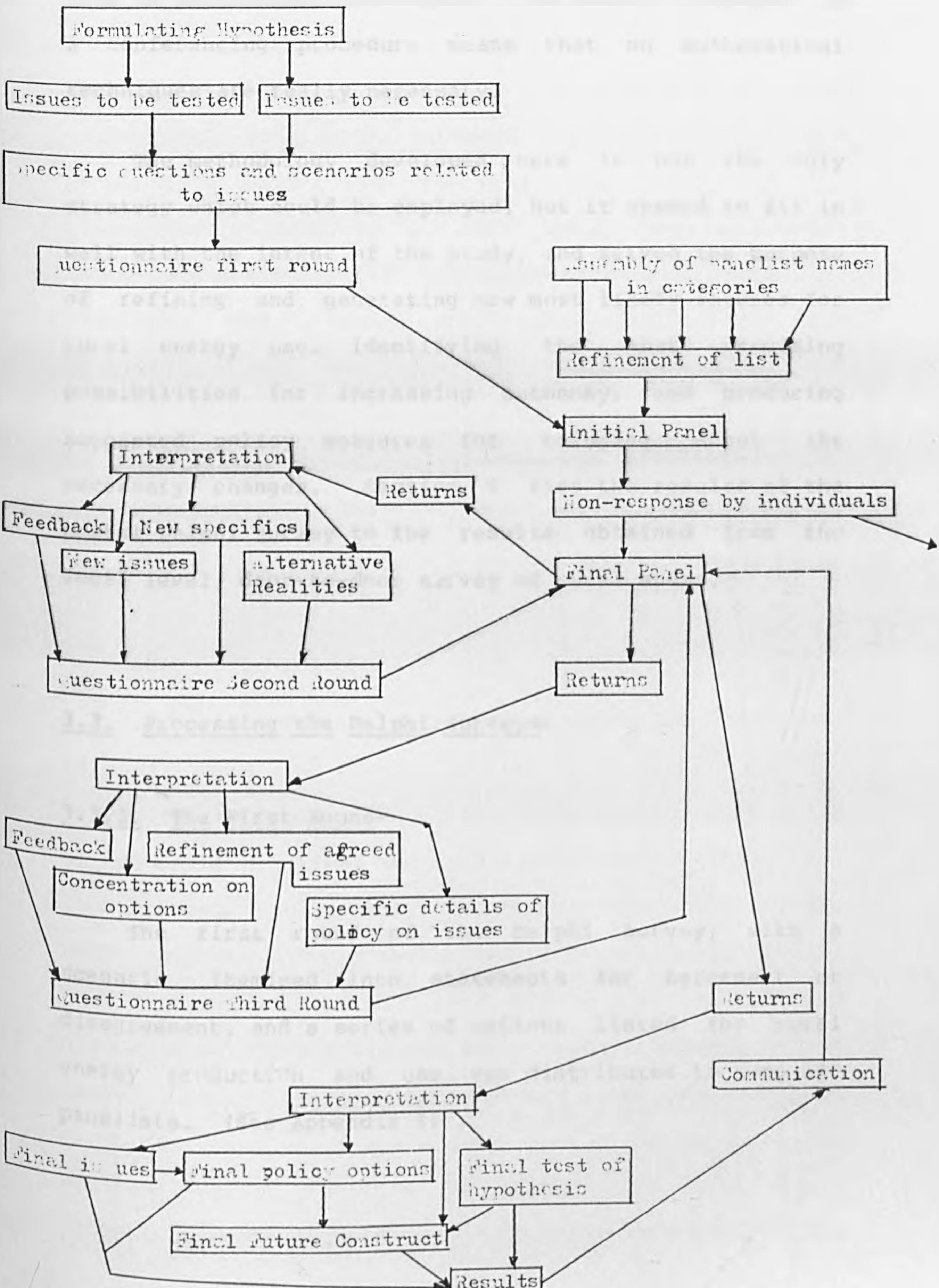
A list of ideas for creating a greater degree of rural energy autonomy was then stated, such as, 'the growth of the use of small-scale biogas plants, increasing insulation standards, use of straw-burning stoves' etcetera, which were to be ranked in terms of importance and had probabilities placed against them, together with space for comment and the suggestion of other ideas which were thought to be of importance. Such an assessment can be carried out assuming, initially, the truth of the assumptions in the initial forecast.

All three rounds of the Delphi questionnaire are included as Appendix 3 together with the introductory letters which were included.

3.2.8.3. Interpretation and Communication-

A system such as The Statistical Package for the Social Sciences (S.P.S.S.) could be employed to process some of the results of the Delphi survey, but the creative enquiry nature of the process means that ideas are being asked for, and responses tend not to be in a form which can easily be transferred into a data file, (indeed it is undesirable that they should be).

Figure 3.10. DIAGRAM OF A THREE ROUND DELPHI SURVEY (69)



Processing was therefore manual, and consisted more in picking out ideas of interest and forceful arguments than in statistical techniques. The nature of Delphi as a conferencing procedure means that no mathematical techniques are really necessary.

The methodology developed here is not the only strategy which could be employed, but it seemed to fit in well with the intent of the study, and served the purpose of refining and generating new most likely futures for rural energy use, identifying the most promising possibilities for increasing autonomy, and producing suggested policy measures for bringing about the necessary changes. Section 9 ties the results of the postal Delphi survey to the results obtained from the local level, door-to-door survey of rural areas.

3.3. Processing the Delphi Surveys-

3.3.1. The First Round-

The first round of the Delphi survey, with a scenario itemised into statements for agreement or disagreement, and a series of options listed for rural energy production and use, was distributed to some 100 panelists. (See Appendix 3)

Response rate was slow however, and the final response after written and telephone reminders remained at only 25. (Appendix 2 shows the revised list of panelists). This low response rate is by no means unusual for a postal survey, and although it was hoped that the specialist interest of individuals would encourage a greater response rate, the length of the questionnaire probably put off many of the panelists. The 25 responses still represented a wide range of opinions, and although the representatives of each specialist group were limited, they cut across all sampled specialisms, and no particular correlation could be found between individuals' views and their specialism. In the context of the non-statistical Delphi procedure, the successful sample represents a valid collection of the opinions of informed individuals. (See Appendix 2 D)

Processing the results of this first round using the S.P.S.S.[70] programme was attempted, ranking the confidence of individuals in particular scenario statements and recording them on a data file. The method gave no means of recording new ideas and positive contributions, and thus cannot really help the the creative nature of the Delphi process. The computerised data was only really useful in assessing consistent differences and similarities between individuals in their assessment of ranked ideas for energy saving and use, and in crosstabulating responses against specialism to check for obvious biasses relating to background and training. Since both of these avenues proved relatively unfruitful, the computer processing methodology for the Delphi survey was abandoned in subsequent rounds.

Points made in the scenario were assembled on a large flow diagram, and all the comments made by respondents were transferred in detail to this diagram. Since the process is not statistical and, if at all possible, a 'majority verdict' should not be accepted, it is important to aim for consensus rather than compromise, and the scenario must be changed to reflect the views of all panelists.

It was found that, for the most part, reasons for disagreement between respondents could be at least partially explained by problems of definition, misunderstanding and talking at cross purposes, and that clearer definition and further explanation could often resolve these differences. The scenario was altered to reflect the views of respondents, and even if only one person expressed a new opinion or a disagreement, the second round documentation reflected that opinion.

The amended scenario was thus compiled, the additions from respondents making it considerably longer than the first round. In an attempt to make completion of the responses a less onerous task, splitting the scenario into discrete points for comment was abandoned, and it was written in a prose form in continuous paragraphs, leaving space for comment at the side. This allowed comment on any matter with which the panelist might disagree, without seeming to force a response on each issue.

The section on 'rural energy options' was reduced somewhat to include only those items in which some confidence had been shown by respondents.

3.3.2. The Second Round-

The round two response rate was further reduced from 25 to 18, even after further postal and telephone reminders.

Processing in this round closely followed the procedure used in round one processing, abandoning computer methods for manual ones. The justification for the accuracy of this type of processing lies in its ability to produce agreement amongst respondents, and no further 'statistical truth' is necessary.

Again consensus, rather than compromise was sought, but where this was not successful, two different approaches to resolving conflicts were followed in the third round. In some cases dissenting opinions, where only expressed by one individual, were recorded separately within the scenario, as written by respondents. In other cases, questions were asked or alternative scenarios proposed, which covered or tried to explain the different views prevalent, in an attempt to clear up reasons for disagreement.

It is in its ability to search for reasons for disagreement that the strength of the Delphi method lies, and where these reasons are not clear, or where they are very fundamental and tied to the ideology of the individual, conflict resolution becomes difficult. It is hard to avoid the temptation to construct a future scenario based on ones own preferences, and it is obvious that this desire to disseminate their own views on what should, rather than what is likely to happen, colours many respondents comments. Be they pessimistic or optimistic, they still tend to put forward their own views on present political issues by projecting these views into the future.

3.3.3. The Third Round-

For round three, energy options were reduced to written statements of the importance of energy saving and production possibilities under broad category headings.

Response rate for the third round of the survey was further reduced to 15, though a reasonable cross-section of specialisms was still retained. (See appendix 2 for the final list of panelists).

Although points of disagreement were almost as many for the third round as for the first, they tended to concentrate on the smaller detail, rather than on the basic form of the suggested future, on which agreement is now quite strong. The processing methodology was the same in this round as in the previous round, and the final scenario, adapted from third round responses, is recorded in section 3.4.

During the course of the survey, several panelists wrote to express their dislike of the method, their major disagreement seeming to rest on the apparent elitism of a method which uses a subjectively selected panel of 'experts'. This problem has already been discussed in section 3.2.3., and although their reservations are shared by the researcher in some measure, it would seem that any rational discussion of the future is valid, and as long as it is not suggested that the final scenario is infallible, it seems a useful contribution to modelling the future shape of rural areas.

3.4. Final Delphi Scenario-

3.4.1. Introduction-

The system used for the presentation of the following scenario is that the scenario itself is indented and at single space, comment is at double space, and quotes from respondents in parenthesis.

Although it was initially proposed to be able to include alternative scenarios based on the occurence of major, catastrophic events, the scenarios in the three rounds were rather long as they stood, and any duplication of issues would have made the questionnaires prohibitively time consuming to answer. Therefore the initial assumption that no world war, (or other major war involving the developed nations), occurs, remains, having been recieved with a high degree of confidence by respondents.

3.4.2. International-

The assumption is made that no world war, (or other major war involving the developed nations), occurs.

World economic growth averages around 2%/annum, (being generally higher in developing than developed countries, though with considerable national differences) , and drops slightly after 2010. Around the same time population growth slows down in most developing countries as the long delayed result of cultural adaptation to rising life expectancy and lower infant mortality.The problems caused by low growth are offset from time to time in some countries, (depending on their internal politics and external influences current at the time from the major powers), by wealth redistribution. Where this is achieved for as long as a generation, low growth 'problems' are diminished by lowered expectations. Yet starvation and malnutrition grow as problems throughout the period. Lack of fuelwood continues to add to problems of desertification in many of these areas. The diffusion of new technologies remains selective by area and class, and they solve few of the problems of the poorest countries. Growth begins to be replaced in public attitudes, and ultimately in some governments' policies, in terms of desirable activities in the solving of problems, whilst maximising gross national products begins to lower in relative importance.

South-east Asia, and to a lesser extent China, can be defined as part of the 'first world' within 50 years, and the first world countries still dominate world trade and the economies of the poorer countries. Latin American countries, whilst in many cases retaining the manufacturing industry, are by and large unable to find the political stability to join the first world due to factors which include the continued patriarchal role of the United States. Africa in particular shows little general improvement in living conditions for its populace. Although much of the more traditional, lower technology manufacturing, requiring lower levels of quality control, resides in Third World countries due to the cheapness of labour, whilst more sophisticated new manufacturing, as well as new service industries such as software production, remain within the first world.

Following initial slump, real energy price increases of 2%/annum, still led by oil prices, are somewhat obscured by continuing fluctuations caused by political infighting. Prices begin to rise at 5%/annum soon before 2010. There is little or no subsidising of oil prices by individual countries, and most countries respond to rising prices by some form of legislative encouragement of energy conservation.

Coal liquefaction becomes an important source of high grade energy by the end of the period, whilst other oil substitutes such as Third World produced alcohol, though locally important in countries such as Brazil, with large land areas and low populations, are not significant energy sources internationally.

New oil finds are still used for non-substitutable purposes by the end of the period, whilst electric vehicles have only limited impact since there are only a series of small improvements, rather than breakthroughs, in battery storage technology.

3.4.3. Europe-

The effects of the E.E.C. grow more far reaching and important to individuals within member countries, yet the additional powers accorded to the E.E.C. are not so far reaching as to give it greater authority than individual member states over the lives of their citizens.

However, recent growing nationalistic trends, as exhibitted both by accepted political parties such as Plaid Cymru and the S.N.P. and by more controversial bodies such as the I.R.A. and Basque Separatists, do not abate, and Europe is not a harmonious, benign entity, but one forced to become more important as a prerequisite of self preservation against other power blocks, in spite of opposition from many small, largely peripheral areas. Third world attitudes to Europe are mixed, with increasing hostility against those countries which are seen as being closely allied to the U.S.A., but less hostility against Europe as a group of nations, due to the influence of Greece, Spain and Portugal as relatively poor countries within the community.

On the International scene, one respondent believed that the IRA problem might be solved by the end of the period, though giving no details of how this might be done. This divergence makes little difference to the basic tenor of the scenario, that of troubled, nationalistic problems against a background of increasing E.E.C. control.

More sweepingly, another respondent criticised the international portion of the scenario on the basis that it did not sufficiently bring out the linkages between international and national issues. In so far as this is true, it results from the past need to change points in the scenario, including more detailed study of peripheral subjects, to achieve agreement amongst respondents. Nevertheless, specific points, such as the relationship between increased EEC prominence and agricultural development, the manufacturing base lying in the third world and forms of employment in Britain, and international energy prices and energy use in Britain, are clear.

3.4.4. Nationally-

3.4.4.1. General-

After the year 2000, present arguments about the problems of unemployment begin to lose weight as government and the people begin to accept different employment structures. Such solutions as job sharing, (a scheme to promote which is already being operated by the Department of Employment, but with negligible success), short hours working in the home and multiple occupations, begin to bridge the gulf between the 'employed' and the 'unemployed, and to relieve the tedium of long hours in repetitive occupations. Moves in this direction are encouraged by a shift in major union policy away from the protection of existing membership and on to job creation. 'Work hours' per capita are reduced by some 20%, (taking account of the increased numbers of retired people), though such statistics become increasingly more difficult to measure, with people not merely being employed for a wage, but doing work for payment in kind, or work the value of which can only be measured in terms of the savings it generates to the individual.

Dissent arises from three respondents on this employment issue. One argues from the point of view that there is much to be done in the world, (mainly the third world), and that full employment must therefore result. This argument displays well the tendency of respondents to argue from the point of view of desirability, betraying their own political views. It is difficult to imagine that this panelist believes that the surplus of labour in Britain will all be employed on third world development programmes.

Of the other two dissenters, one states that unless the unemployed become much more numerous and vocal; "these desirable changes are unlikely to occur, given the interests of 'capital' in opposing them." The other states that demographic effects may prevent unemployment; "reaching such a disastrous level".

Taking the latter point first, the scenario clearly states that unemployment, as such, does not grow, and indeed it is the very 'demographic changes' spoken of, in the form of an inevitable ageing of the population structure, that will help to work towards the 20% reduction in working hours per capita.

The former objection is rather more serious, particularly as regards the power of the unemployed to effect change, in isolation as they are from both money and the unions, and it may only be my own particular political ideology that encourages my belief in the inevitability of such changes. It is difficult to envisage 50 years of massive employment without some such redistribution of work and capital.

> Thus does 'self-reliance' become increasingly more important, not so much in terms of total personal or family autonomy in such matters as food supply, but by the replacement of some specialist wage labour by 'DIY' work at home. Such fields as cheap,recycled components in vehicle maintenance, and the growth of occupant labour in house construction and repair, are able to replace an additional 10% of wage labour.
>
> This present trend coexists with the current tendency to accept technologies which are impervious to 'DIY' (such as the microchip), and is indeed fueled somewhat by

continuing specialisation in other sectors of the economy. This creates a dual economy of increasing 'DIY' on the one hand and unapproachable high technology on the other.

These changes in the structure of the labour market affect the validity of conventional left-wing politics, and the Labour Party continues to become more centrist to retain support. The Conservative party moves only slightly away from the extremes of laissez-faire capitalism, and the Liberal/SDP parties, though gaining support and becoming a more significant force in parliament, never gain the status of being the main opposition party. Green party politics grows as a minority force throughout the period.

"I dont think centrism is the answer for the Labour Party, rather a radical decentralised approach to socialism".

The State continually withdraws from many areas of its present concern, particularly service provision which requires State finance, though without relinquishing control over these areas. Privatisation of Publicly owned industry continues, though support for the Welfare State halts the privatisation of these social welfare activities. The effects of an ageing population and changing employment structures mean that pensions are one area of growth in public finance.

"This may be only temporary as the contradiction between service in the general sense and private motivation to provide them becomes more clearly perceived. Unless a complete restructuring away from profit takes place (unlikely although desirable)".

These last two dissenting opinions come from the same respondent, and do appear to represent preferred political solutions, without pretending to be the most likely future reality.

> 'Leisure' grows in importance, though its definition becomes much changed to include the self-financing activities of many people, and the boundaries between work and leisure become increasingly blurred. Leisure facilities are provided more by private than by public funds. Service industries, including non-manufacturing industries such as computer software development, continue to grow in importance compared to manufacturing in the U.K.
>
> Pressured by low economic growth and low employment levels, the concept of 'family' becomes increasingly important, and independence from the extended family becomes increasingly difficult, though a smaller 'counter-culture' of non blood-related groups grows up to counteract this trend slightly. More and more of economic life becomes based on these individual family units.

A basic problem arose in dealing with U.K. economics and employment, since respondents disagreed fundamentally on the issue of whether economic growth was a basic necessity in any society, or whether stability, rather than stagnation, could be achieved without it. In an attempt to clear up this difficulty, the following argument was included in round three;-

> Comment- On the question of the necessity for economic growth, most respondents see no absolute need. Of those who perceive growth as a necessity, most assert that human beings need to better themselves continually, and that this includes economic advances, and thus infer that society as a unit also needs this. My personal view is that it is wrong to see society as if it were an individual, for it is obviously a group of individuals, each of whom can, due to the mortality of other individuals, become progressively better off economically throughout his life, even in a no growth situation. Indeed if one's income from school leaving age to retirement increased only at the same rate as the G.N.P., one would certainly be considered to be an economic failure. Though the cultural attachment to individual

betterment is a strong one, I imagine that attachment to collective betterment is rather less deeply rooted. Please comment.

There were only three dissenting opinions to this argument, as follows;

"Still need economic growth, because people in every age group and at every economic level want it".

Due to the fact that no more rounds of the Delphi survey can be carried out, it is necessary to be somewhat heavy handed here, and argue the case without giving the right to reply. This first statement, though undoubtedly true in so far as the desire for increased income cuts across all age and social groups, does not seem to interfere with the stated principle that such betterment can occur in a no-growth situation. The same would appear to apply to the second objection;

"Surely some people's real income does decline during their lifetime, betterment often comes from the informal sector or moonlighting, petty crime etc.".

Again, both the basic statements in this comment are true, and again they do not necessarily interfere with the principle of the argument, for as the respondent seems to accept, it is social organisation, rather than economic growth, that dictates which individuals may not obtain betterment, and the individuals described exist in all societies regardless of economic growth.

The third note of dissent was;

"I disagree, betterment can only be gained collectively, regardless of individual performance".

This is rather more difficult to answer. Since betterment can obviously accrue to an individual, this respondent presumably means that betterment can only be brought about by collective effort in an organised society. Whilst this is undoubtedly true, I would still argue that people attach more importance to their own betterment than to that of a group, be that group a village, a factory or a nation. Since the argument is that all, or most of the individuals in a nation can improve their incomes over their lifetimes, without necessarily increasing G.N.P., given a steady population, the fact that this income is derived from an organised effort of society seems irrelevant.

3.4.4.2. U.K. Energy-

> The use of coal increases throughout the period, whilst the use of oil for heating, and to a lesser extent transport, but not petrochemicals, drops. North Sea oil production peaks before 2010, reducing to almost nil by 2044, leaving some very small operations to the west of Shetland as the only U.K. production. The rise in coal use is most dramatic after 2020, encouraged by the perfection and common use of coal liquefaction techniques, as other sources of oil dry up, and oil is only consumed for highly specialised uses by 2044.

Questions on nuclear power were altered in the third round as a response to the Chernobyl accident, and the following alternative scenarios were included;

> Please state which of the following three scenarios for nuclear power seems the most likely, giving your reasons briefly-
>
> 1. Continued conservative politics means a relatively large share of the market for nuclear power, particularly fast breeder reactors, in the short term.
>
> 2. The aftermath of the Chernobyl disaster creates such public ill feeling about nuclear power that all expansion programmes are halted by 1988, the halt is permanent and there is no replacement of older plants, which are run down more quickly than previously planned.
>
> 3. Rising cancer statistics in parts of Europe around 2000 are attributed to nuclear accidents such as Chernobyl, and the European nuclear industry runs down from this point.

Additionally, a scenario based on the results of the preceding rounds was included;

> Fusion does not become commercial by 2034, though there is still much expenditure on its development, whilst with uranium reserves finite and becoming very expensive, fission is not seen as a permanent solution by anyone. Nuclear fission peaks as a power source around 2015, at a peak capacity of 20GW , and thereafter begins to run down, with the only new development being the replacement of some older plants.

However, comments were so varied and contradictory as to make consensus impossible within the confines of the survey method. Perhaps it is the very uncertainty over the future of this fuel source that encourages entrenched positions on both sides. A list of scenarios suggested by respondents is included below;

"The problems and costs of 'safe' nuclear power rule it out eventually".

"Labour stop expansion whilst in power".

"Halt, but not a permanent one, research and development continue, the issue is whether they will achieve enough to restart".

"Although there are rising cancer statistics, still carry on building programme".

"Continue building programme, cancers due to Chernobyl undetectable against background".

"Price of uranium, presently low, drops further as some countries move out of nuclear power, restricting demand. Continued building programme".

"By 2010, uranium will be priced by its energy content, and therefore will be expensive".

"Nuclear fission peaks before 2015".

"Nuclear fission peaks after 2015".

These responses range from; nuclear power can never be viable, to; nuclear power viability is inevitable; and contain a wide variety of political viewpoints. In a three round survey it has proved impossible to debate the nuclear issue any further than this, and the situation remains one of conflict of opinion. The future balance of thermal and nuclear fission power generation remains cloudy, and based really on no more than a single postulated political decision, though there is strong negative opinion on the ability of fusion power to prove successful.

> Conventional thermal electricity generation becomes slightly more efficient throughout the 50 year period, reaching 40% efficiency, with the help of combined cycle gasification, for the actual generation, (not counting transmission losses). Combined Heat and Power scheme development in limited urban areas, takes the overall average efficiency of primary fuel use in thermal power stations up to 45%. Problems of emmisions such as SO2, lead to expensive means of emission control.
>
> Electricity use rises slowly, though more quickly towards the end of the period, with the more general introduction of electric vehicles, though these are largely restricted to public transport. Towards the end of the period, one large tidal power scheme is built.
>
> In terms of renewables, breakthroughs in photovoltaic cell manufacture make it a very important source of energy worldwide after 2020, particularly in underdeveloped tropical and subtropical countries, though it also has some impact in the U.K.

"Is there any evidence that such a breakthrough may happen here rather than in any other area".

It would seem that the answer to this respondent is 'yes'. All other renewables rely on more or less traditional methods and use quite large amounts of material. Though the materials may change, there is little reason to expect any lowering of price, except that which can be achieved through production in bulk. Photovoltaics, however, are highly specialised, and use expensive materials in short supply. There is more room for technological breakthrough in this relatively new technology.

Aside from the tidal power scheme and existing hydro plants, a few large renewables schemes are generating electricity by the end of the period, with one large wind farm and a large wave energy scheme.

"Not convinced about wind farms".

Most other renewables schemes are small-scale however, and largely restricted to the more remote areas of Scotland, Wales and parts of Northern England, where small-scale hydro and wind projects make up some 15% of the total elecricity consumed. (Albeit that it is hard to assign such percentages when most of this power is distributed on a national grid.)

The use of wood as a fuel, increasingly through short rotation coppicing etc. also grows in these areas.

"Wood is very expensive if the true costs of planting, reaping, cutting etc. are calculated on a commercial basis. Without alternative evidence I would not support this statement".

Most people's awareness and practice of energy conservation grows considerably as energy prices continue to rise, (a trend which continues, in a perhaps more educated form, the present predilection for hard sell tactics by double glazing companies etc.) As this trend continues and demand for energy saving products increases, growth in research and development is largely taken up by the private sector, with the role of Government funding little different from the present. By the end of the period, micro-electronic control systems are able to save 25% of the energy used for most purposes.

"Over rates the impact of micro-electronics in energy saving, and reflects the fashion of talking about the IT revolution and what it can do".

3.4.4.3. U.K. Rural-

'Rural districts', as presently defined by the local authority areas, increase their share of total population from 23% to around 33% over 50 years. Only the most isolated of areas see any continued depopulation, whilst rural inmigration, though affecting areas in the South East of England the most, eventually affects areas further and further away from present centres of population, largely as a result of changes in employment structure and advances in information technology. This new rural population concentrates largely around existing village communities and small market towns, and housing remains at fairly high densities rather than being scattered. The new housing development needed for such an influx takes some of the impetus away from urban renewal. (Obviously by the end of the period, this migration has changed the nature of many areas so that they can no longer reasonably be defined as truly rural).

Though there is attendant friction between incomers and the indigenous population, these definitions become slowly blurred, and friction arises even between the early and late 'newcomers, although no particularly serious problems are caused thereby.

There remains considerable disagreement on the issue of planning control in rural areas, with several people believing that the scenario of dismantled general planning control and more emphasis on strict control within limited conservation areas is unrealistic. Several people suggest that increasing environmental awareness is likely to force improved control over land use, whilst one cites the example of Conservative controlled Shire Counties in encouraging planning controls.

It would seem that past and current public environmental concern, which has been consistently growing, has focussed itself to date only on highly specific parts of the rural environment, such as nature reserves and parts of National Parks. Simultaneously with this increase in public environmental awareness has come, more recently, a relaxation of planning controls in many areas. Passive control of development, as opposed to active measures, cannot really be effective unless there is a lot of pressure for development. In a low growth economy with less development pressure, controls tend to be lifted as far as possible, to encourage development of almost any site.

Obviously there is a major difference here between the situation in fairly remote rural areas, and that around major conurbations, where development pressure is much higher. The following scenario is therefore suggested;

> Planning regulations in all rural areas become progressively more 'conservative' and conservationalist. In more remote rural areas, away from the major urban centres, many general restrictions are totally removed, and the emph asis is more on extreme control within well defined areas of varying size, such as the conservation of historic buildings, villages and nature reserves, rather than on more general environmental control. Limited remote areas, such as parts of National Parks, retain fairly strict planning control. Around major urban areas, particularly in the South-East of England, more general, stricter planning controls remain in force.

As such planning controls are lifted in rural areas, and the need for face-to-face communication in business is reduced due to advances in information technology, some small, high value new industries tend to locate in the rural districts, largely on the grounds of providing a 'better environment' for employees and management. Initially this occurs around major centres of population, particularly in the South East of England, but eventually most areas see some influence from this movement, albeit a small one in the more remote areas.

"Face to face communication can only be reduced so far before we come up against the limits posed by our own humanity".

I would argue that the fact that business communication was automated would not necessarily signify a faceless world without any human relationships, since people would still be living in communities with other human beings. The respondents argument suggests that some 70% of women, without the benefit of communication through employment, have in some way being lacking 'humanity' for generations.

There is a decline in the level of public service provision in relation to the amount of private services, whilst in spite of the large influx of population into many areas, there are generally few more services provided than at present, reflecting new, more individualistic attitudes.

Rehabilitation remains a 'fashionable' and important sector in rural building for some time, particularly in areas where 'recolonisation' occurs later. This predilection for rehab is encouraged both by a subjective preference for the old and 'traditional' in building, and a rational return to the advantages of certain vernacular building techniques blended with new building technology. (Such factors as using smaller windows on all but the south face of a building, and the adaptation of heavy masonry construction to provide Trombe walls being particularly important). This trend is helped further by changes in building society policy which admit to differences in desirability between different building types. However, the slack is soon taken up in terms of building availability, and rehabilitation only becomes the most important housing sector in a few areas for a short time whilst properties are still available.

Historical trends towards higher car ownership continue for a while, with cars becoming increasingly smaller and more energy efficient, eventually at the expense of performance, steeply rising oil prices after the year 2010, together with gradual attitudinal changes which no longer stress private transport as an essential status symbol, finally halt this growth and bring a slow but steady downward trend after 2020. Private car ownership is thus slowly replaced both by improved forms of information technology,including attendant trends such as working from home, and by a rural 'mass transit' system which is increasingly privately or community financed for short distance travel, rather than being paid for by public money. Such a system makes use of information technology to create highly efficient forms of car sharing and the flexible timetabling of small, probably electric, buses. Subsidised publicly financed transport is restricted to a minimum skeleton service in those few areas where it still remains uneconomic for transit systems to be privately run.

3.4.4.4. U.K. Agriculture-

The most response in the whole scenario was received on the question on the nature of agricultural surplus, important in mapping out the whole future of U.K. agriculture, which is reproduced below;

Question- There remains much disagreement as regards agriculture, based on total amounts of U.K. food production. Many respondents argue, on the basis of surpluses of certain foods, that Britain produces a food surplus, and that we should be cutting back on agricultural production, even in the long term, at the same time saying that Third World countries should not rely on food imports, (even, in some cases, if they have the industrial wherewithal to pay for them). Others argue from the basis that agricultural production must be maximised to meet future world shortfalls, presumably aiming at a position where the U.K. produces enough 'gross food value' to feed itself. This issue colours people's reactions to all other agricultural parts of the scenario, please comment.

All the comments on this question are recorded below. Two respondents hit on a part of the problem when they criticised the question on the grounds that it sought to elicit what should, rather than what would, happen. Some respondents put down their own most likely scenario, whilst others were perhaps influenced by what they thought was the moral position.

However it is clear that only two people believe that U.K. food production will drop in the long term. Most believe that a rationalisation of CAP will lead to the same or greater production, but of a wider range of commodities. Only one person believes that long term food aid is likely, due to public opinion affecting the moral stance of governments. (Conversely, another respondent believed that growing public opinion on the excessive cost of agricultural support policies will lead to a withdrawal of support and hence a lowering of food production. This suggested direction of public opinion does rather seem to go against observed current trends).

Much more work would have to be done to resolve these conflicts, since differences appear to arise partly from both differences between practical/economic and moral stances, and differences in specialism leading to differences in perceptions of public opinion on land use issues.

It seems likely however, that agricultural changes will be relatively minor, and that policy changes, particularly in CAP, will be adjustments to avoid surplus, rather than sweeping changes in intent.

The responses to the question on agricultural surpluses were as follows;

"The primacy of agriculture in land use will be questioned, and land taken out of food production for forestry and energy production".

"The cost of public support means that people do not want to support agriculture now. (The scales are falling off their eyes)".

"Increasingly, agriculture in the whole of Europe and the political nature of the community will be the imperatives that dictate U.K. food production, and the land used for it, on the basis of comparative advantage. U.K. production will decrease within Europe, starting with marginal hill land".

"Can't see a reduction in food production, unless large areas are taken out of farming, or unless livestock falls in numbers due to a change towards vegetarianism (unlikely). This means there would be a food surplus unless government intervenes".

"Situation likely to be dominated by E.E.C. and C.A.P., and cutbacks in excess commodities are unlikely to be compensated by increased production of non-surplus ones".

"The third world should be encouraged neither to export food (cash crops), nor to increasingly import food necessary for survival. Instead they should be encouraged to feed themselves. (Not us selectively)".

"Controlled agricultural surplus, (i.e. with a planned outlet to the third world or the communist bloc), should be aimed for, but not to any great extent. It is best for third world countries to be more self-sufficient in food production, and many of them are now progressing along this road".

"In so far as I understand, I agree. Why should food not be treated like manufactured goods and traded accordingly, without the nonsense of the current CAP, which is a distortion of the workings of the marketplace".

"Food is currently a small part of people's spending (except the poorest sector), it is possible to afford more exotic items. As food becomes more expensive, there will be a move back to more basic, home produced foods".

"R. and D. relevant to Britain (and other developed countries), has increased production. Until third world countries have had similar opportunities it is immoral for any country to restrict its food production. Public opinion is growing on this".

"Only a surplus of certain E.E.C. foods, not an overall surplus, exists".

With the relaxation of planning controls comes a change in the structure of land values, and whilst some agricultural land near major centres of population rises in value with the prospect of possible future development, 'building land' as such can no longer command such high prices. Most land prices remain fairly static or fall slightly before 2000, with the abatement of speculative 'land fever' and the return to agricultural land values based more accurately on potential agricultural production. Ultimately however, land remains an inflation proof investment.

Large private estates, though experiencing some continued pressure from death duties etc.,causing some of them to change hands, are rarely split up into smaller units, and there is no particular political pressure to do so, though there is some slight economic pressure from the influx of new rural residents. The growth in institutional farm ownership slows down, though such bodies as the pension funds continue to own and manage farms in large numbers, particularly in the more profitable farming areas.

With more people moving into rural areas, 'environmental' opinion sees the countryside less as a static landscape and more as a community with similar needs to other communities. Thus those estate owners who presently under utilise their resources are encouraged to fall into line with the better estates and concentrate on building employment etcetera in the community. A thriving local economy is seen as being more important than a thriving grouse shoot. Of course improvements which can be made in this direction are dependant both on land quality and the efforts which have already been made to create a diverse employment structure.

Eventually rising costs of energy and fertilizers, as well as increasingly hostile public opinion against farm chemical use, are reflected in their lower use, enabled by improved crop strains, more complete use of organic fertilizers, and particularly refined management practices with regard to fertilizer application. The effects of movements towards healthier foods reducing fertiliser use are negated by a lowering in meat consumption making organic fertilisers less abundant. Chemical fertilizer use is reduced to around 80% of the present level.

More resistant strains, and strains designed to perform well with less fertiliser, the use of more selective pesticides and herbicides, particularly shorter lasting biological pesticides, and the more careful monitoring and control of amounts and timing, are able to reduce these inputs down to 60% of the present level, possibly encouraged by some legislative restriction on chemical input induced by 'pesticide incidents'.

Areas which have gone over almost wholly to monoculture tend to return somewhat towards mixed farming due to high transport costs, higher emphasis on organic fertilizer use, pressure from public ecological opinion, changes in the structure of C.A.P. subsidies, and higher energy prices. This trend is somewhat restricted however by some changes in dietary habit away from meat consumption. The mixed farming also enables more energy to be created and used on the farm more easily, thus increasing overall energy efficiency.

Organic farming also grows in importance, all farms becoming more organic by 2034, whilst 10% of farms, whether for truly economic or other reasons, are fully organic by 2034.

"Organic farming cannot really become significant."

Albeit in a small uneconomic way,in a perhaps misplaced idealisation of the 'good life', some people, particularly many rural inmigrants, turn to food production, usually for home consumption. The number of people working their own small plots in this way doubles over 50 years.

Including these owners of small food producing plots, farmers' spouses with an active involvement on the land, part time and seasonal workers, some 10% of all adults have some involvement on the land by 2034

This trend is added to by a movement towards increasing farmers' margins by increasing on-farm processing of products, thus more people are involved in farming without necessarily working 'on the land'. In this way the decline in the number of full time agricultural workers is halted by 1995, thereafter the numbers increase slightly.

Only about the same area as today is ploughed in 50 years time, as subsidies for producing crops from marginal land are changed, so that it becomes no more lucrative. Emphasis is more on the better use of the most marginal land for livestock production.

Unlike the situation in many other countries, National Parks are never vested with highly restrictive conservational measures, and they remain conservation areas more in name than in practice. Instead, rigid conservation is restricted to smaller areas such as nature reserves and S.S.S.I.s, which become more rigidly conserved than at present. Other areas become subject to new classifications such as 'Environmentally Sensitive Areas', administered by M.A.F.F. and D.A.F.S. under E.E.C. agricultural structures regulations. However the effect of conservation on farming on a national scale is little more than negligible except through the voluntary action of farmers.

Forestry, having had more emphasis put on mixed species plantations, peripheral belts of deciduous trees, and carefully chosen plantation shapes and contours, becomes seen as more compatible with the aspirations of environmentalists, and some growth is seen in the uplands.

Fuel price rises force a considerable move towards energy conservation on the farm. This is brought about both through improved machinery design, in common with sectors outside farming, including the use of more correctly sized machines for the job at hand, and savings through better management, such as the use of multiple implements on single passes over a field, which altogether save not only time, but some 25% of the energy presently used. There is also a greater awareness of intensive building energy costs, and whilst many farmers concentrate on energy saving and the use of renewables, others abandon intensive animal rearing techniques altogether, partly due to the energy costs, but also due to social pressures.

There remains considerable divergence in farm sizes, with no increase in size of the largest units, but some amalgamation of smaller and medium sized units and a larger number of very small units. Larger farms tend to become more internally diverse. Economically the larger units do grow however, as other food processing functions are adopted by farmers and the boundary between farming and the rest of the food industry becomes increasingly blurred.

"Not enough account has been taken of the potential of factory food production. The technology of bioengineering and controlled environment is taking us there, so that it will become economic to produce raw material in 'growth units' for the food manufacturing industry."

The dissent in this section comes from a respondent who disagrees with most parts of the agricultural scenario. Inserted as a comment in the third round scenario it gained no support, and indeed takes a view dramatically opposed to that of most other respondents.

Given the rising energy price scenario, and indeed the prospect of general growing resource shortages, it does seem unlikely that a type of farming relying more and more on non-renewable inputs, and less and less on solar radiation, will grow to become much more important, however high tech it is able to become.

3.4.5. Energy Saving Options-

The final part of the scenario listed opportunities for energy saving and use in rural areas, suggesting the most beneficial possibilities that came out in the second round survey. The following is therefore amended to take account of third round responses.

> On energy production in rural areas, though agreement is by no means unanimous, there is generally higher confidence in small scale projects (particularly wind projects integrated such that storage is no longer such a problem, and heat pumps) and biomass. There is little confidence in the future of methane production from waste, this being limited to very large farms and urban or small town sewage plants. Photovoltaics development seems to depend exclusively on the development of techniques which will make photovoltaic cells much cheaper. (The majority of people have no confidence in it, one respondent however is adamant that this is the most important British renewable of the future.)
>
> The types of biofuels which are seen as having the most potential are new forestry plantations (more particularly short rotation coppicing), straw and forest thinnings.
>
> In domestic energy use insulation standards, passive solar design (in new housing rather than retrofit), and micro-electronic control devices, together with heat pumps in

larger buildings, are seen as having the greatest potential, whilst the building of homes smaller than present private housebuilders standards, direct energy saving without any technological change, and particularly the voluntary rejection of consumer goods are seen as non-starters.

Reductions in intensivity are seen as the best energy savers in agriculture, both by moving away from intensive animal rearing and the reduction of field chemical inputs. The replacement of some machinery by human labour, on the other hand, is rejected by nearly everyone.

"Is intensive livestock production expensive in terms of energy? E.g. much of the waste energy in a livestock housing unit can be recycled to keep the unit warm. I dont think there is much to save here by reducing intensivity".

This note of dissent does not tally with the facts, for intensive animal production is intensive in energy (see section 2.2). It is also a circular argument to suggest that the recycling of the large amounts of energy used in some way negates the initial use of that energy. Certainly in food value alone, intensive livestock rearing is very inefficient.

In rural transport, avoiding the need to travel is seen as a better solution than making travel more efficient. Most respondents giving the replacement of travel by non-physical forms of communication, and the use of mobile services, higher priority than more efficient mass transit or car sharing.

"Efficient mass transport providing human contact will be more important than I.T. based communication".

This respondent again ignores the local human contact achieved in small communities.

> In general, energy saving in the home and in agriculture, are seen as having greater potential than energy production in rural areas, with savings in domestic energy use at the top of the list and renewables given far less confidence, even by those whose specialist field is in renewables. Energy in transport is seen as the least important sector.

"Is rural domestic energy consumption sufficiently large in comparison with agricultural consumption to permit greater absolute savings".

The local survey, section 7, shows that domestic energy use, at least in the surveyed areas, is indeed considerable, being greater than agricultural energy use.

3.5. Summary of Scenario Results-

3.5.0. Introduction-

Certain points in the scenario have not been finalised, which does detract slightly from the validity of the end results. Yet for the most part it remains a cohesive scenario, and there follows a summary of the main points in the 50 year projection.

3.5.1. International-

World economic growth at 2%/annum to 2010, dropping thereafter.

Population growth slows around 2010.

Wealth redistribution sporadic.

Starvation and malnutrition grow as problems throughout period.

Maximising gross national product lowers in significance.

South East Asia and China become part of 'first world'.

Africa shows little improvement.

Traditional manufacturing resides in the third world.

High tech and service industries based in the present industrialised countries.

Energy price rise averages 2%/annum, 5%/annum after 2010.

Coal liquefaction begins to replace oil, third world alcohol production less so.

Still new oil finds by 2035.

Electric vehicles of only limited importance.

3.5.2. Europe-

E.E.C. grows in importance, though Europe still troubled by extremes of nationalism.

Attitude to E.E.C. member states varies depending on ties to U.S.

3.5.3. National-

3.5.3.1. General-

Employment structure changes, working hours reduced by 20%, work for payment in kind by 2000.

DIY movement becomes a major force in the economy.

Parallel with current high tech, DIY impervious specialist economy.

Political parties move to the right, 'Green' parties gain prominence slightly.

Continued, if sporadic, withdrawal of the state from service provision.

Service industry continues to grow in the U.K.

Economic life based more on 'family'.

3.5.3.2. U.K. Energy-

Coal increases in use compared to oil, most dramatically after 2020, with the introduction of coal liquefaction techniques.

North Sea oil peaks before 2010, down to almost nil by 2044.

Conventional thermal electricity generation up to 40% efficiency.

CHP schemes in limited urban areas only, bring overall efficiency up to 45%.

Electricity use rises slowly, more quickly towards the end of the period.

One large tidal power scheme built.

Photovoltaics most important renewable worldwide after 2020.

One large wind farm and one wave power scheme built.

Most other renewables small scale and restricted to remoter areas.

15% of electricity used in these remote areas generated by renewables.

Use of short rotation coppiced fuelwood grows in importance.

Public awareness and practice of energy conservation grows.

Micro-electronic control systems can save 20% of energy by 2035.

3.5.3.3. U.K. Rural-

Rural population increases from 23 to 33%. Only very isolated areas see continued depopulation.

Housing remains high density in settlements, this rural development takes some impetus from urban renewal.

Friction between indigenous inhabitants and incomers becomes blurred.

In remote areas, many planning controls lifted, but not around major urban areas.

Planning more restricted to conservation of specific sites.

Some small, high value new industries locate in rural areas.

Decline in public service provision.

Rehabilitation remains popular, along with vernacular and passive solar techniques in new building.

Steeply rising oil prices after 2010 curtail the growth in car ownership.

Mass transit privately financed small operations, non-physical communication more and more important.

3.5.3.4. U.K. Agriculture-

Land value structure changes in remote areas as 'building land' is no longer so valuable, other land prices rise somewhat. Slower price rises than in the past, but land remains inflation proof.

Large estates are rarely split up.

Growth in institutional farm ownership slows.

'Environmental opinion' becomes more concerned with 'economic local communities'.

Chemical fertiliser use falls to 80% of current use.

Pesticide inputs down to 60%, some legislative restrictions.

Some return to mixed and organic farming, 10% of farms fully organic by 2034.

Number of people growing their own food doubles in 50 years.

10% of all adults have some involvement on the land.

More on-farm food processing.

Area presently ploughed remains static.

Better use of marginal land for livestock production.

Rigid conservation restricted to Sites of Special Scientific Interest (S.S.S.I,s) and nature reserves, together with new 'Environmentally Sensitive Areas'.

Improved machinery design and management saves 25% of on farm energy.

Intensive livestock rearing lowers in importance.

3.5.4. Conclusions-

The above set of characteristics therefore corresponds to a 'most likely scenario' for a 50 year period into the future. These characteristics are applied in section 9.2 to the results of the local surveys as reported in sections 5 to 8. In this way the current potential for a greater degree of rural energy autonomy is projected into the future using the results of the Delphi method postal survey. Although the foregoing study of futures has initially concentrated on larger scale issues than the local surveys will, the final Delphi scenario contains many suggestions for the future of specific features of rural areas, which can be applied to the smaller scale areas of local survey.

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4. A REGIONAL SURVEY OF FUEL SUPPLIERS; METHODOLOGY AND RESULTS-

4.1. The Background-

A macro-scale survey of total regional fuel use throughout a large part of Grampian Region was conceived as a back-up to the more detailed core of the project, the local scale door-to-door survey of households and agricultural holdings, with a view to gaining knowledge of patterns of present energy use on a larger scale, both to check against the results of the local survey, and to apply to the Delphi results , assessing how such patterns might change in the future.

Its tentative purpose was to collect information for the whole region on amounts of different types of fuel used, such information to be split, wherever possible, into small local areas of supply, such as Ordnance Survey grid squares or parishes, the exact methodology for such a split to be dependant on the quality of information obtainable from the suppliers.

Such information could then be used partly as a check against local level surveys, to determine their accuracy and applicability in the wider context, and partly in its own right to determine the relationships between energy use and such things as land use and settlement patterns and available non-commercial resources.

4.2. Methodology-

The area to be surveyed was determined as Gordon, Banff and Buchan, and Kincardine and Deeside districts of Grampian Region, thus encompassing the majority of the region, whilst excluding the complicating influence of Inverness based suppliers on Moray District, and avoiding the urban environment of Aberdeen City. Within this area, suppliers of different fuels were contacted with a view to ascertaining their last 12 months figures for amounts of fuels supplied, with the data broken down into as small areas as possible.

A particular feature of this supplier sampling frame is its lack of homogeneity; the omission of just one supplier of a particular fuel type might make little difference, might be of only local importance for individual areas or villages or, in the case of large suppliers, might have considerable general impact. With this in mind it should be noted that it proved impossible to achieve a 100% list of suppliers for most fuels with any degree of confidence, since the Aberdeen Chamber of Commerce do not keep lists, whilst commercial directories are constantly changing, incomplete, and may not specify dealings in particular fuels in the case of multi-purpose companies. Another common feature which needs to be eliminated is multiple handling of materials, with many smaller suppliers purchasing from the larger suppliers, often on an irregular, and sometimes unrecorded basis.

Two types of enterprise were identified, which were dealt with in different ways; local and regional suppliers, and national public and private bodies, for whom Grampian Region represents only a small part of their markets. The local suppliers, by and large, were sampled by means of a series of short telephone questionnaires (see Appendix 4), designed to extract information in as consistent a form as possible. The informal, telephone approach was felt to be more likely to achieve success when dealing with people more used to verbal requests and dealings than to written communication, and who do not have the kind of organisation which is set up to handle a lot of 'official mail'. It was also felt that the telephone approach was more likely to be able to allay peoples fears as to confidentiality.

National bodies and larger organisations, on the other hand, were approached through a letter not structured as a questionnaire, and subsequent telephone conversations and meetings, since information availability and the form that it took was more varied, and more important in the individual case.

The categories into which fuel was divided for the production of questionnaires were, peat, wood, coal and smokeless fuel, bottled gas and domestic and agricultural oils. Electricity, vehicle fuels and mains gas were dealt with exclusively through letter contact with the larger supply companies.

4.3. Surveying Coal Supply-

The one national agency involved in coal supply, the National Coal Board, supplies most of the coal to smaller suppliers, but felt unable, for reasons of confidentiality, to itemise their supplies to individual merchants, or indeed to provide a list of merchants within the area, partly due to their being in a continual state of flux. In addition, much coal does not actually pass through their hands, being from licensed mines or open cast sites, or imported. However, most coal is supplied via the Coal Board, and the figures in table 4.1, for the period 30/9/1982 to 30/9/1983 give a rough indication of amounts supplied within the old counties of rural Aberdeenshire, Banffshire and Kincardineshire, which form a close approximation to the newer districts being studied, except for the more recent expansion of Aberdeen City District.

Table 4.1. Coal Board Figures for Annual Supply; Destinations in Rural Grampian- (Metric tonnes)

	Bituminous	Smokeless	Total
Aberdeenshire (excluding city)	19500	1500	21000
Aberdeen City	66000	5000	71000
Banffshire	17000	600	17600
Kincardineshire	9000	500	9500
TOTAL	111500	7600	119100
TOTAL RURAL	45500	2600	48100

A further complication arises from the fact that these figures relate to bulk deliveries to suppliers, the final destination of the coal could present a very different picture of supply, particularly since one would expect many Aberdeen merchants to be delivering outside the city.

With a view to getting a more complete picture, broken down more accurately by area, than could be provided by the Coal Board, a sample of 29 depots, the largest sample which could be gleaned from commercial directories, were telephoned and asked questions about amounts supplied and areas of delivery. This number was first reduced to 22, due to the fact that several companies had more than one depot, whilst some companies turned out to be subsidiaries of others. Of this sample, 6 merchants had recently gone out of business or moved out of the area (and assuming normal trading conditions, it seems reasonable to assume that an equivalent number might have become established since the latest records were made available), 6 were either unable or unwilling to provide any information, particularly where their main deliveries were within Aberdeen City, but a few deliveries were made within a wide range of the rural areas, whilst 10 were able to give some kind of positive response as to amounts delivered.

Assuming that 22 suppliers are in operation at any one time, a 45% sample was achieved, although in fact many smaller merchants, such as those found in the local survey areas, exist, who undertake no form of advertising. Nevertheless it is felt that a much larger proportion of total coal supply than 45% was sampled, given that most of the positive responses came from the larger and more organised merchants.

A rough total figure for these suppliers is 35000 tonnes into the rural areas, although some of this goes outside Grampian, whilst other suppliers, not based in Grampian, bring coal into the region for direct delivery to consumers. The above figure loses accuracy still more because one Aberdeen supplier has had a rough estimate taken of the amount he supplies to rural areas, whilst most of the figures represent rough estimates by suppliers from memory of annual amounts delivered.

In terms of the areas to which coal is delivered, it has been possible to map out some assessment of coal supply for ten merchants by area (see Appendix 5), but again delivery areas could only be given roughly from memory, and concentration of delivery is likely to be very uneven across these areas. Any grid square statistics worked out from these figures would be misleading given the number of problems met with in the sample. Furthermore, few suppliers were able to break down deliveries by coal type or end use (such as whether domestic or industrial), and the eventual pattern becomes relatively meaningless in statistical terms.

4.4. Surveying Fuelwood Suppliers-

The only national body concerned with the supply of wood for fuel is the Forestry Comission, and correspondence with them was able to glean little more than a single figure for fuelwood sales which represents a relatively small and unknown percentage of total wood burned. Their figure of 1400m3 from April to November 1983 is difficult to extrapolate to cover a 12 month period, since one would expect felling to be far greater in the summer months. Since their figure includes the whole of the East Conservancy, it takes in a much larger area than is needed for the purposes of the survey, whilst it omits such items as sawmill offcuts, firewood produced from timber sold standing, fuelwood from privately owned woodlands, and that used by Forestry Comission employees and other non-commercial timber collection.

The 1400m3 figure is interesting however, in as much as it represents less than 1% of their total timber sales by volume, a far lower percentage than could be expected were the maximum use to be made of felled timber not suitable for other purposes, such as forest thinnings. Yet all in all, the results which can be obtained from a survey of fuelwood suppliers do not do justice to the potentially great importance of the fuel resource in a rural context.

In terms of the smaller, retail suppliers, a sample of 29 was identified from those people advertising themselves as fuelwood suppliers, sawmills and timber merchants (both rurally based and in Aberdeen). Of these, 13 supplied no firewood at all, (or were unwilling to admit to doing so), 11 were unable or unwilling to give any idea of the amounts they sold, whilst only 5 suppliers were able to give any figure at all for the amounts they sold. Even within this last small category, 4 were unable to give more than a rough approximation, and only one could be traced that kept proper records of the annual amounts supplied.

This partial success rate of 17% is made still lower by the fact that many people supply firewood without advertising, many of whom may not want to be traced since they are making undeclared income, and may not even be acquiring their stocks legally. Larger concerns, such as sawmills, are also probably making undeclared income, having written off offcuts as waste, and then selling it as firewood on a casual basis without keeping records.

Even were it to be possible to isolate all suppliers, the smallest ones would doubtless be treading a fine line between casual collection and commercial operation, it not being easy to differentiate between actual sales and 'favours for friends' which involve some kind of payment.

The one supplier who did keep proper records expressed the feeling that achieving a 100% sample was an impossible task, the belief that most trade was done on an undeclared, part-time basis or by people registered as unemployed, and a degree of frustration that these semi-commercial enterprises could undercut the larger, full time suppliers.

Many suppliers of small quantities of wood would also be unable to state with any degree of accuracy what the end destination of the product was, whilst the fact that many people use wood in small amounts on an irregular basis or merely as kindling, makes resource use very diffuse and difficult to trace.

Patterns of use ascertained at local level were much more useful than the supplier survey in the case of wood.

4.5. Surveying Bottled Gas Suppliers-

Though no national agency exists for the supply of bottled gas, the main suppliers are quite few in number and consist of Calor, B.O.C., Shell and Mac-Gas. Of these, by far the largest supplier of domestic bottled gas is Calor, who supply some 3500 tonnes of cylinder gas to Grampian Region (no figures are available for bulk gas), including Aberdeen City. Although one would expect most of this to be used in rural areas, where piped natural gas is less widespread, there is no way of checking this assertion by extracting the rural figure.

Calor were of only limited help in supplying details of their dealers in the region, since they only keep readily available lists of major suppliers, and not of small sales from local shops. 6 major suppliers in the area were listed, who were included in the telephone sample of 18.

Due to the limited number of manufacturers and the consistent terms of measurement, slightly greater success was achieved in the telephone questionnaire than for firewood suppliers, though identifying all of the suppliers again proved impossible.

Of the 18, 6 either delivered no gas any more, only sold industrial types of gas or dealt only within the city, 3 were subsidiaries or depots of larger companies, 2 were unable or unwilling to impart any information, 3 suggested approaching Calor head office before they would help, whilst 4 gave positive replies of some sort.

A complicating factor is that much gas is supplied by major dealers to customers or smaller suppliers in rural areas, meaning that there is a degree of double handling, but no information is available on the amounts delivered by or collected from the larger suppliers by area, whilst it is impossible to identify small rural traders where bottled gas forms only a small part of a more general retail business. Collection by consumers, rather than delivery, also means that the area of end use is not known in many cases, and it is reasonable to assume that much gas leaves the cheaper, larger suppliers in Aberdeen through collection by consumers, particularly those who commute into the city.

So both the amounts and the geographical pattern of supply are again very difficult to ascertain, and the rough weekly figures obtained from some suppliers do not make adjustments for seasonality of supply, and since the survey period encompassed a spell of particularly bad weather, these are likely to be overestimates, especially since power cuts were being experienced or expected in many areas.

4.6. Surveying Peat Suppliers-

Although no national agency or supplier exists for peat, Dr. R.A. Robertson of the Macaulay Institute for Soil Research, the head of the British branch of the International Peat Association, was of some help in giving general information on the use of peat as a fuel within the region (1). Were the study to have been carried out on the West coast of Scotland or the Western Isles, the Crofters Comission would have been able to supply details of the considerably greater number of peat hags in these areas, yet for the East of Scotland there exists no such convenient record of the small-scale, self cut operations, such as they are.

In commercial terms, there are only two peat cutting enterprises of any size in the region, both situated near Peterhead, and both taking some interest in research into the winning and utilisation of peat as a fuel. Yet neither company was able to supply any information as to amounts supplied, mainly due to the extent of their operations and the fact that they themselves make no deliveries of peat.

Their very size and success means that a large but unknown quantity of peat leaves the region, and indeed Scotland, whilst all sales are by collection, and no particular track is kept of major customers or the areas to which the peat goes. The retail sale point may be petrol stations, small general stores, coal merchants or travelling salesmen, and outside of the crofting areas, peat use is likely to be diffuse and occasional.

Indeed it seems doubtful whether peat, unless privately cut on a non-commercial basis, really provides a competitive fuel source at present, for its cost doesn't justify its use over such fuels as coal, and it may only be able to command its present share of the market due to a kind of desirability derived from its tendency to be included in people's minds under the heading of 'alternative' fuels.

So with peat, the great majority of usage can be identified back to the suppliers, but problems exist at two poles which make it impossible to find any supplier who can give quantitative information. The small suppliers and non-commercial enterprises are too small to be identified, whilst the large suppliers are too large to be able to isolate the proportion of their supply going to the survey region.

As with supplies of wood, more useful information can be gleaned at consumer level, so long as it is accepted that peat use will vary widely from community to community according to availability.

4.7. Surveying Natural Gas Suppliers-

A major factor differentiating rural from urban areas is the domestic use of piped natural gas, for whereas 56% of domestic heat nationally is provided by gas, one would expect much lower figures than this in rural areas. Natural gas is supplied to only a few major settlements in the region, such as Ellon, Peterhead, Inverurie, Stonehaven and Banchory, and is unlikely to have any impact on smaller settlements.

Potentially, surveying the use of gas is a much easier job than with any fuel other than mains electricity, the one supplier being British Gas. Unfortunately however, this concern has a large public relations department, and can therefore offer no coherent answers to questions other than to shower the enquirer with a mass of glossy publications which hold forth on the excellent qualities of British Gas. Yet in the case of piped gas, all that is really necessary is to know which areas are supplied, so that an assessment may be made as to the proportions of people to whom the service is not available, whether they wish to use it or not.

In fact, the only settlements in the region which are supplied are large enough not to figure in the definition of rurality made in previous sections, and thus supplies of natural gas to rural areas in the region can be considered to be nil.

4.8. Surveying Mains Electricity Suppliers-

Again electricity ought to be relatively easy to survey, due to the fact that it is all supplied by one central body, and it has considerable importance as perhaps the most universal and widely used of all fuels.

However, problems arose in trying to obtain data on its use. Although anxious to help, the North of Scotland Hydro-Electric Board only keep records in terms of individual consumers, rather than by area or by supply line, and the only way of extracting this data is to aggregate individual accounts and assign them to an area.

There are two basic problems in trying to achieve this, firstly, the number of consumers is so large as to preclude this type of processing, since the Hydro Board accounts are not in such a form that this can be done on their computer system, and secondly, and with even greater finality, the Board's Commercial Department felt unable to hand over individual accounts without the explicit consent of each of the consumers concerned.

Although utilising this data at local level, by appending a letter of consent for signature by questionnaire respondents, was considered, this approach was dropped after the pilot survey, in which it was found that the individual's knowledge of the size of his own accounts was greater than for any other fuel, and adequate data could be got by direct questionning.

Data on the number of consumers connected for Scotland by regions was obtained, and presented a picture for Grampian Region of more household connections than there were households. This anomaly was caused by the census definition of a household, and the fact that some may have several separate metering arrangements, but the figures do demonstrate that electricity connections now extend to all but a very few rural households, as is borne out by the local surveys.

4.9. Surveying Domestic and Agricultural Oils and Vehicle Fuel Suppliers-

In terms of suppliers of heating oils and the like, an initial sample of 31 suppliers was quickly narrowed down to 10 once head offices had been traced, subsidiary companies had been eliminated, companies not dealing outside Aberdeen City and companies dealing only in industrial or marine oils or lubricants had been removed. This small number is more or less a function of the fact that the small number of major oil companies tend to employ only one agent for oils in each region.

Two companies in this survey took considerable time and effort to produce information on oil deliveries in detail, whilst at subsequent meetings expressing misgivings as to the likelihood of being able to acquire similar figures for other companies, due to the problems of confidentiality. One other company was able to give limited information, yet this section of the survey was suspended once three other companies had suggested approaching the Institute of Petroleum in the first instance.

In terms of vehicle fuel supply through petrol stations, all major oil companies carrying out pump sales were contacted by letter, rather than by structured questionnaire. The companies contacted were; Shell, B.P. Texaco, N.E.F., Esso. Conoco, I.C.I. and Chevron. Replies from all of these companies with the exception of N.E.F. were entirely negative, unimpressed by assurances as to the confidentiality of data, they all refused point blank to disclose any information whatever. N.E.F. on the other hand, were able to impart useful information about their sales which, due to its confidentiality, would only have been of any use if aggregated with the data from other companies. Since this information was not forthcoming, the N.E.F. data could not be used.

The Institute of Petroleum was approached, and it was ascertained that they, in conjunction with the Petroleum Industry Association and Southwark Computer Services Ltd, produce data for the whole country on a 1 kilometre grid square basis, of different types of oil sold and delivered ("PINGAR" data). This information encompasses some 80-85% of sales and includes different categories for petrol and derv, kerosine, gas oils and light and heavy fuel oils which, together with the N.E.F.

figures would provide a near 100% sample of oil supplied to the rural areas under consideration (2).

Although complete in total, some of ths data is not as accurate as it might at first seem, for the Petroleum Industry Association feel that returns from some suppliers, especially the smaller ones, may not be too accurate in terms of area of delivery, a problem which is probably compounded in sparsely populated rural areas by a tendency to lump together various grid squares due to the work involved in keeping records. Thus the information is likely to be more accurate when considering larger areas.

Yet the accuracy of this data is far greater than that which was aohieved for other fuels, for none of which anything like satisfactory data was obtained. Since for the purposes of the survey, oil supply data was considered to be completely useless in isolation, and the survey is only as good as its weakest link, it was decided not to obtain this expensive data, or to undertake the extensive computer programming necessary to access it on R.G.I.T. equipment.

4.10. Summary of Results-

Of the 8 basic different fuel types surveyed, only one, oil, yielded any results that might have been worth pursuing further, were it not for the fact that information on one fuel type was meaningless in isolation. Therefore the original intention of a comprehensive mapping procedure for all fuel could not be realised. What mapping that could be carried out is included as Appendix 5, whilst a full list of organisation surveyed in included as Appendix 6.

The surveys did have some usefulness however, in identifying the types of supply pattern for each fuel, the broad size and organisation of suppliers, and the geographical areas and methods within which they work. Yet without a full picture of regional supply, they do little to expose the potential for a greater degree of rural energy autonomy.

Notes and References, Section 4.

1. ROBERTSON, Dr. R.A. 1984, Personal communication.

2. INSTITUTE OF PETROLEUM, 1984.
PETROLEUM INDUSTRY ASSOCIATION, 1984.
NORTH EASTERN FUELS LTD, 1984.
Personal communications.

5. DEVELOPING THE LOCAL SURVEY-

5.1. Introduction

Previous sections have dealt in more general terms with energy futures and their application to rural areas, and the resource potential for agricultural/domestic integration of energy use in rural areas. These sections isolated areas of interest for study in terms of taking a systems approach to subjects about which there are gaps in knowledge , and suggested the type of survey design which might be appropriate.

This chapter goes onto discuss survey design in some detail under three headings, the design of a sample for the study, the design of the questionnaires, and the results of the pilot survey.

Data collected by the local area surveys relates to size of energy usage and the way in which it is used, size of the rural energy resource, and attitudinal factors such as people's preferences for different types of fuel and their ability to adapt to different future scenarios. It is used to test the hypothesis that rural energy resources, though large, are untapped to a large extent, and that attitudinal changes or economic conditions could bring about a much fuller use of the energy sources available.

The broad areas chosen for the study were, for various reasons, the Kincardine and Deeside, Gordon, and Banff and Buchan districts of Grampian Region.

Aside from their obvious ease of access from Aberdeen, these areas also have a number of other advantages for the study. They exhibit a wide range of farming and landform types, from lowland arable farming to poor upland areas with little profitable land use aside from shooting rights. It is possible to achieve great extremes of rurality and isolation without coming into contact with the complicating factors of tourism or commuter influence, whilst in other parts of the area there is no dearth of such influences should they be required. Patterns of land ownership are also diverse, encompassing both small family farms and very large estates, as are settlement patterns, with both nucleated and scattered settlements. As a large block of land, part of which is a considerable distance from the coast, it is easy to avoid complications caused by a mixing of rural agricultural occupations with such factors as the fishing industry.

Within this broad region several survey areas were chosen as demonstrated below, for the application of a 100% door-to-door questionnaire survey of houses and farms, with commercial, industrial and service premises being omitted .

As well as questionnaire surveys, some land use oriented survey work was done, on the basis of maps and on the ground observation, particularly having regard to the assessment of the size of the rural energy resource.

5.2. The Design of a Sample-

5.2.1. Sampling Methodology-

The chosen method of sampling, that of 100% coverage of areas selected by non-random methods, departs from principles of unbiassed sampling in many ways, yet in other ways it provides the best sample.

With a 100% sample, as long as a reasonable level of completeness can be achieved in practice, the conditions of a perfectly randomised sample from a complete sampling frame are easily met, but in theory the actual population being sampled reverts from being, say, the population of rural Britain, to being merely the populations of the villages which are sampled.

Yet plenty of studies have restricted their populations in this way, often for no better reason than convenience, whilst in the present case the desire to look at rural areas in terms of systems means that individual 100% area coverage is essential in order to be able to view such open systems as a whole. The non-random choice of settlements is a function of the desire to use controlled variables, particularly land use and agricultural systems, and the need to include discrete settlements of comparable size, yet with populations not too large to be dealt with in a limited time and with limited funds.

In a large region, where there are predictable variations in many factors by area, and where land holding patterns are such that a single individual isolated by sampling may have an inordinately high influence, it is better to treat a more integral unit such as a village, recognising the limited ability to make valid statistical extrapolations, than to claim an advantage for randomised sampling which does not exist. A further advantage of the 100% sample was the ability to check that the sampling frame is complete on the ground, leaving fewer problems of, say, omitting holiday cottages in a random sample based on the electoral register.

A further important feature of the sample choice was the need to instigate an initial pilot survey, in order to create data which helps in refining both procedure and questionnaire design to ensure more meaningful final results. The pilot area need be neither large nor particularly rigorously chosen, since it simply provides a guide to the execution of the survey, yet it is worthwhile considering what end use might be made of pilot survey data, and thus the choice of an area for this is discussed further later in this section.

5.2.2. Controlled Variables in the Sample-

It is important that the two areas chosen should differ in certain characteristics as it is that they should be approximately the same in other characteristics. Since what is being measured is different energy uses and different resource characteristics in different types of rural area, and since much of the resource is agricultural and land based; whilst land form, perhaps more than any other single feature, dictates much of the structure of rural life, agricultural pattern and landform are the main controlled variables between the two areas.

Although it might be possible to define an area which had something like 'average' agricultural form, this would be a fairly meaningless concept, (more meaningless than say, averages of population density or accessibility to services, for instance), and so it seemed appropriate to choose areas from two extremes of suitability for agriculture; broadly speaking, a predominantly arable area and a predominantly hill area. Such a choice is likely to yield differences in crop types, land holding structure, employment on the land, amount and type of unproductive land, and outlying population density.

In other respects the two areas were broadly designed to be the same, such as in terms of total population, services, commercial activity, accessibility, influence of tourism and commuter housing, age of dwelling stock and the like, so that constraints arise as to exactly which areas and settlements prove suitable for the study.

5.2.3. Choosing Survey Areas-

It was felt that an optimum number of households, including farms, to be included in each area, in terms of the practical ability to carry out 100% surveys, was around 200, and thus, with average occupancy of around 2 to 2.5 persons per dwelling (1), populations of around 400 to 500 were required in each area. Each district council involved has produced, as part of their local plans, both lists of settlements with their respective populations, and settlement maps which rigidly define the boundary of each village, and the housing, industry and services to be found within it.

By a process of adding together the populations of each settlement within a district, and subtracting this from the total district population, one comes to an assessment of the proportion of the rural population living in nucleated villages, from which a proportional addition can be made to the basic settlement population, to cover the correct number of those living in outlying areas. If the inclusion of this proportion corresponds to an area extending roughly half way to the adjacent nucleated village, then a further rough measure of the appropriateness of the sample is achieved.

Thus, for Banff and Buchan District, if all settlements with over 6000 population are removed, i.e. Peterhead and Frazerburgh, leaving a total population of 51,789, then with settlements over 150 but less than 6,000 having a total population of 35450, some 68.45% of people outside the towns live in villages, 31.55% in the outlying countryside (2).

The corresponding figures for Gordon District are; a population outside towns of 48,030 and a village population of 26,622 , meaning that 55.43% of people live in the villages and 44.57% outside, a somewhat lower proportion than in Banff and Buchan, and further emphasised by the generally smaller size of the villages in Gordon District (3).

So, given an optimum number for handling by a single surveyor of around 200 dwellings, and a persons/ dwelling ratio of about 2.57 (4), the population coverage ought to be about 2.57 x 200 = 514, or a village population of 514 x .6845 = 352 in Banff and Buchan District and 514 x .5543 = 285 in Gordon.

The settlements which most closely meet this figure are shown in Table 5.1.

Table 5.1. Settlement Sizes in Banff and Buchan and Gordon Districts/-

BANFF AND BUCHAN DISTRICT

SETTLEMENT	POPULATION	DEVIATION FROM REQUIRED NO.
Cuminestown	400	+13.64%
Rothienorman	357	+ 1.42%
Fetterangus	279	-20.74%
St.Fergus	289	-17.9%
Stuartfield	459	+30.40%

GORDON DISTRICT

Kirkton of skene	242	-15.09%
Lumsden	240	-15.79%
Methlick	315	+10.53%
Rhynie	320	+12.28%
Udny Station	281	- 1.40%

The two settlements which most closely meet the suggested number are Rothienorman and Udny Station. Of these, Udny Station can quickly be eliminated as being too close to the influence of Aberdeen commuters and thus not fulfilling the requirements as to rurality, Kirkton of Skene can be eliminated for the same reason, whilst St. Fergus is too near the coast, and too influenced by nearby major oil dvelopments.

Thus Cuminestown, Stuartfield, Fetterangus and Methlick are left as possible settlements in lowland, arable areas, Rothienorman in a more hilly area, and Rhynie and Lumsden in upland areas.

Matching Rhynie with Methlick is impractical, since the two have rather different accessibilities, Methlick being rather more accessible for commuting than Rhynie, as it is situated not far from the major growth area of Ellon. Methlick also has none of the industrial land zoning set aside in Rhynie, and so there would seem to be sufficient different characteristics, other than those of land use and type, to preclude Methlick from the study.

Thus four settlements remain, two from each district, Rhynie and Lumsden, and Cuminestown and Fetterangus. Although Lumsden and Fetterangus have various similar characteristics other than size, such as their distance from Aberdeen and estate village type of layout, there are also various immediately obvious differences, such as the number of persons per dwelling, at 2.1 in Lumsden and 2.6 in Fetterangus. The location of Fetterangus also presents some difficulties, since it is situated rather near to Peterhead and is overshadowed by the proximity of Mintlaw, Maud, Old Deer and Strichen, to the extent that it cannot be said to have a significant catchment area for it's services, or to have any real potential for autonomy by itself.

On the other hand, Rhynie and Cuminestown are better matched in all these matters, both being situated within a relatively large area of few other settlements, and both being well outside the influence of commuting to either Aberdeen or Peterhead, neither is tourism likely to prove a great influence in either settlement. Both have similar areas for recreation, commercial and new industrial uses, whilst both have the facilities of sewage treatment plants and primary schools. The persons/dwelling ratio varies little between them, 2.21 in Cuminestown and 2.12 in Rhynie, their sizes are also appropriate to within 1.5%, and the requirement to find a hill and an arable area is met admirably

However, a considerable problem exists with Rhynie, which legislates against it's inclusion, in as much as in the year preceding the survey fieldwork, two seperate surveys, both intended to have 100% coverage, have collected social data from the village. These were, a transport survey at Aberdeen University Department of Geography, linked to 'Scotmap' bus transport changes, and a social conditions survey carried out through the Open University. Although not coincident with the present project academically, the undertaking of a third survey in the village in such a short space of time could cause considerable resentment amongst the over-surveyed residents, which problem could far outweigh the potentially useful effects of information exchange between the three surveys. A further point is that, although on the face of it merely coincidental, the choice of this small village by 3 separate surveyors in such a short space of time, tends to cast doubt on the validity of the sample design. It seems that Rhynie's position in a hill area, being of handleable size for a single surveyor, and not being influenced by tourism and commuting, makes it not an 'average agricultural settlement', but a highly unusual village in it's isolation and apparent 'unremarkableness'. It perhaps demonstrates the unconscious bias carried out by academic surveyors in their implicit idealisation of the structure of rural communities.

For the above reason, and in spite of the difference in size, it was decided to choose Lumsden as the village in a hill area to be surveyed, rather than Rhynie, and to recognise the bias which might creep in if identical size was stipulated as a condition.

Lumsden lies in the quite large and tortuously shaped parish of Auchindoir and Kearn, and is the only settlement of any size in that parish, which includes much hill land, and also the main road running south-east almost as far as Bridge of Alford. Lumsden is situated a little near Rhynie for an unskewed 5 kilometre radius area to be the sampling frame, but if an area was taken to points half way between Lumsden and the next major settlements, a satisfactory sample might be achieved. This parish has some advantage in being free from other villages.

Cuminestown, on the other hand, though the largest settlement in Monquhitter parish, is not the only one, with small settlements such as Maryhill and Garmond swelling the numbers of people in this larger parish. It was therefore necessary to artificially split Monquhitter parish in order to achieve a more manageable sample size.

5.3. Sample Area Choice for the Pilot Survey-

In order to test the efficacy of the questionnaire design, in terms of the individuals' ability to respond to the questions, the ability of questions to accurately reflect energy use patterns, and the ease of data processing, it was felt to be essential to conduct a pilot survey of a small area, including data collection, processing, and elementary statistical tests and conclusions using S.P.S.S., before carrying out the main survey.

Sample design and questionnaire application for this pilot survey was the same as for the main survey, though the design of the actual questionnaires was refined as a result of the pilot. The size of the area of the pilot survey is not crucial, except that it should be small enough to make 100% survey manageable.

Theoretically, the characteristics being measured ought to be roughly the same in the pilot area as in the main survey areas, and a village exhibiting median characteristics between Cuminestown and Lumsden ought to have been chosen. On the other hand, aside from being merely a trial run, the pilot survey can yield some results which can lead to some interesting conclusions in their own right, if the area chosen encompasses more different characteristics than can be considered in the two main villages. Two factors of considerable interest, which do not have a large influence in the two main survey areas, are tourism and commuting.

The latter factor can also be an advantage in as much as the inclusion of commuter influence also means that the sample is likely to be more accessible and easily worked from Aberdeen, a factor which, though not good practice to include as a parameter in the main survey, can safely be considered in the context of the pilot study.

As already stated, the size of the pilot area was not of importance, but a sample size which is manageable, but large enough to have some statistical relevance, lies around the 50 household mark.

Allowing for an area around the village to be taken into account, this means a settlement of between 30 and 40 houses should be chosen, representing a population of between 60 and 100. The Banff and Buchan District Plan lists no settlements as small as this, but a list can be extracted from the Gordon District Plan of settlements of a suitable size (See Table 5.2.).

Table 5.2. Settlement Sizes for the Pilot Survey-

Villages	Populations
Dunecht	104
Garlogie	88
Gartly	106
Hatton of fintray	101
Lynn of skene	95
Sauchen	66
Tipperty	97
Udny green	83

Of these possibilities, Tipperty is rather too coastal and Gartly is unlikely to be affected by commuting, being too far away from Aberdeen. Udny Green is rather too near to the larger settlement of Pitmedden. Lynn of Skene, though probably not as well surveyed as Rhynie, has had some work done on it, and a return might have caused some resentment (5). Sauchen, on the other hand, is perhaps a little too small to constitute a village in the same way as Lumsden or Cuminestown.

Of the remaining 3 settlements, Garlogie is perhaps too lacking in the facilities found in larger villages, such as a school and shops, whilst it has a very dispersed linear form.

There was little to choose between the remaining two villages, Dunecht and Hatton of Fintray, except perhaps that Hatton of Fintray might be considered to be rather too urban in it's influences, situated as it is so near to Dyce, whereas Dunecht ought to have preserved rather more of it's rural and agricultural nature.

Thus Dunecht, and an area around the village corresponding to an additional population of 45% of the total surveyed, was the subject of the pilot survey, with the sample drawn from the annually updated electoral register, in order to capture the whole of the geographical area chosen.

5.4. Designing the Questionnaires-

5.4.1. Introduction-

Aside from the basic purpose of the pilot survey, that of testing the applicability of the survey design in a kind of 'fine tuning' exercise, the hypothesis and purpose of the whole local level survey, as stated in section 2.1 is ; to study both rural energy use and the rural energy resource, with a view to ascertaining the extent to which a greater degree of rural energy autonomy is possible through the medium of integration between domestic and agricultural/forestry sectors. Thus the nature and size of the resource must be measured, present use characteristics should be ascertained, and technical ability and the willingness to aspire to energy autonomy on the part of both sectors must be gauged.

The environment in which such use of energy takes place must also be measured, particularly having regard to the potential for energy saving through such improvements as insulation, and to the flexibility of fuel use as gauged by both fuel using appliances and mental flexibility and willingness to adopt local resource use and conservation strategies.

There are various prerequisites for a more autonomous energy system, and various other factors influencing the ability to be more self-sufficient. These requirements are; the existence of an untapped resource, the technical ability to use such resources, and the knowledge and willingness of both consumers and the local land-owing power base to undertake such strategies. Other factors influencing the ability to be autonomous include the ability to save on present levels of energy import without substitution, in terms of the ability to introduce any necessary changes in fuel burning systems, and the willingness and wherewithal to conserve in this way.

Thus all the above factors had to be gauged by the two questionnaires, and this means the establishment of a very full picture of the characteristics of the areas through the development of a very comprehensive set of questions. Commercial premises were excluded from the sample both for purposes of simplification and to produce suitably homogenous data to allow a greater degree of extrapolation into wider areas than those being surveyed.

The two questionnaires involved data collection in various fields as follows; the household questionnaire collected data on the individual inhabitants of each dwelling and their origins, the tenure, available services, structure, insulation, type, size and structure of the dwelling unit, full energy use characteristics and installed fuel using equipment, and attitudinal data on the acceptance of local fuel resources and renewables, attitudes to autonomy and opinions on energy issues, economic conditions and political factors at the national level. The agricultural survey, on the other hand, aimed to acquire data under the following heads; farm size, position and tenure, employment, land use and stocking levels, subsidiary enterprises, amounts of produce marketed and amounts of various energy intensive imports bought, farm buildings and machinery, fuel use characterisics, straw production and burning, the use of and attitudes to renewables, and various attitudes on the future of farming and energy related matters.

Although conceived as blocks of questions in the above manner, actual questionnaire layout reflected the need for a flow and ease of questioning. The philosophy of the design, at this stage, admitted to the lack of perfect knowledge of the eventual usefulness of each question, and was therefore prepared to include more data than might be needed for the main survey areas, in order to ensure that all avenues of enquiry had been covered for initial data processing and questionnaire redesign.

5.4.2. The Household Questionnaire-

5.4.2.1. Data on Inhabitants-

It was felt that it might be useful to have a complete profile of all household members, so that such factors as travel to work might be incorporated into energy use, and so that data on age, occupation and origins can be set against attitudinal factors and other variables. For this reason data was collected on the age, sex, relationship to the head of household, occupation and travel to work of each household member, and origins and vehicle ownership for the household as a whole. Most of this data was presented in a tabulated form for compactness, whilst problems regarding the difficulty of computer processing, where several variables describe the same factor and many zero values must be input to account for the household with the maximum number of members, were accepted at this stage.

Various problems were encountered with data on the individual members of households in the Dunecht survey. A problem encountered at the processing stage was the repetitive strings of nil values needed for missing individuals in each household with fewer than the maximum number of people. However, this is mainly a problem of the time-consuming nature of data processing, and no way round it was found for the main survey areas.

Another problem in the pilot was the lack of a variable recording the education level of respondents, information which is by no means always obvious from their occupations. Thus this information was included in the main surveys. However, it was felt that to ask this question directly was often likely to lead to offence, so that the information was often gleaned by inference. Thus whilst not being entirely hard and objective data, the question on education level does help to record insights into peoples' level of knowledge on particular subjects.

A further addition to the personal data is the mode of travel to work, backing up the data on miles travelled to enable an assessment of fuel use, for whilst car ownership was recorded in the Dunecht survey, this does not necessarily reflect the travel mode of each individual within the household.

Finally, to help identify any bias arising from the individual answering questions on behalf of the household, the main area questionnaires recorded which member of the household it was who provided the responses.

5.4.2.2. Data on the Dwelling Unit-

The energy use characteristics of a house are obviously dependant on its size, type and structure, and so these factors were incorporated into various questions to ascertain house age, number of floors, whether the house was detached, semi-detached or end terrace, mid terrace, or a flat, construction materials, details of any insulation or any grant aiding which might have been received, house tenure and number of rooms. Additional questions were incorporated to ascertain the general housing standard, by asking about access to certain services such as mains electricity, mains drainage, bathroom and telephone, although in retrospect it is doubtful whether this data says much about housing standards, since some services are universal, whilst others, such as connection to mains drainage, have little bearing on housing quality. Satisfaction with housing standard was also investigated through a question on desired improvements.

Partly in order to be able to pick up any large areas of land not included as farms, but also to gauge ability to use renewables or store large quantities of wood or peat, a series of questions were asked about land area and use, and details of any outhouses associated with the dwelling unit. Due to the limited usefulness and time consuming nature of these questions, they were simplified in structure and content for the main survey.

For the main surveys, tenure was extended to facilitate the recording of the names of landlords. Types of services such as water and drainage were expanded to include private supplies, and construction data was increased to include floor insulation, percentages of different floor coverings, glazed areas and percentage double glazed. A value for the level of ventilation and values for exposure and house aspect were also included.

An additional variable, the gross floor areas of dwellings, was also included in the main questionnaires.

Adding these construction statistics enables a more complete calculation for heat loss to be made, which can be compared with fuel use and correlated against other factors. The most spurious of these new figures is probably the loss of heat through ventilation. This figure was arrived at by assuming that only ventilation not occasioned by the deliberate opening of windows and such like need be considered, and thus the general standard of such features as windows and doors was taken into account, together with residents complaints about draughtiness and such factors as whether new windows have recently been installed. This data was used to produce a simple three tier assessment of ventilation values. House exposure is then simply entered as either exposed or not exposed by a simple visual assessment of the siting.

An extra item was included under 'desired improvements' to the house, to help distinguish between planned improvements and those which are extremely unlikely to take place, perhaps because of tenure or high cost.

5.4.2.3. Data on Energy use-

Energy use data was also put in tabulated form, under the categories heat, cooking, power, total amount used, unit of measurement and occasional use, for the following energy types; mains electricity, home generated electricity, mains gas, bottled gas, coal, smokeless fuel, commercially bought peat, home cut peat, commercially bought wood, home cut wood, heating oils and paraffin, so that a full picture can be ascertained of energy use within the home.

Again this tabulated form created some problems in data processing, due to the need to duplicate large numbers of missing values for fuel types which are not used, yet the structure of these questions proved basically satisfactory. Additional questions were asked on the number of open fires available and used, the presence of solid fuel stoves, and the presence of and desire for central heating systems. No section was included allowing the surveyor to indicate the degree of confidence in the accuracy of figures for each household, and missing values, as opposed to genuine nil values, also presented a problem in processing.

The gathering of basic data on energy use remained more or less in the same format for the main surveys as for the Dunecht survey, with tabulated information for different fuel types. Though this approach facilitates initial recording of data, the same problems exist as for data on individuals, that of repetitive strings of nil values.

Data on the presence of central heating was expanded to include the number of radiators or other heating points served, as a rough measure of the extent of the system, as to whether it provides merely background heat or is a full installation. Preferred heating type has also been extended, with one item asking whether any change has been considered, and another asking for preferred heating type irrespective of any constraints which might prevent its installation. These two questions separate genuine intent from preference and allow the deeper questioning of those individuals, such as tenants, to whom the question of preferred heating type may seem irrelevant.

Finally, the letter giving permission to access Hydro Board accounts was not included in the Lumsden survey. It was found that of all the fuels, electricity use was the most easily and accurately obtained without resorting to this measure. Electricity bills seem to have a habit of sticking in people's minds. Although this letter caused few real problems in Dunecht, its signing was time consuming and difficult to explain to respondents, whilst a few of those surveyed took exception to being asked to put their name to anything.

5.4.2.4. Attitudinal Data-

Some of the attitudinal questions, such as on local fuel supply problems, exist merely to pick up any important information which might have been overlooked up to this point, and the answers, though potentially interesting in the individual case, bear little statistical significance. Other questions were concerned with attitudes to expending physical work to gain fuels rather than paying for them, and the perceived opportunities to do so, consideration of the local use of renewables, and feelings about existing and potential local energy autonomy under different conditions.

A grouped list of questions were asked at the end of the questionnaire, aimed at gaining opinions on the future course of various issues, such as the use of different fuel types, including renewables, the cost of living, oil prices, the level of technological diffusion, and political change, all on a national, rather than local scale.

Many of the attitudinal questions could not be expected to produce a full data set, since many people have no strong opinion on some issues, whilst strength of opinion could not be measured accurately, so that strong verbal views given to the interviewer often have more significance than statistical averaging of simple yes/no results. With this in mind, some adjustments were made to the attitudinal section of the questionnaire prior to conducting the main survey.

The domestic questionnaire form for the pilot area is included as Appendix 7.

In the Dunecht survey, the most difficult information to gather in an objective fashion and make meaningful conclusions about, was attitudinal data. Many questions produced little response, and when they did attitudes were seldom simple enough to be categorised easily and still retain their interest. Nevertheless, the fact that interesting responses are received from some people to some of the questions makes them well worth including this section, and only one question was removed after the pilot survey. Several new questions have been included, on political change, the importance of energy saving, multiple occupations, commuting, voting habit and attitudes to incomers. Little information was collected on many of these issues, though they provided some prompting to the surveyor on interesting lines of questioning for those respondents with strong opinions. and encourage more interest in other questions.

5.4.3. The Agricultural Holdings Questionnaire-

5.4.3.1. Basic Farm Details-

The questions on basic farm details aimed to achieve a full picture of the position and land area farmed, the ownership of the farm and status of the farmer, the relationship of any multiple holdings to one another, the uses to which all the land in an area is put, and any subsidiary enterprises which might be run through the farm, as well as livestock stocking levels. It was hoped to be able to draw direct statistical inferences as to the energy resource characteristics of farms for wider areas from this data.

As with various other sectors of the questionnaires, simplification of categories for adequate coding proved difficult, and a balance must often be struck between the need for absolute accuracy, and the need for relative simplicity in categorising data. This would apply, for instance, in assessing the numbers of cattle, where variations occur of type, age, use, length of stay on the farm and seasonality. For the most part, however, a clear enough picture of farm characteristics can be built up in this way.

The pilot agricultural survey did not reveal as much as had been hoped about farming characteristics, which could be used statistically. This was largely due to the fact that only two farms were located within the area, but also due to the difficulty of eliciting much of the information.

A basic change in survey procedure was made, reversing the order of questioning to put the agricultural survey first, so that if information becomes harder to glean as more and more time is taken, the small percentage of household questionnaires involving farmers will suffer, rather than the agricultural questionnaires themselves.

Details of land area and tenure, apart from the addition of some missing values, remained the same as in the pilot survey.

Employment on the farm was extended to distinguish between family and other employees, between part-time and seasonal employment, and allowed for the inclusion of hours worked for part-time workers.

Land use characteristics were extended to allow for an explanation of how woodland and forestry on the farm is utilised, if at all. Thus the questionnaire concentrates more heavily on perhaps the most likely source of under utilised rural energy resource. However, the tendency for much of this woodland to be retained by large estates, often based outside the survey area, means that a large acreage of such woodland may be omitted.

5.4.3.2. Production Characteristics-

A set of questions were designed to record both amounts of produce and the purchase of materials such as feed and fertiliser, so building up an input-output picture of biological energy sources. Most of this information was tabulated, but several separate questions deal with straw production and burning practices, and additional data might have been sought on the use of on-farm woodland. Tabulated questions here also included data on markets used, in an attempt to tie down the area of influence of the farm, though the rigid structure of this data collection proved difficult to handle, and a simpler, more flexible single question was later introduced.

Again, simplifying classifications proved to be a difficulty, such as in ascertaining the types of chemical fertiliser used, but some accuracy can be sacrificed in the interests of being able to process data in a meaningful way.

For the main surveys several items were added under the category of produce, notably the inclusion of separate categories for beef and dairy. Marketing was rationalised to be less time consuming in the field, whilst the same applied to purchases of feed, fertilisers and the like.

Straw production, thought of as potentially a very important factor in rural energy use, was detailed rather more in the main surveys, though perhaps producing rather negative results in terms of demonstrating the existence of an energy resource.

5.4.3.3. On-Farm Capital-

Capital investment on the farm, aside from the dwelling unit, was dealt with under three sections; buildings, fuel using plant and non fuel using plant. Again this information was tabulated, for buildings by use, dimensions, construction, insulation, age, heating type, fuel use, lighting and location, and for plant, for each type of machine, by make, model, horsepower, age and fuel use. Considerable simplification of these sections was required for the main areas, due to the difficulty, and in many cases impossibility, of achieving this level of detail on buildings and plant.

Information was also gathered on the amount of fuel used on plant each year, for which more accurate figures were generally available.

5.4.3.4. Attitudinal and Renewables Data-

Aside from questions ascertaining any present use of renewables on the farm, the attitudinal questions were concerned with gleaning the farmers' views on the use of renewables such as wind, solar, animal wastes and fuel crops, both in terms of their viability on their own farm, and their applicability to farming in the wider context. A few additional questions ascertain the farmers' perceptions of the future of such activities as burning straw in the field, the use of chemical fertilisers, the general intensivity of farming, and the improvement of hill land.

The seeming duplication of questions on renewables in the local and more wide contexts is useful, in that it differentiates between lightly held opinions and serious views on the respondents personal use of the resources. As well as simple codeable answers, many of the attitudinal questions put to farmers produced interesting opinions and pieces of knowledge on wider topics, which may add to the researchers knowledge of the local area.

The layout of much of the section on attitudes was condensed somewhat for the Lumsden and Cuminestown surveys, whilst several questions were added to the final list of attitudinal questions, which was altered to allow for a more sensitive response to peoples attitudes, giving more weight to the strength of particular opinions.

The additional attitudinal questions included those on friction between farmers and conservationalists, changes in large estate ownership, organic and mixed farming, number of field operations and number of small food producing plots. They were added for comparison with the final Delphi scenario results, to be able to compare the views of farmers with those of the panel of experts.

Both agricultural and domestic questionnaire forms for the main areas are included as Appendix 8.

5.4.4. Questionnaire Design for S.P.S.S. Processing-

Though it is important in questionnaire design to consider the ability to transfer data onto a workable data file for processing, in this case through the S.P.S.S programme, it is equally important not to allow the need for statistical interpretation to override the desire to acquire certain types of information which may not be easily coded for computer interpretation.

Thus no questions were excluded from the questionnaires specifically for reasons of difficulty of coding, whilst those questions where a simple, classifiable answer was more or less guaranteed were assigned coded numbers on the printed form, and other questions were allotted space for eventual coding, once the range of answers had been ascertained. Although usual practice is to transfer data first onto coding sheets before entry onto computer data files, these surveys were designed such that all coding could either be carried out as questions were asked, or completed later on the same form. Thus coding could be transferred directly onto the mainframe via a keyboard, avoiding both transfer onto coding sheets and card punching.

Due to the complexity of coding in the pilot survey, and to the low sample size of two, the agricultural holdings survey was not processed by computer in this instance, since many basic problems remained in the design. Computer processing was however used for the agricultural questionnaires in the two main surveys.

The household questionnaire data for the pilot survey, on the other hand, was entered onto disc and run through S.P.S.S. A data file was set up containing numeric data at nominal, ordinal and ratio levels, with various problems remaining, such as the need for the input of repetitive strings of zeros for up to 6 additional persons in houses with fewer than 7 inhabitants.

Additionally, problems arose in the pilot study in the treatment of the dwelling unit, rather than the individual, as the unit of analysis, in trying to ascertain statistics on such things as occupation, where there may be more than one person in employment in each household. From this point of view, ratio level data have the advantage of being able to be aggregated for several similar variables, whilst nominal and ordinal level data have advantages when it comes to cross-tabulation and other statistical procedures.

A brief description of the capabilities of the S.P.S.S. package is included as appendix 10.

5.5. Results of the Dunecht Pilot Survey-

5.5.1. General Characteristics of the Survey Area-

In spite of Dunecht's proximity to Aberdeen and to the commuting settlement of Westhill, the indigenous population was found to be extremely parochial in many ways, and the commuting influence was quite low, with only one in six heads of household travelling over three miles to work, and two thirds of regional origins being in the North East. The proportion of retired people is also quite high, with over 20% of households occupied by single retired people.

Employment in manual jobs in agricultural and forestry related occupations is high, making up a third of head of household employment. Owner-occupation of houses is low, at 18%, whilst only one house is rented from the local authority, and the housing stock is generally old, with 80% of dwellings being over 70 years old and no new building presently in progress.

These features, reflecting the general nature of the village and environs of Dunecht, are a product of one overriding feature, the extreme level of control exerted by the main estate in the area, centred near to Dunecht village. Some 80% of all the housing stock in the area is owned either by this estate or by the adjacent estate. Some 60% of head of household employment (or ex-employment in the case of the retired) is on one of these estates. As all the land in the area, aside from the few owner-occupied houses, is estate owned, building control is their sole prerogative, whilst with over 80% of households using wood as a main fuel source, the estates have an effective monopoly on the supply of this resource as well.

Perhaps more significant than these statistics is the generally feudal state of mind of the majority of Dunecht's inhabitants, and their ready acceptance of this extraordinary level of control exerted over their lives by one man. An example of the reliance of the respondents on the estates can be seen in answers to a question regarding the area's ability to be self-sufficient in fuel in a crisis situation. Most people were confident in the estate's ability to organise replacement fuels on a large scale, whilst others found it impossible to envisage a situation in which they would be able to gain wood for themselves, forthe estate, they felt, would not let them. Even when this question was pushed to the extreme, and they were invited to imagine Dunecht as the only surviving village in a global nuclear war, they still replied that they would be unable to get their own timber for fuel, since the estate would prevent them.

More than any other factor, landlord control influences the environment of Dunecht, in a stronger way than would ever be the case with a large monopoly employer in an urban environment, and exerts far more control than the Local Authority.

5.5.2. Survey Application-

The survey was applied in June of 1984 to 94 houses in an area delineated by having Dunecht as the nearest settlement with at least one shop, so that a reasonable catchment area could be achieved in which most people looked to Dunecht as their immediate centre for basic services. In practice however, old estate boundaries hold greater sway than proximity to the village, and many people living within one kilometre of the village, yet living on land owned by the estate adjacent to Dunecht, do not see themselves as being part of Dunecht at all.

Within this area (see map in Appendix 9), 66 households produced completed questionnaires, only two of which were also farms, 4 households refused to cooperate, and in 24 households there was no response from at least one return, giving an around 70% success rate for the survey as a whole. Although only 2 farm surveys were completed, this represents a 100% return of farm management units centred within the area, though only some 60% of the land area was covered.

Because of the general fear and respect in which the landlord is held, it was not felt to be appropriate to contact the agents of the estate, albeit that this policy did cause some slight problems of access to certain parts of the estate. Many respondents expressed surprise at the lack of contact with the estate, and seemed to feel it strange that anyone should seek to question them without being in the pay of, or having the permission of the estate. Yet the ability to assure them that this was not the case increased the accuracy of some of the answers, and some respondents outspokenness in their opinions.

Of the houses surveyed successfully 32 were in the confines of the village as delineated by the District Plan, whilst 34 were outside, a slightly higher proportion of dispersed population than the average for the District. The refusal rate was relatively high, yet of the 4 refusals, only 2 showed complete lack of interest, the others had genuine reasons for refusal, and the erratic and individual nature of these refusals makes it apparent that the 6% refusal rate cannot be taken as a statistical norm.

5.5.3. General Results from the Pilot Household Survey-

Cross-tabulations were carried out between occupation of the head of household and variables for the total energy used per household in MJ, the presence of different kinds of central heating, the use of solid fuel stoves, the use of wood as a major fuel, the presence of loft insulation and attitudes to self-sufficiency.

Problems arose in the pilot survey in comparing social status with total energy use because of the vast range of quantities used and the unique nature of each data point, making cross-tabulation unrealistic. Relatively easily categorised items such as the presence of central heating are rather more illuminating however, showing a strong correlation between central heating and social staus as measured by occupation. 95.8% of retired people have no central heating whatever, as against 22.2% of professional and executive categories, whilst fewer than a third of total households have central heating, and of those that do over half have just background heat from a solid fuel open fire.

The view of solid fuel cooking stoves as traditional rural implements is shown to be wide of the mark, since none of the retired or agricultural/forestry workers use them, and 7 of the 8 found were owned by households in the professional and executive, clerical, self-employed or farmer categories. The general picture is of a high correlation between class, housing standard and standard of fuel-burning equipment, and a tendency for the commuter, professional classes in the area to put a higher value on some 'traditional' rural pursuits than do the indigenous population.

No significant correlation can be observed between attitudes to self-sufficiency and occupation, and distribution is more or less normal across the different attitudes. 60% of people believed that total energy autonomy for Dunecht could be achieved either easily or with only a few difficulties, and only 29% felt that hardship would be considerable or that such a move would be impossible. The recording of this data was open to much interpretation and surveyor prompting, but the general result is one of a high confidence in the adaptability of the area to change and enforced self-sufficiency.

Cross-tabulations were also made of the way in which occupation relates to the existence or absence of roof insulation, controlling for house tenure. Of the very low number of owner-occupied houses, 10 had some form of roof insulation, whilst of the 54 rented homes only 15, or 28.3%, had any form of roof insulation. Moreover, two thirds of owner-occupied houses belonged to the small number of professionals and the self-employed. So just over a third of dwellings had any insulation, with the situation being particularly bad in the case of houses owned by the estate, where only the houses occupied by the manager of Dunecht Home Farm and the clerk to the estate have any loft insulation. Additionally, many people had no idea whether or not there was any insulation, since they had nothing whatever to do with the maintenance of their housing.

Dunecht showed much stronger correlations between occupation and material factors such as central heating and loft insulation than the two main areas, and this can largely be put down to the effects of housing ownership and employment by the local estates. In non-material variables such as attitudes to self-sufficiency Dunecht showed no such correlations, but a generally higher confidence in their own autonomy than either Lumsden or Cuminestown.

In terms of travel, only 11 of the 66 heads of household travel more than 3 miles each way to work every day, whilst 33 of the remaining 108 people exceeded this distance, most of whom were schoolchildren. The majority of the people who commuted travelled to Aberdeen. Most of the commuting heads of household belonged to the professional and executive and self-employed strata. Determining transport fuel use in the pilot survey proved impossible, since a variable for mode of transport was not included. This omission was rectified for the main surveys.

It was hoped that the regional origins of families would give some idea as to mobility and attitudes, but in the end this data proved less simple to interpret. 48 families had their origins within the North East, and 19 in the vicinity of Dunecht, and though it may be true that many people have limited horizons and see their whole lives revolving around the estate, those with their origins in the North East are spread throughout the occupation classes, with some entrenched estate workers having moved from other estates and other regions, albeit often with a rather more critical eye towards authority than their indigenous counterparts.

47 of the 66 respondents had lived in their present accomodation for more than 5 years, and had this data been extended to include the recording of longer periods of stay, this would have been a useful indicator of mobility, since many of the older inhabitants of Dunecht have lived in the same house all their lives.

The age of the housing stock was cross-tabulated against the presence of roof insulation, and a strong correlation was found, where new houses almost all had insulation, whilst older houses, which are in the great majority, exhibit a strong correlation between insulation and their ownership by particular estates, for whilst one estate has insulated the lofts of all its houses, the other has done so only for its most senior employees.

Central heating, when cross-tabulated with house age, produces the same sort of correlation as the above, though there are some older estate houses with background heating from solid fuel open fires.

Attitudes to the use of renewables were interesting, there being some confidence in the spread of those items which were considered to be 'high tech.', with 27 people feeling that solar power would increase in importance over the next ten years, and 26 people having the same confidence in wind, as compared to 17 and 21 households respectively who had no confidence in these resources, and 22 and 19 people respectively who felt that their knowledge was not great enough to be able to express an opinion, so that awareness, as well as confidence, was quite high. Other sources were seen as less likely to succeed, particularly those which are perceived as being less socially desirable, with only 3 people feeling that methane produced from waste would be a viable energy source, as against 5 who felt that it would not, and 58 with no knowledge of the subject, many of whom expressed considerable incredulity at the very concept of using animal wastes as fuel within their homes (Table 5.3.).

Table 5.3. Attitudes to Renewables, Dunecht.

	Numbers of people having confidence in different renewables		
	Increase in use	No increase	Don't know
Wood	21	29	16
Solar	27	17	22
Wind	26	21	19
Methane generation	3	5	58

A strong general feeling is one of begrudging acceptance of technological innovation as a leading force, albeit that such change is not thought likely to affect Dunecht. Thus 32 people thought that reliance on electricity nationally would increase, with only 17 disagreeing with this, whilst only 21 people felt that their own major fuel source, wood, would increase in use nationally.

The extent of the expectation of increasing technical diffusion is exhibited by the fact that 48 people expressed the opinion that most homes would own a computer in the next ten years, even though not one of these people felt that their own households would have one.

The overall picture arising from the household survey is one of a fairly high level of self-sufficiency, matched by an even higher opinion of their own individual present and potential self-sufficiency, and a high degree of confidence in both the stability of Dunecht and the instability of the rest of the world. All these factors produce generally favourable conditions for the establishment of a degree of local energy resource using techniques and the replacement of imported resources, with the main restrictions on such movement being the lack of individual capital availability, the extreme level of control by and reliance on the landlord, and the top heavy age strata of the inhabitants.

5.5.4. General Results from the Pilot Agricultural Holdings Survey-

In terms of agriculture, no pattern of family farming exists, and of the study area of around 2000 hectares, only 1250 hectares are farmed by units centred within the study area, the rest of the land areas, other than roads, buildings and gardens, is either farmland operated by a management unit centred outside the area, or woodland and parkland under the direct control of the Dunecht estate. Indeed the 1250 hectares only includes two farm units, and thus cannot provide statistically significant conclusions which can be extrapolated over wider areas.

One of the farms in the sample encompassed some 1140 hectares, and was owned by Dunecht estate, the other was 110 hectares, and was rented from the same estate. The former farm employed 13 people full time excluding the manager, whilst the latter was worked entirely by the family.

The land use details for these farms showed around 90% of the land to be rotational arable, 1 to 3% roads and buildings and 7 to 9% rough grazing land. No other uses were identified, since all woodland is managed directly by the estate and doesn't fall within either of the farm units. The larger farm runs some 1500 ewes, 400 beef cattle and 400 young stock, whilst the smaller has just 118 beef cattle. No other livestock or any subsidiary enterprises are run by either farm, making the data from this area relatively simple to assimilate under these categories.

The horizons of the larger farm included produce marketing in places as far afield as Perth, whilst the smaller farm marketed no produce further than Aberdeen.

Purchased feedstuffs amounted to only 10kg per animal, mainly in terms of minerals, whilst fertiliser amounted to some 450kg/hectare. Small amounts of straw are sometimes purchased by both farms, none is sold or produced inexcess of requirements.

The smaller farm had 1600m2 of utilised farm buildings of various sizes, construction and use, none of which had any significant energy requirement in their running costs. On the larger unit there were 15 original farm units amalgamated, with all their associated farm buildings, making the task of accurate documentation by discussion all but impossible.

The ownership of farm machinery on the larger unit extended to 14 tractors, 3 combines, several grain driers, together with 3 road vehicles, pumps and numerous pieces of unpowered field machinery. The smaller unit had only one tractor.

Attitudes to the use of renewables were generally favourable, though no thought had been given to the installation of such schemes on the respondents' own farms. Animal waste use and fuel cropping were seen as uneconomic, and likely to remain so in the context of the relatively productive arable land of Dunecht. On the estate Home Farm some interest was shown in the future of wind as an energy source, though it was not seen as being economic at present, whilst no interest was shown in this technology on the smaller farm. Both farmers were united in seeing most renewable sources growing in importance nationally, straw burning and the improvement of hill land decreasing, and the general level of intensiveness of farming and the use of chemical fertilisers, under much regretted increases in environmental pressure group influence, also going down.

There was generally a high enthusiasm for modern, high tech farming methods, though without supreme confidence in their continuance, an interest in energy saving techniques, and an approach which sees their business as separate from the life and functions of the village, unlike the parallel organisation of the estate itself.

5.5.5. Domestic Energy Use Data-

Reliance on the local energy resource in Dunecht is high, with 75% of households using wood as a main fuel source, and 26.5% of all energy used aside from mains electricity being in the form of wood. It is also notable that almost all wood used is purchased from either estate.

A problem arose in trying to assess heat loss values from the pilot survey, since no values were taken for floor area, ventilation rates, glazed area and the presence of double glazing, and these calculations were omitted from the Dunecht survey.

The general picture is of quite high use being made of local resources, but a high total energy use due to poor housing standards, poor insulation, and inefficient fuel burning appliances, and it is in the field of direct domestic energy saving that the greatest progress can be made towards a higher level of local energy autonomy.

The number of fires used, the presence of a solid fuel stove, the presence of central heating and the preferred heating types give a picture of standards, attitudes and preferences in domestic fuel use. Of particular note is the homogeneity of some of the results, with only 4 out of the 66 households using no open fires on a regular basis, and other heating types paling into insignificance beside this source.

As to preferred heating types, data was incomplete, since it was not collected where no desire to change was specified. Cross-tabulations were carried out to determine whether occupation or age had any bearing on preferred heating types, and it was found that those who desired change were mainly young manual workers, with the old being happy with open fires, and the professional and self-employed categories being in the financial position to have already installed the heating equipment of their choice. It is worth mentioning in this context that gas may well have been specified as a preferred fuel type if people had felt able to identify it as an option for Dunecht, and greater uniformity in answers was achieved in the main surveys by asking specifically for preferred heating type whether or not it was presently available in the area.

5.5.6. Agricultural Energy Use and the Energy Resource-

Imports of energy into the area in the form of fertiliser and feed have been discussed in section 5.5.4. above, as has the use, or lack of use, of energy in farm buildings. Agricultural machinery energy use per annum amounted to some 70 litres/hectare for the larger unit, 55 litres per acre for the smaller, or some 3500MJ/hectare and 2250MJ/hectare respectively. No figures were recorded in the pilot on fuel used in grain drying.

Though straw production averages around 0.7 tonnes per hectare over the whole area, none is wasted and there is generally felt to be a shortage rather than a surplus, with some small amounts bought in. All straw produced is used for bedding or feed supplement, leaving no potential as a fuel resource at present. There is no peat in the area, and aside from the universal resources of wind and solar power, which the estate, with a high availability of capital and control over so much of the land and housing, is in a good position to utilise or encourage, the most plentiful source of energy in the Dunecht area is timber.

With large amounts of deciduous woodland in the area under the control of the estate, which is managed fairly intensively for timber without clear felling, good use is made of this resource, and around 4 million MJ of energy is distributed or sold annually, the productive capacity of some 40 hectares of this type of woodland.

Notes and References, Section 5.

1. Adapted from 1981 Census data for individual Enumeration Districts, H.M.S.O.

2. BANFF AND BUCHAN DISTRICT COUNCIL, 1980, "District Plan, Report of Survey".

3. GORDON DISTRICT COUNCIL, 1980, "District Plan, Report of Survey".

4. Ibid. and
   BANFF AND BUCHAN DISTRICT COUNCIL, op. cit.

5. HARTLEY, J. 1983, "A Study of Transportation and Accessibility in a Small Area of Grampian Region, N.E. Scotland". Unpublished MSc. Thesis, Aberdeen University.

6. GENERAL RESULTS OF THE LOCAL SURVEYS-

6.1 General Survey Results, Lumsden-

6.1.1 Results of the Domestic Survey-

6.1.1.1. General Area Characteristics-

In order to test the potential for a greater degree of rural energy autonomy, it is important to look at both the capabilities of rural people in being able to take advantage of opportunities for self sufficiency, and at some of the material conditions which affect both present and potential energy use. Section 6 endeavours to do this, whilst succeeding sections look in more detail at energy use and resource characteristics.

A feature of Lumsden making it suitable as a survey area is the spread of domestic tenure types. It was established from the 1981 census data for enumeration districts that there was a reasonable split between council tenants, private tenants and home owners (1). However, perhaps the main reason for the large number of council dwellings, (40% of houses in the Lumsden survey area are local authority, the same number as are owner-occupied), is that many of them are small, single person houses for the elderly, reflecting an extreme skew in the population towards the over 65's, and the low level of local employment available. Yet this last feature, far from being unusual, perhaps confirms Lumsden's representativeness as a remote rural community

(2).

Service provision in the area is low, with one village shop (and another craft shop some 3 miles from the village), one public house, one garage and a fencing supplier. The Post Office has recently been the latest of 7 shops to close down, reducing service provision and its attendant employment to a minimum.

6.1.1.2. Survey Application-

The Lumsden survey was carried out over four weeks in March and April 1985, and covered some 150 dwellings, of which 113 were successful surveys, 32 were unobtainable after one return, and 5 were refusals.

It was decided that one return would be sufficient for houses where no response was received at the first visit, in line with accepted survey procedures, though an exception to this was made in the case of farms, where two return visits were made to ensure a high percentage coverage of land area.

Of the 113 completed domestic questionnaires, 72 were carried out within the boundaries of Lumsden village (as shown on map, Appendix 9), whilst 41 were from outside the village, of which just under a third were farms. These figures reflect a slightly lower percentage of people living outside the village than suggested by the District Plan. This is perhaps the result of a higher success rate in carrying out surveys in the village, where so many householders are retired and more likely to be found at home.

All in all, the number of refusals is quite low at around 4%, and the overall 75% success rate for domestic questionnaires is quite adequate. (3)

6.1.1.3. Population Characteristics-

In terms of population characteristics, Lumsden has a high proportion of retired people, at 22.85%, the highest number in any age category, whilst 43% of the houses in the area are occupied solely by one or two people over 65 years old. 80% of the single person dwellings, and 50% of the two person dwellings are occupied by the old. Only 39% of dwellings are 'family houses' or other units with three or more inhabitants, (see Table 6.1.). This picture is even more pronounced within the village boundary itself, where 50% of houses are occupied by the retired only. Such a picture, of a population skewed towards the old living alone does not lend itself to thoughts of individuals taking action over procuring their own fuel supplies.

Furthermore, over half the houses have no person in them with an occupation. In the village itself this figure is over 60%, and very few jobs are to be found in the village.

Of the heads of household who do work however, farming and forestry is the largest employer by far, with 29% being farmers and 20% being agricultural or forestry workers. 18% are other manual workers, skilled or unskilled, 14.5% are professional or executive classes, 14% are self employed in some capacity and 2% work only part time. (see table 6.2.)

Table 6.1. Percentages of Houses with Different Numbers of Occupants, Lumsden.

Persons	1	2	3	4	5	6	7
%of houses	23.0	38.1	13.3	17.7	4.4	2.7	0.9

Table 6.2. Employment Details, Lumsden.

(Percentages of heads of household and of the total survey population having different occupations)

Occupation	Head of Household %	Total %
Farmer	14.2	8.30
Farm worker	10.6	4.76
Other manual workers	6.2	2.54
Skilled manual	2.7	2.54
Clerical	0.9	1.29
Professional and exec.	8.8	3.79
Self employed	7.1	5.08
Part time	1.8	4.44
'Housewife'	1.8	11.74
School or student	0	16.82
Unemployed	4.4	1.57

The withdrawal of most forms of employment has left farming, albeit that manning levels have gone down drastically here as well, as by far the greatest contributor to head of household employment, though the extremely large number of retired heads of household is the only thing that prevents Lumsden being an unemployment "blackspot".

The average miles per day travelled to work or education by the survey population of 288 is 4.3, the average for working heads of household is 11 miles each way, 8.6 and 22 miles respectively for the round trip. These statistics for travel can be broken down further by occupations of working heads of household. The bulk of travelling is carried out by the professionals, all but one of whom travel daily to Aberdeen, a distance of 40 miles, or further.

Perhaps the most significant feature of employment and travel in the area is that, aside from farmers and agricultural workers, and the self-employed working from home, only three people work in the Lumsden area, all the rest must travel at least 7 or 8 miles each way to Alford daily for work. Of these three employed locally, two work part-time at Kildrummy Castle, the third is a professional working from home. Even the self employed often do not truly work from home, but must travel to different destinations daily, whilst only nominally being based in the area.

Two farmers and two agricultural workers also travel to work some distance, but farmers make up 46% of local jobs, farm workers another 29%, and the self employed 22%, and if farmers are assumed to also be self employed, then 68% of local employment can be considered to be self employment.

So the local employment and resource base is still firmly fixed in the agricultural sector, with no other category being fully 'local' even though individuals may have lived in Lumsden all their lives.

One further point about employment, the 'resource base' as it were, of able bodied unemployed, stands at only 5 persons, and this can be said to represent the bulk of available additional labour.

In terms of regional origins, 80% of the people interviewed originated in the North East, and of the incomers, the bulk fall into the professional and self employed categories. Indeed all those listed as professional and executive come from outside the region, and resentment of these people by the indigenous population is quite strong in some quarters.

Turning to the actual dwelling units, the balance of tenure types in Lumsden is quite even, with 46 owner occupied houses, 45 council houses and 22 private rented. Of the owner occupied houses, 22 belong to the 31 farmers, professionals and self employed. 100% of professionals, 75% of the self employed and 57% of farmers live in their own houses, whilst only 27% of retired people do. Within the village itself, 63% of houses are council owned, and only 3% private rented; four of the houses in the village are ex council houses purchased by their tenants.

Old people are rather over represented in council houses, whilst private houses are mainly owned by those in the 25-45 age group, with fewer of the retired in their own houses. Thus, whilst 51% of the over 65's are in council accomodation, and 34.7% own their own house, only 12.2% are in private rented accomodation, perhaps reflecting the preponderence of accomodation 'tied' to employment, and therefore not available on retirement in the past, in this sector (4).

Four estates predominate in the ownership of rented properties, with a total of 17 sampled houses owned by them. None of these private rented properties are in particularly good condition, though there are anomalies here. For instance, one estate owner, whilst doing very little else by way of maintenance, has received grants for 100% double glazing to his properties, so that almost 1/3 of houses with full double glazing are owned by him, albeit that none of these has any other form of insulation, external doors commonly have 50mm gaps under them, and the general standard of these properties is very poor.

Insulation standards are generally fairly high, much higher than those found in Dunecht for example, but this is a feature of the large number of council houses, all of which now have some form of roof insulation, and several of which have cavity wall insulation. Yet outside of the council sector, only 27 of the 68 houses have any form of insulation at all. Of privately owned houses, 24 have insulation in the roof, or just over 50%, and the only employment category over represented here is the professional, all but one of whom have insulation, as might perhaps be expected.

Table 6.3. Tenure and Insulation Levels, Lumsden.

	Local Authority	Owner-Occupied	Private Rented
Total No.	45	46	22
No. with loft insulation.	45	24	3
Occupancy (Rooms/person)	1.25	1.78	1.66

Perhaps it is also significant that the only people having insulation in private rented accomodation are one farmer, one professional and one self employed.

Turning to the perhaps less than scientifically measured variable of education level, of 17 owner occupiers with an education level above school level, 88% have some form of roof insulation. Below this education level, however, only 32% of houses have insulation, reflecting perhaps a higher awareness of the mysteries of heating and heat loss amongst the former group. Education level also is related to tenure, with only 30% of owner occupiers having an education level of minimum school age, compared to 50% of private tenants and 70% of council tenants.

In terms of occupancy rates, most houses in the area house one, two or four people, and the majority have either 2, 3 or 4 rooms. (Number of rooms being the remainder after subtraction of one bathroom and the kitchen)

Average occupancy is 1.63 rooms per person, though this figure is 1.78 rooms per person for owner occupation,1.25 for council properties and 1.66 for private rented accomodation. In council properties there is a narrow spread of house sizes, with no houses over 4 rooms. In general the occupancy rate is fairly rational, with the exception of several older people inhabiting larger houses on their own or as a couple.

Private dwellings however range from 2 to 12 rooms, and occupancy rate varies from 3 room houses with 4 inhabitants to a 10 room house with two people and a 12 room house with only 3 inhabitants. The pattern is similar for private rented accomodation, with some extremes of over and under occupation, though generally the pattern is for over, rather than under occupation, and reflects general population trends in the larger, older dwellings.

Turning to the attitudinal questions, probably the most interesting is the one on the potential for total local self-sufficiency in energy. 38 people felt that self-sufficiency would be easy, 17 foresaw a few difficulties, 24 suggested that there would be considerable hardship, and 15 thought that it would be impossible, whilst the rest had no opinion or could not decide. Thus a relatively high confidence in their own ability to survive isolation in energy terms is demonstrated.

Yet of those who gave some explanation of their views on this question, 8 said that problems would exist only for the old, one that the problems would only arise for the young, 7 that only incomers would have difficulty, 6 that people were neither organised nor motivated enough, 5 that the lack of availability of peat and wood would be the major constraint, 7 that the estate landlords could be called upon to organise things successfully, and only 6 considered fuel for mechanical plant and transport to be a major problem. Only this last group were able to see beyond heating fuels to the whole spectrum of fuel use, and thus recognised their own vulnerability to being cut off from them.

Table 6.4. Attitudes to Local Self Sufficiency, Lumsden.

The Ability to be Energy Independent in Lumsden, Numbers of Respondents.	
No problems forseen	38
Few problems	17
Considerable hardship	24
Impossible	15

Specific problems in achieving energy self-sufficiency, Numbers of Respondents.	
Problems for the old	8
Problems for the young	1
Problems for incomers	7
Organisation and motivation problems	6
Lack of fuel availability	5
Organisation carried out by estate	7
Problem of mechanical plant and vehicle fuel	6

All in all there is a considerable defiant confidence amongst the people of Lumsden in their own ability to be self-sufficient, coupled to a grateful acceptance of the comforts of modern living. The relatively low number of people cutting peat for instance, compared to the number of people in favour of it as a fuel source, might merely reflect availability, but it might reflect a lack of willingness among individuals to practice what they preach.

6.1.2. Results of the Agricultural Holdings Survey-

6.1.2.1. Land Use and Holding Pattern-

The principle on which the boundary of the survey area was defined was that Lumsden village should centre on an area for which it could be considered to be the main local sevice centre. Thus, because of the proximity of Rhynie to the north, Lumsden doesn't form the geographical centre of the area.

It was hoped that, unlike in Dunecht, landholding patterns would be rather more fragmented, with farmland being owned and farmed by more individuals. This proved to be the case, with a mixture of owner-occupied and tenanted farms, one very large farming enterprise encompassing eight discrete original farm units, and two estates, one farmed by the hereditary owners, the other under minimal management on behalf of an absentee landlord who had recently purchased the land with the proceeds of North Sea oil.

Considerable amounts of land inside the area are owned by concerns based outside the area, and thus were not surveyed, whilst the larger landowners proved difficult to contact for interview. For these reasons some quite large areas of land within the survey boundary remain unsurveyed, and only a few basic facts about their ownership and management are known.

Most of the statistics which can be produced on land within the area tend to refer to the better farming land. Although very large areas of hill land, rough grazing, forest and grouse moor surround Lumsden, only one block (albeit of around 3500 acres) of this rougher land could be surveyed, due to the fact that whilst most of the better land is either sold or rented to farmers, hill land and forest tends to be retained by the estates.

15 successful agricultural holdings surveys were carried out, out of a total of 20 managed units identified within the area, 5 farms were unobtainable after 2 returns. Unfortunately these five included the largest farm and the largest estate in the area, yet as will be shown, the statistical accuracy of the results is adequate, since the sample included the full range of farm sizes and types.

The survey covered an area of some 27 square kilometres around the village of Lumsden (including unpopulated hill areas), and the farm survey also accounted for some 27 square kilometres. (Some of this area surveyed, however, is outside the intended study boundary, whilst much land within this boundary is run by owners or tenants from outside the boundary, approximately 17 of the 27 kilometres intended to be surveyed was probably covered in reality).

However, although the farm surveys also have a 75% success rate, and this is statistically adequate, the great variety of farm sizes and the relatively small sample size means that interpolation to the non-sampled farms is difficult, where the missing data might relate to a farm some 10 times the mean size. Therefore, differences in individual farms not included in the sample are taken account of where possible.

Of the 15 successful agricultural surveys carried out, 11 were of owner occupied farms, and 4 were tenanted farms owned by 4 different estates in the area. The size of farms surveyed ranges from 4 hectares up to 1732 hectares. Mean farm size is 124 hectares for tenanted farms and 193 hectares for owner occupied farms, covering a total area of 2737 hectares or 27 square kilometres. Four of the farm units are under 8 hectares, and cannot really be considered as providing full-time occupations for their owners.

When the one very large estate and the units under 8 hectares are removed from the sample, mean farm size is 123 hectares, so that the presence of a large estate has a greater influence on the mean than the small units. In addition to the tenanted farms, some 110 hectares is also let out to the farmers in the sample for grazing.

In terms of land use, some 32.4% of the land area of farms is rotational arable, 11.3% is grass, 43.5% is hill land, 12.2% is woodland not managed for timber, 0.1% is woodland managed for timber, and 0.77% is in roads and buildings. However, when the one large estate is removed from the sample, only 19.1% and 0.3% of land is in hill and woodland respectively, whilst some 68.8% is rotational arable.

This preponderance of rough land retained by estates, with most of the better land being sold or tenanted to farmers, is probably fairly typical of estates in the area, though the estate sampled may be rather more wasteful of its land than others, since according to the estate owner, no management is carried out on the over 300 hectares of woodland, and the rest of the hill land, predominately grouse moor, seems no longer to be used even for this low productivity purpose.

6.1.2.2. Farm Production and Employment-

Although these 15 farms provide more or less full time employment for some 25 persons, it is notable that only 3 of these people are not members of the farmers family. However, since the term family extends to more than just nuclear units, to include for instance, three brothers employed on the same farm, living in separate houses with their own families, employment actually extends to providing livelihoods for some 20 households.

It is interesting to note that the owner of one estate, with an area of some 1732 hectares, employs only his son and one tractorman on the whole estate, and whilst he considers himself to be a serious full time farmer, he only actually exercises any management over some 23% of the land he owns, and whilst average employment on other farms is around one worker per 45 hectares, on this estate it is one worker per 577 hectares. Even allowing for the considerably poorer land quality on the estate than elsewhere, this level of employment is very low.

In terms of stocking levels in the survey area, there is one ewe kept per 2.9 hectares, with beef cattle at the rate of one per 4.2 hectares. Apart from the estate, these figures are 1.3 and 0.6 respectively. Although one farm runs a dairy enterprise, and one has a pig house with 20 sows, there is no other livestock rearing apart from 12 ponies bred for sale on one small unit, and a few poultry kept free range for providing eggs for the farm houses.

Although potatoes are produced in large quantities, this is almost entirely on one of the large units for which no survey could be carried out. This large enterprise is composed of what was originally eight separate farm units. The only other production is of barley and turnips, with 6 farms marketing barley in fairly small quantities, and turnips mainly for on farm use.

In general, the large estate in the sample seems to be symptomatic of a general rural decay in the area, and this on an estate run personally by an hereditary owner professing concern over the lack of employment in the area, popularly believed to be one of the best kinds of landlords to have. It is difficult to accept that, even given the general decline in agricultural workforce, and the poor nature of the available land, an estate of 1732 hectares can only support an employed workforce of one, and that the potential capital available on an estate that size cannot make for a more viable business.

The fact that such landlords do not see their possessions in a commercial manner is also evidenced by the landowners attitude to domestic properties lying empty. When asked why several houses on the estate were being left empty, instead of, at the very least, being sold in their present condition, the researcher was told that the estate had considered renovating one house in particular, an imposing ex schoolhouse of around 140 square metres on two floors, but since an estimate for the whole work had come to £7000, it was not worth their while, even though there was obviously no purchase price to be paid on the property.

Even the one employee on this estate cannot rest easy, the landlord expressed the belief that overmanning was perhaps the greatest problem that employers faced today, and alluded to his own extensive workforce by way of example.

It is noticeable that questions on renewables produced rather more favourable responses to wind than to solar, which may reflect the fact that wind pumping was an economic power source on farms in the area within memory of the present incumbents. Small hydro on farms also produced a more favourable response than it did in the household survey.

Few farmers felt that fuel cropping or the production of methane would hold any importance for the future, though many felt that odd patches of woodland, shelterbelts and the like could be better utilised for fuel, perhaps because these areas seldom actually fall within their own farms. The only landholding with real potential for any of these biofuels, again the sampled estate, did not see them as viable propositions, even for fuel cropping on land presently totally unused.

6.2. General Survey Results, Cuminestown-

6.2.1. Results of the Domestic Survey.-

6.2.1.1. General Area Characteristics-

Cuminestown reflects its longer tradition of private farm ownership than Lumsden (5), with a spread of tenure types shifted considerably more towards owner-occupation, with 65% of houses owner-occupied, 31% local authority housing, and only 4% private rented.

The lower figure for council housing in part reflects the slightly younger age structure in Cuminestown, requiring fewer smaller dwellings for elderly couples and individuals, whilst the very low figure for private rented accomodation reflects the lack of estate control over land and employment.

Service provision in Cuminestown far exceeds that in Lumsden, with 3 general stores, 2 newsagents, a greengrocer, a butcher, a post office, a clothes shop, a baker, two pubs and two garages, together with more industrial units, a car body repair shop, a large joiners workshop, a small mechanical engineering firm, a road haulage company and two building plant hire concerns. This is a total of 20 commercial firms, compared to the 4 around Lumsden and 3 around Dunecht. Of particular importance is the full time employment provided by some of these firms to several local people, whereas in

Lumsden there is no full-time employment provided by the local businesses, except for their respective owners.

6.2.1.2. Survey Application-

The coverage of the Cuminestown domestic survey was not as high as for either Lumsden or Dunecht, at 58%, with 116 dwellings being sampled, of the 200 in the survey area, with 9 refusals and 75 occupants unobtainable after one return. The large number of houses where no response was obtainable probably reflects the higher rate of employment in the area. As in Lumsden, 2 returns were made to farms, and 18 respondents were interviewed, though much of the land in the area is farmed from units outside the immediate survey boundary, so that only around 50% of the land area was sampled.

Of the houses sampled, 89 were in the village and 27 were outside, of which 18 were farms. These figures compare with figures for the whole of Banff and Buchan District of 68.45% within settlements and 31.55% outside, and in the same way as Lumsden, this reflects the greater ease with which village residents are obtained, due to the higher proportion of retired people.

The refusal rate of about 8% of the sample, 4.5% of the total dwellings in the area, is rather higher than in Lumsden, but still within acceptable limits, given the sporadic and individual nature of the reasons for refusal.

6.2.1.3. Population Characteristics-

Compared to Lumsden, in which the largest occupation group is that of retired people, this particular group is rather less conspicuous in Cuminestown, at 19.8%, whilst 26.8% of residents are children under 16 and students. A smaller percentage of houses in Cuminestown (32.7%), are occupied by only one or two retired people, and a higher percentage of the elderly live as a part of larger family groups than is the case in Lumsden. Yet at 19.8%, a high proportion of dwellings are occupied by only one retired person, and this represents some 85% of the single occupant dwellings.

Table 6.5. shows percentages of houses with different numbers of occupants, revealing that 47.4% of dwellings are 'family houses' with 3 or more occupants, as compared to 39% in Lumsden.

Table 6.5. Percentages of Houses with Different Numbers of Occupants-

Persons	1	2	3	4	5	6	7
% of Houses	23.3	29.3	15.5	19.8	7.8	3.4	0.9

Within the village boundary, the figure for houses with 3 or more occupants is 46%, outside the village the figure is 50%. This creates a picture of a rather less dependant community than in Lumsden, in terms of the availability of capable labour within households. Nevertheless, 42% of households have no person in them working, whilst of those that do work, many are employed in the immediate vicinity, again unlike the situation in Lumsden.

Of head of household employment, skilled manual workers form the largest group, at around 25%, followed by farmers (15%), professional and executive (12%), the self-employed (10%), farm workers (3%), clerical workers (2%), and unskilled manual workers working outside farming (2%). This is a very different picture to the employment characteristics of Lumsden, where farming related jobs are the dominant group.

The working population of Cuminestown makes up around 37.5% of the total population, compared to 47% in Lumsden, reflecting larger numbers of school children in Cuminestown.

Table 6.6. Employment Details, Cuminestown

Occupation	Head of Household%	Total%
Farmer	12.9	6.37
Farm worker	2.6	1.63
Other manual unskilled	1.7	5.11
Other manual skilled	20.7	10.85
Clerical	1.7	5.11
Professional and executive	10.3	6.15
Self employed	7.8	4.19
Part time worker	0	3.19
Housewife	0	12.48
School or student	0	21.80
Unemployed	5.2	3.22
Retired	37.1	19.81

Though 58% of heads of household are employed, compared to 50% in Lumsden, non-agricultural full-time jobs in Cuminestown absorb some 23.4% of the population, whilst in Lumsden the figure is a very low 10.2%.

Average miles travelled to work or place of education each way per day, by heads of household in Cuminestown is 5.7, the same as in Lumsden, whilst the mean number of miles for the whole population is 2.7. Working heads of household, however, travel a mean distance of 9.2 miles, compared to 11 miles each way per day in Lumsden. Local employment is much higher in Cuminestown, with 24 of the heads of household, aside from farmers and agricultural workers, working in the survey area.

Of the locally employed people, 9 are skilled manual workers, 5 are professionals, 3 are self-employed, one is a clerical worker, and one is an unskilled manual worker.

Farming and self-employment, on the other hand, make up only 45% of local employment, as opposed to 97% in Lumsden. Six heads of household, and 3.2% of the total sample population are unemployed, and these people can be said to make up the bulk of the available 'surplus labour' in the area.

The regional origins of respondents were similar to those in Lumsden, with 87% of people having originated in the North-East, whilst 50% of the professional and executive sector originated outside the area, a lower percentage than in Lumsden, reflecting the greater opportunities in Cuminestown.

The balance of tenure types in Cuminestown is skewed much more than in Lumsden in favour of owner-occupation, with 64.7% of houses in this category, as opposed to 31% council housing, and only 4.3% private rented accomodation.

Of the 75 owner-occupied houses, 14 belong to farmers, 14 to manual workers, 10 to professionals, 8 to the self-employed and 24 to retired people. 83% of professionals, 93% of farmers and 89% of the self-employed own their own homes, whilst 56% of retired people are also home owners, a much higher proportion than in Lumsden. Within the village itself however, 40%

of houses are council owned, and only 1% private rented. The sample contains 7 houses which have been purchased from the local authority by the occupiers.

By and large, old people are rather less well represented in the owner occupier sector than age groups from 25 to 65, though this tendency is not as marked as in Lumsden, and many of the former do own their own homes. The elderly are also under represented in private rented accommodation, reflecting the nature of this tenure type as being tied to the job.

No one individual has any real control over the private rented housing stock, with landlords including the Health Board, the Church of Scotland, and three farmers working various sized holdings. Although the condition in which these rented properties owned by farmers are kept is poor (and in one case appalling), the small number of such houses means that they do not have a large statistical effect, albeit that their effect on their inhabitants is obviously dramatic.

Roof insulation standards are generally quite good in Cuminestown, with 100% of local authority housing having some insulation, and 65% of owner-occupied homes, together with 40% of the 5 private rented dwellings. These are rather better figures than for Lumsden, and the links between insulation standards and education level amongst owner-occupiers are rather less pronounced, with 75% of those with education over basic school level having loft insulation of some kind, and 60% of those with only school level education. The link between education and tenure type is also rather less strong than in Lumsden.

Occupation rates in Cuminestown are slightly lower than in Lumsden, at 1.76 rooms to each person, with an average of 3.9 rooms per dwelling and 2.7 rooms per dwelling respectively.

Controlling for tenure, council house occupants typically live at around 1.3 rooms per person, and owner-occupiers at 1.80 rooms per person, with private rented accomodation at 1.9 rooms per person. As in Lumsden, the spread of council house sizes is relatively small, with occupancy rates quite rational, except for a few cases of elderly people living by themselves in larger houses.

Table 6.7. Tenure and Insulation Levels, Cuminestown.

	Local Authority	Owner Occupied	Private Rented
Total No.	36	75	5
No. with loft insulation.	36	49	2
Occupancy (Rooms/person)	1.30	1.80	1.90

Mean gross floor area is around 83m2 per dwelling, an average of around 30m2 per person.

The sense of isolation and self-sufficiency in the Cuminestown area is rather less than in Lumsden, reflecting the lesser degree of physical and economic isolation, and fewer people are able to envisage being able to survive in isolation from the outside world. This also reflects the lack of obvious supplies of under-utilised fuelwood, and indeed both the local resource and the amount of that local resource presently used as a fuel source in Cuminestown are lower than in Lumsden.

Particularly outside the boundaries of the village however, there is still a certain amount of defiant independence amongst respondents, who see their ability to survive in isolation more strongly than do village residents.

It is possible that some of the lack of confidence in ability to survive in isolation is related to the lack of historical reliance on centralised estate control of employment, housing, services and local fuel resources.

It is again noticeable that few of those expressing independant attitudes actually gain fuel such as peat or wood for themselves, despite its, albeit limited, local availability.

6.2.2. Results of the Agricultural Holdings Survey-

6.2.2.1. Land Use and Holding Pattern-

Cuminestown falls within the rather large parish of Monquhitter, a parish too large to form the actual survey area, and the same techniue for defining the area was used as for Lumsden, taking an area within which the nearest retail outlet is in Cuminestown. However due to the proximity of Turriff, 5 miles to the west of Cuminestown, and a much larger settlement, the survey area did not extend as far as half way between Cuminestown and Turriff, to reflect the greater influence of the latter settlement over a wider area.

The land holding pattern in Cuminestown proved, as was expected, to be more fragmented than in Lumsden, and much more fragmented than in Dunecht. Ownership, as well as management, is more diverse, with no rented farms in the sample, all 18 units surveyed being owner-occupied. No large estates were included in the sample, and as in Lumsden it often proved more difficult to obtain a response from the larger landowners than from small farmers. One very large farm (450 hectares) was included in the sample however, though much of the land farmed by this concern is situated on other units to the north of the survey area.

Most of the less productive land in the area (parkland, woodland and forest), is owned by the one estate, and by the Forestry Commission, and there certainly is not the same concentration of land ownership in a few hands as in the other survey areas.

There is little rough grazing land in the area, and aside from small amounts of woodland and one plantation of coniferous trees of around 100 hectares, almost all the land area in the sample is either rotational arable land or permanent fenced grassland.

Eighteen successful farm surveys were completed, whilst there were 2 refusals, and from 10 farms responses were unobtainable after 2 returns, a rather higher failure rate than in Lumsden.

1001 hectares were sampled, with some 150 hectares of this falling outside the survey area. 10km2 of the total 20km2 (50% of the area) was therefore sampled, which is not as good a figure as for Lumsden (100% of the 27km2), yet if the one large estate were to be removed from the Lumsden statistics, the land area covered is the same for both areas, and percentage coverage is slightly higher in Cuminestown.

Of the 18 successful agricultural surveys carried out, all were of owner occupied farms. Unit size ranged from 5 to 450 hectares, and 3 farms at the lowest end of the range cannot be considered to provide full-time occupations for the farmers, who also have other occupations. Mean farm size is around 56 hectares, a lower figure than for Lumsden, reflecting the presence of one very large unit in that area. Removal of units under 8 hectares leaves a mean farm size of 62 hectares.

Not all of this land is farmed directly by the owner however, since 15 hectares of grass and hay are sold standing in the area.

In terms of land use, some 75% of surveyed land is rotational arable, most of the rest being permanent fenced grassland, with around 1% woodland and 1% rough grazing, less than 1% is in roads and buildings. Some 90 hectares of coniferous and 30 hectares of deciduous woodland lies within the area but outside the sample, compared to 150 hectares of deciduous woodland outside the sample in Lumsden.

Thus the preponderence of arable land in the sample is probably rather unrepresentative, due to institutional and absentee control over other land uses in the region. By and large, land use in the sample seems fairly rational and complete, though there remains some on-farm woodland in shelter belts and the like, which might be better utilised for fuel.

6.2.2.2. Farm Production and Employment-

Full-time employment is provided for some 23 people on the 18 farms, with 6 of these being from outside the farmer's immediate family, whilst the sample farms provided a living to some 17 families.

There is a small amount of seasonal employment in potato picking, and 3 people only work their farms part-time, whilst three other people are employed part time on other farms. 5 of the 6 full-time agricultural employees are employed on one farm, the 450 hectare unit.

Stocking levels in the area are; beef cattle at a rate of 1 per hectare, ewes at 1 per 1.85 hectares, together with 5500 poultry and 25 sows on farms in the sample. Although no dairy farms are in the sample, one farmer is a milk retailer, who has now abandoned dairy farming infavour of the bulk purchase of milk from near Aberdeen. The poultry are in only one large unit, with a few free range hens run on a non-commercial basis on other units. Several farms have a few acres of potatoes, the rest of the arable land being dedicated largely to barley and oats.

Even outside the sampled farms, there seems to be no enterprise run on such a non-commercial basis as is the main estate in Lumsden. All the farms are run on a commercial basis, and the one larger estate (not included in the sample), is at least largely commercial arable farmland.

Yet, for different reasons to those pertaining in Lumsden's estates, investment in such things as tied housing by farmers is low. One old lady in particular lives in an old cottage with a tin roof, outside chemical toilet, one cold water tap in the kitchen, no insulation, almost completely rotted windows, and, in spite of the proximity of the mains electricity supply (some 10 metres away from the dwelling), even this service has not been provided by a landlord who appears to be waiting for the demise of his tenant. It seems likely that his attitude to investment in renovation will change somewhat when this eventuality occurs.

There are considerable numbers of derelict properties on farms in the area, most of which are virtually beyond repair, and there is little sign of any attempt at renovation.

Attitudes to renewables, and particularly to solar water heating, are rather more favourable amongst farmers in Cuminestown than in Lumsden, perhaps due to the fact that a major sales campaign has been initiated by one supplier. One farm has domestic solar hot water, and the occupants seem interested in the potential and satisfied with the results. In this more lowland area, confidence in the future of wind and small hydro power is rather less than is confidence in solar water heating.

The idea of fuel cropping was received with less interest than in Lumsden, as might be expected from a sample made up predominantly of quite good quality arable land.

Straw burning in the field is seen by some farmers as being more widespread than the survey results would suggest, which may be explained by the reticence of farmers in admitting to this activity. One farmer, who was not available for interview, has installed a straw burning stove for domestic use in recent years, and is able to use some of the relatively large surplus of this material.

6.3. General Area Comparisons-

The choice of survey areas was largely influenced by agricultural form, topography and isolation from large towns. Therefore these differences appear in the surveys. Cuminestown is a largely arable, lowland area, outside the main commuting influence of Aberdeen, although quite near to several small towns. Lumsden is an upland, hill farming area in a particularly isolated location. Dunecht, the pilot area, is a smaller village much nearer to Aberdeen than the other two, and ostensibly in the commuter belt, whilst being made up largely of arable land.

Perhaps the greatest difference arising between the areas which was not planned from the outset is land ownership patterns.

In spite of its proximity to Aberdeen, Dunecht was found to be parochial almost to the extent of feudalism, due to the all-pervading influence of one landlord. Incomers were at a minimum, housing standards were poor, home ownership virtually unknown, and reliance on one source of employment, the estate, almost total.

By contrast, Lumsden is traditionally an area of large estates which have disintegrated somewhat over the years to create a more diverse land ownership pattern. It has a far wider spread of tenure types and housing standards, raised somewhat by the presence of so many council houses, yet has practically no employment locally, and far less a sense of the sort of 'paternal organisation' to be found in Dunecht. Although three or four times further from Aberdeen, Lumsden has more commuters and incomers than Dunecht, due to the freer ability to purchase houses.

The estates having relinquished control over housing, services and employment, however, this has left Lumsden with very little. Although estates around Lumsden have disintegrated somewhat, they typically retain control over most of the marginal hill land. This affects the fuel resource in particular, most of the potential for which lies on this land, unsuitable for more intensive agriculture. Although economic uses for this land may be minimal, the landlords relinquishment of 'paternalistic responsibility' over the area has left it highly unproductive.

By contrast, Cuminestown, an agricultural area similar to Dunecht, yet without the historical reliance on landlord control, has retained employment and services to a large degree, without having to rely on one individual for this provision.

Home ownership is a larger sector in Cuminestown than in either of the other two survey areas, largely at the expense of the private rented sector, and the standard of owner-occupied housing is somewhat higher. General housing standards, such as insulation levels, are greatly affected by tenure in all the areas, with such provision in Dunecht being at the whim of the landlord, and the level in Lumsden being improved by the influence of local authority housing, with standard provision of insulation to all dwellings.

Cuminestown has a younger population than the other two areas, with 26% being of school or pre-school age or students, and the area doesn't suffer from the same lack of renewal of the population as the other two sample areas, whilst a higher proportion of the over 18 year old population is employed.

These differences cannot be entirely explained by differences in land holding patterns, since Cuminestown is in an area of higher population and greater opportunities than Lumsden, yet the all sector influence of the Dunecht estate on that area certainly has its effect.

Given the Delphi scenario for rural population, (Section 3.4), it seems likely that the difference between Dunecht and the other two areas will increase, for whilst repopulation affects both Cuminestown, and to a lesser extent Lumsden, the artificial blocking of all development by the Dunecht estate, if continued, could push the population of that area into stagnation indefinately, in spite of that area's proximity to Aberdeen.

Whilst the greater isolation of, and the presence of much marginal land and large peat deposits around Lumsden, and the level of centralised control operating in Dunecht, might make these areas more able to create greater autonomy in their fuel use, their undercapitalisation and ageing populations tend to legislate against it.

By contrast, Cuminestown, less in isolation and perhaps with fewer potential fuel resources, lends itself better to such strategies due to the larger amount of money available to a more fully employed population, and the control over housing standards and fuel use in an area with a higher degree of owner-occupation.

Yet in terms of fuel resources, it is the large estates which are most likely to be able to provide the capital and land for their exploitation, if perhaps not the interest needed to carry this through.

Thus it can be seen that the existence of an energy resource and a potential use are not sufficient conditions for achieving a greater degree of rural energy autonomy. The attitudes of individuals, the availability of labour and, most importantly, the land holding pattern of an area, are also important variables in the equation.

Notes and References, Section 6.

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7. PATTERNS OF ENERGY USE-

7.1. Energy Use Patterns, Domestic-

7.1.0. Introduction-

For the three survey areas, energy use data on the dwelling was gathered in convenient units (such as tonnes of coal, gallons of oil), and converted by means of a simple fortran programme into megajoules supplied, with a total figure being calculated for megajoules of all fuels. It was decided to use figures for 'fossil fuel requirement', and thus total delivered MJ of coal was included, with no allowance for conversion loss, whilst MJ of electricity was multiplied by a factor to represent the around 40% conversion efficiency. This factor does not pertain specifically to the survey area, but once the extra transmission losses in bringing the power to remote areas has been set against the higher efficiency of generation gained through higher use of hydro-electric power than the national average, 40% is probably a reasonable average. Actual figures for electricity production efficiency are not available by small area.

This then represents unavoidable losses to the consumer, losses in the conversion of other fuels in the home, whilst to some extent inevitable, can be minimised, and the potential for doing this is brought out by the survey results.

One slight inaccuracy remains, the energy needed to mine and process coal and other fuels, which also applies to electricity generation by solid fuels, and the energy used in the distribution of those fuels to the consumer.

Having achieved a picture of total household fuel use, it is important to be able to set this against an assessment of fuel requirement.

Data on construction type, floor area, volume and ventilation were used, through a simple computer programme, to work out the heat loss figure for each house in the samples, using a generous hypothetical heating regime, with a 9 month heating season, and the whole house kept at 20 degrees centigrade during the day, 14 degrees at night.

Various inaccuracies exist in this method, but as a way of comparing energy use in a highly varied sample of dwellings and families, it provides a good guide to comparative energy requirements.

Perhaps the greatest inaccuracy relates to ventilation rates, and therefore ventilation heat losses. Ventilation rates were estimated by taking a standard number of air changes per hour, and making a deduction for new houses or those with major new improvements such as new windows and doors, whilst making additions for houses in exposed positions and those where the occupants either complain of draught or express the need for major improvements.

Other inaccuracies lie in the assessment of construction U values, due to the difficulties of inspecting such things as insulation. Yet the occupier generally has a reasonable idea of what has been done, and by taking a range of standard constructions in an area of predominantly vernacular, traditional constructions, quite good accuracy is achieved.

Gross floor areas of dwellings were assessed by measurement on the ground, and are felt to be accurate to within 10%.

Information gathering in the pilot area was insufficient to be able to carry out these full calculations, and they were restricted to the two main areas.

7.1.1. Lumsden-

7.1.1.1. Data Processing-

The data gathered in the Lumsden domestic survey was entered onto disk in a manner compatible with S.P.S.S. (Statistical Package for the Social Sciences computer Programme) processing, in much the same way as the Dunecht data, though missing values were specified for many of the variables, to get round problems arising where some data points for a variable might not exist, whilst others might simply not be known. For instance, one dwelling might use no coal, whilst another, though using coal, might be able to give no indication of how much is used. Specifying missing values enables S.P.S.S. to distinguish between these two phenomena.

After entering data onto S.P.S.S. and producing control files for generating output, much of the basic data was transformed to create new variables. Thus a more accurate picture of energy use is built up by creating new values in megajoules (MJ) from incompatible figures on tonnes of coal, litres of oil etc. These variables can then be summed to produce one variable for total megajoules of energy consumed by a household.

Naturally enough however, this leaves a picture of far more energy being consumed by those burning fossil fuels directly than by those using only electricity, due to the inefficiencies of domestic heating appliances. A new variable was therefore created, increasing MJ of electricity used by a factor representing the loss of energy through power station inefficiencies. Thus, when summed, the resulting variable represents all fuel used aside from that used in transporting fuels to their point of use.

Although this total MJ figure still produces much higher figures for those burning fossil fuels, it is far more realistic, since gaps in efficiency could be closed by better burning practices.

Another variable to be calculated from the basic data is one for heat loss. This variable, though it can never be a particularly accurate measure, could at least put into perspective each dwellings energy needs in comparison to one another. A calculation is made using all the constructional data from the questionnaires, to work out U values for different constructions, creating separate new variables for floor, walls, roof, windows, ventilation and exposure, from which the average heat loss over a more or less arbitrary temperature gradient can be calculated by the formula:-

((ext. wall area x ext.wall U value) + (roof area x U value) + (floor area x U value) + (window area x U value)) x temperature difference in deg. K = HEAT LOSS IN W (1)

Ventilation heat loss can be calculated from the formula:- $1300 \times v \frac{\times n \times}{3600} t$, where v is the house volume, n is number of air changes per hour, and t is the temperature difference (2).

7.1.1.2. Heating Installations-

In terms of household energy use, 100 of the 113 houses have an open fire or solid fuel stove which they use most of the time, whilst 4 have oil fired central heating, one has gas, and the rest rely totally on electricity. So solid fuel burning predominates, with coal being the, or a, main fuel source for 72 households, smokeless fuel for 17 households, purchased wood for 55, home cut wood for 30, purchased peat for 4 and home cut peat for 16 households.

21 council houses have central heating, of which 16 are run from back boilers to open fires, 2 use storage heaters and 3 use electric ceiling heat. There is a tendency for those in employment to have central heating, and for the unemployed and retired not to, even in these council houses, which can perhaps be explained by the relative freedom of choice of housing enjoyed by the former group.

In owner occupied houses, 26 of the 45 houses are centrally heated, with 3 using oil heating, 5 with solid fuel stoves, 11 with back boilers to open fires, 2 with bulk gas, 4 with off peak electric and one with solar panels, though in this last case only domestic hot water is provided, so that it is not strictly central heating. In all occupation categories but farmers and the retired, more than 50% of houses have central heating, and all but one of the professionals have it. Obviously the presence or abscence of central heating reflects the availability of capital, though the smaller number of farmers having it perhaps reflects length of stay and resistance to change amongst this category.

Only 3 of the 22 private rented dwellings have central heating, reflecting the generally low standard of this accomodation, and those that do have it are, a farmer, a professional and a self employed person.

Table 7.1. Domestic Heating Installations, Lumsden.

Heating type	Total houses	Local authority	Owner occupied	Private rented
Solid fuel central heat	35	16	16	3
Oil	6	0	3	3
Bulk gas	2	0	2	0
Off-peak electric	5	1	4	0
Electric ceiling heat	3	3	0	0
Solar water heating	1	0	1	0

Table 7.2. Numbers of Dwellings Using Different Main Solid Fuel Types, Lumsden.

Fuel type	No. of houses
Coal	72
Smokeless fuel	17
Purchased wood	55
Home cut wood	30
Purchased peat	4
Home cut peat	16

In all but 11 dwellings electricity is the fuel used for cooking, but 14 houses have solid fuel cooking stoves, and 9 use these all the time, 11 at some time, making these dwellings more flexible in the use of fuels and less likely to be dismayed by any lack of electricity.

In terms of preferred heating types and the desire to change from present types, only 14 people expressed the intention to change their heating installation, mainly to central heating off open fires with back boilers, of whom 60% have no central heating at present. 22 householders expressed no desire for central heating, or a positive dislike of it, only one of whom actually had central heating already. The remaining 91 householders desired central heating, of which 63% stated radiators from a back boiler as their preference and another 11% wanted a solid fuel stove, 9% preferred bulk gas, 8% oil and 4% electric, whilst 5.5% wanted central heating, but expressed no preference as to type. Of those without central heating, 34% have no desire for it and 66% would like it. There therefore exists a high level of satisfaction with solid fuels, coupled to a fairly strong desire for the comfort and convenience of central heating, and the preponderance of open fires seems to represent preference rather than necessity. (See Table 7.3.)

Table 7.3. Preferred Heating Type, Lumsden.

Heating Type	No. of Respondents
Central heating	91
Open fire back boiler	57
Solid fuel stove	10
Bulk gas	8
Oil	7
Electric off-peak	4
Any central heating	5
Not central heating	22

7.1.1.3. Energy Use and Heat Loss-

For fuel use, calculations were made for megajoules of different fuels used in each household, and new variables were created for the total number of megajoules used by each house, correcting for power station inefficiencies to give more meaningful values for electricity use. (See Appendix 11)

Mean corrected energy use per household was 176,688 MJ, with 34.5% of this being in the form of coal, 23.6% electricity, 12.4% smokeless fuels, 11.4% bought wood, 7.6% home cut wood, 5.7% oil, 3.3% home cut peat, 1.0% bought peat, 0.9% gas, 0.3% diesel generated electricity and 0.1% paraffin. (See Table 7.4.)

Table 7.4. Percentages of Different Fuels Used, Lumsden-

Fuel Type	%of Total Fuel Use
Coal	34.5
Electricity	23.6
Smokeless fuel	12.4
Purchased wood	11.4
Home cut wood	7.6
Oil	5.7
Home cut peat	3.3
Purchased peat	1.0
Gas	0.9
Paraffin	0.1

So coal and smokeless fuel predominates considerably over electricity, probably due to inefficient burning practices, with 'free' resources of wood and peat making up some 11% of total fuel use.

The fuel use of individual households varies from 35000 to 360000 MJ, i.e. by a factor of 10. The standard deviation is around 39% of the mean, reflecting a large spread of fuel use values. Low energy users are exclusively those households without open fires, all 6 households below 85000MJ using only electricity for heating. The distribution of the variable for total megajoules is skewed positively (i.e. there are more households falling above than below the mean, and therefore those above the mean are more extreme and tend to lie further away from it), reflecting a 'cut off point' at the lower end, below which hypothermia would presumably result. Finances permiting, such a cut off point does not exist at the upper limits.

When another new variable is created, coding the amount of fuel used under 8 categories of 50,000 MJ increments, so that cross-tabulations can be carried out using the data, reasons for discrepancies in fuel use can be partially explained. Fuel use was cross-tabulated against number of rooms as a rough guide to size, controlling for tenure, the most significant feature of these figures being the lack of a relationship. Although larger houses do, by and large, tend to consume more energy than smaller ones, isolated cases exist of 3 room houses consuming three times more energy than 8 room houses etc.

With council housing, where standards are more comparable, some kind of relationship can be seen in terms of maxima and minima for fuel used in houses of different sizes, though between these two figures the spread of values is considerable. In owner occupied and private rented accomodation the relationship is more difficult to follow, and the most that can be concluded is that there are minima below which fuel use cannot go.

It is worth noting as an aside that the two people in the village expressing the most interest in renewable energy sources, (One of whom also has the lowest electricity use in the area, and prides himself on what he sees as his 'low energy using lifestyle') are also the areas largest consumers of total energy.

In an attempt to explain fuel use relationships more fully, the same cross-tabulation was carried out, but this time controlling firstly for central heating and secondly for occupation.

In the case of central heating, it is notable that the house with solar water heating uses more than the mean amount of energy, whilst those houses with ostensibly the most inefficient heating form, electric ceiling heat, use rather less energy. This latter point can be explained by the relative energy effectiveness of electricity, and by the lack of use of the installed system in favour of other electric heating appliances.

Only for oil central heating and enclosed solid fuel stoves can a positive relationship be said to exist between house size and energy use. Those without central heating and those with back boilers both use the most energy and have the widest spread of values, a reflection of inefficient burning techniques on old open fires.

In the case of occupation, again it is difficult to arrive at relationships with fuel use and house size, with only the self employed using noticably more as a group than the others.

U values of the different constructional elements were calculated, and a programme was written to calculate heat loss from houses under a rather generous hypothetical heating regime, of constant temperatures throughout the house of 20 degrees centigrade for 14 hours in the day, and 14 degrees centigrade for 10 hours at night. Degree-days were based on figures for Dyce, adjusted for the greater altitude of Lumsden. Thus a heat loss figure was arrived at for each house, and a new variable created by the formula energy needs/energy use x 100 = % useful energy. (See Appendix 11).

For Lumsden the mean for this variable was 69.83%, i.e. this percentage of the energy used should be necessary to heat the house, and 30.17% of energy use is wasted. The range of this variable was large, from 20.7% to 157%, i.e. some houses appeared to use around 5 times more energy than they needed, others only two thirds of the required amount.

An error arises in this variable, since it is not known precisely how much of total energy use is consumed in lighting and power rather than in heat, since although most of this energy is itself dissipated in the form of heat into the dwelling, this does not necessarily occur at the times when space heating is required.

An assessment of how much energy is required for non space heating purposes can be made by looking at the electricity consumption of those houses which do not use any electricity for space heating, and which do not have domestic water heating off a back boiler. Mean electricity consumption for these dwellings is 18958MJ/annum, or 10.9% of total energy use.

Thus 89.1% of energy is used for space heating, and this is by far the most important input, and the one with most potential for savings. Additionally, energy not used for space heating dissipates itself as heat, (such as that from light bulbs, cookers and appliances), and much of this will add to the useful space heating load, whilst calculating the percentage of this energy used at times when there is no need for space heating is impossible without long term observation of individual dwellings.

Adjusting mean percentages of energy usefully used to take account of non space heating energy, brings the figure from 69.83% to 78.37%. Thus it would seem that, even taking an extremely generous heating regime, energy used in dwellings in Lumsden is excessive.

It is unlikely that this heating regime is followed by very many people for several reasons. Firstly, whilst 43% of houses are occupied by retired people, an additional 1.5% by the unemployed, and 30% of houses having non working women, making 74.5% of houses which may be occupied during the day on weekdays, the other 25.5% are unoccupied during much of the assumed heating period, and thus will not be heated, whilst even many of the potentially occupied houses will not be occupied all day every day of the year.

Secondly, very few people heat their entire dwelling to the same temperature, nor do they heat even the central living space all the time. Those that do are typically people with full central heating and a plentiful supply of either cheap fuel or money. Those without central heating almost all only use one point heat source most of the time, usually the living room open fire. The whole of the rest of the house is normally only heated in extremely cold conditions or for short periods, such as electric heat in bedrooms for an hour or so in the evenings.

The mean energy use figure is brought down considerably by those dwellings with only electricity for heating, and whilst the low energy use in these houses can be partly explained by efficiency of conversion to heat, it is felt that most people suffer a lower standard of heating due to the expense of this fuel.

Although the very high energy use figures might be explained by errors in the survey of heat loss, particularly in the figure for ventilation rates, it is felt that most of this excess energy is lost by inefficiencies in fuel conversion.

It is popular to decry the use of electricity for space heating as very wasteful of energy, given the below 40% efficiency of power stations, it is normally suggested (4) that with potential efficiencies of up to 80% in domestic solid fuel burning appliances, it makes much more sense to burn fossil fuels directly than to convert them to electricity and then to heat.

Yet in the Lumsden survey area, only 9% of houses have any form of solid fuel stove, or any other kind of fossil fuel boiler system (oil or gas), whilst a further 14% of houses (all in the local authority sector) have closed anthracite fires utilising existing chimneys. By contrast, 55% of houses have open fires, many with old, unlined chimneys and large open grates. Although it is impossible to measure accurately the conversion efficiency of these fires, this could go down to 10 or 15% in some cases (5). Testing this hypothesis by comparing houses with open fires, with those with newer, more efficient solid fuel stoves shows little obvious saving, but since solid fuel stoves typically run large central heating systems, and tend to be installed in the owner-occupied homes of the professional and self-employed sectors, it may simply be that these people choose to heat their houses more completely.

Recalculating the figures for useful energy based on conversion efficiencies of 90% for electricity, 80% for closed fossil fuel stoves running central heating, and 20% for solid fuel burnt on open fires, produces a rather more realistic figure of 143%, i.e. only 57% of the energy needed for the suggested heating regime is actually used.

Policy for increasing fuel use efficiency and heating conditions in dwellings has long been restricted to insulation standards, whilst public interest in new fuel burning appliances is generally limited to the provision of full central heating, which is outside the budgets of the rural poor, and of most local authorities at present. Yet it is felt that considerable fuel savings, and/or improvements in heating standards, could be made by encouraging the installation of small, simple and efficient solid fuel burning stoves and new flues. Most of the available appliances are expensive and concentrate on larger units for running central heating, and the development of smaller, simple units adapted for burning wood and peat could drastically improve energy use efficiencies in an area such as Lumsden.

Assuming that 'laboratory efficiencies' of up to 80% (6), could not be achieved in practice, due to variations in fuel quality and user competence, but that such units could work at 70% efficiency in all the homes in Lumsden which currently only have open fires, percentage useful energy figures would be 124.4%, reflecting either an energy saving or a more comfortable heating regime.

Turning to the attitudinal questions, the response here was very mixed. The large section on the use of different fuels, worded to get reaction to the prospect of their increased use nationally during the next ten years, produced a higher confidence in solid fuels and electricity than other types , and a particularly high confidence in the use of peat.

7.1.1.4. Energy Use in Transport-

Turning to fuel use in transportation, only travel to place of employment or education was considered, it being felt to be impossible to accurately measure other travel, whilst if this was done, variations may rely more on individual whim than on necessity. An assessment can be made however, of local travel to retail outlets by those respondents living outside the village.

Miles travelled to work or school daily was recorded, as was a variable for mode of travel, under the categories: car with single occupant, shared car, bus, motorbike or moped, and bicycle or walking. An assessment was made of energy used based on national averages (7), for estimated numbers of days a year differing between employed people and those in education.

For Lumsden, mean miles travelled each way per day for the head of household was 5.7, representing an energy use of 37.37MJ each way per day. Total MJ used in travel per annum for all household members, per household, was 28009MJ, about 15% of household energy use, and quite a large figure considering the number of retired people and others not travelling to work. In fact school children make up the majority of the travelling, and do so by a quite efficient means, bus or shared car, in which there is little room for savings. The small numbers of adults travelling makes it unlikely that any energy savings can be made by having recourse to such things as car sharing.

Adding a figure representing two return journeys a week per household into Lumsden for all car owning outlying residents gives an additional 1371MJ, so that total necessary local travel energy use is 29380MJ per person.

7.1.2. Cuminestown-

7.1.2.1. Heating Installations-

Cuminestown data was processed in the same way as the Lumsden data, building up a picture of energy use in MJ, and the heat loss from dwellings, and a final figure was produced comparing energy use with energy need under the hypothetical heating regime, by the formula: ;

$$\frac{\text{Energy needs to satisfy heating regime (MJ)} \times 100}{\text{Energy use (MJ)}}$$

= percentage excess or shortfall.

In terms of heating type, 93 of the 116 dwellings have an open fire or solid fuel stove which they use most of the time, 6 have oil fired central heating, three use bottled or bulk gas extensively, 10 have electric off-peak storage heating and 10 only have electric fires or radiators without the benefit of white meter tarrifs. As in Lumsden, solid fuel burning predominates, with coal being the main (or a main) fuel for 78 houses, very little smokeless fuel, ((3 houses), unlike in Lumsden, where many council dwellings have had anthracite stoves installed, and this is an important fuel type), purchased wood for 37 homes, home cut wood for 26 homes, purchased peat for 22 and home cut peat for 12 houses.

As in Lumsden, the occupants of houses with electric ceiling heat have been promised that a new system will soon be installed, and as in Lumsden, the fear of switching on this expensive heating at all means that these households actually consume fairly small amounts of fuel.

Assessing heating types by tenure, 9 of the 36 council houses have some form of central heating, a smaller proportion than in Lumsden, though 6 of these have ceiling heat, whilst one has off-peak electricity and two have radiators run off the back boiler of open fires.

Again there was found to be some correlation between occupation and central heating type, with 64% of farmers, 58% of retired people and 100% of unskilled manual workers having no central heating, as against 25% of the self-employed and none of the professionals.

In the owner occupied sector, 40 of the 75 houses have some form of central heating, with solid fuel stoves in 14, and 9 having radiators off an open fire back boiler, the reverse of the situation in Lumsden.

Six of the owner-occupied dwellings have oil fired central heating, and three have gas, so that all those with gas, oil and solid fuel stoves are owner-occupied. 8 houses have electric storage heat. (See Table 7.5.)

Table 7.5. Domestic Heating Installations, Cuminestown.

Heating type	Total houses	Local authority	Owner occupied	Private rented
Solid fuel central heat	26	2	23	1
Oil	6	0	6	0
Bulk gas	3	0	3	0
Off-peak electric	10	1	8	1
Electric ceiling heat	6	6	0	0
Solar water heating	2	2	0	0

Table 7.6. Numbers of Dwellings Using Different Main Solid Fuel Types, Cuminestown.

Fuel type	No. of houses
Coal	78
Smokeless fuel	3
Purchased wood	37
Home cut wood	26
Purchased peat	22
Home cut peat	12

Domestic hot water is largely provided by a combination of back boiler and electric immersion, whilst one house has no hot water system, and two use recently installed solar panels, part of a local hard sell campaign by one manufacturer.

Few council houses have any central heating in Cuminestown, only 25%, and of those that do the majority (20%), are occupied solely by retired people. In the owner-occupied sector, 53.7% have central heating, and this is made up of 100% of the professional and executive sector,75% of the self-employed, 100% of clerical grades, 43% of skilled manual workers, 42%of the retired, 36% of farmers and none of the unskilled manual workers. So there is a clear correlation between central heating and occupation, though this may not be entirely based on income, for instance a smaller percentage of farmers than of retired people have central heating.

Two of the five private rented dwellings have central heating, one with a back boiler on an open fire, and one with off-peak electricity. These two houses, predictably enough, are the manse and the doctor's house.

In all but 10 of the sampled houses, electricity is the fuel used for cooking, whilst 4 dwellings use solid fuel cooking stoves, rather fewer than in Lumsden (one of these has no electricity), and 6 use gas for cooking. Reliance on electricity is therefore rather greater in Cuminestown than in Lumsden, making the occupants slightly less adaptable to using local fuel resources.

In terms of preferred heating types, fewer people expressed a desire to change their heating installations in Cuminestown (53 respondents), than in Lumsden, largely as a result of the lower number of private rented dwellings and the high number of owner-occupied houses, over which people have greater control. Even if financial constraints dictate that they could not change to a preferred heating type, they are more reticent about admitting to this than are people in rented dwellings. As in Lumsden, central heating preference was largely for solid fuel back boilers (18 respondents), though 19 people expressed a desire for mains gas if it were to become available. 6 people wanted central heating but had no preference as to what type, whilst 4 preferred oil and 6 electric off peak-storage.

Fewer people still were actually intending to change their domestic heating system (17 respondents), and of these the majority wanted solid fuel stoves or electric storage heat, for a variety of differing reasons.

Table 7.7. Preferred Heating Type, Cuminestown.

Heating Type	No. of Respondents
Central heating	53
Open fire back boiler	18
Mains gas	19
Oil	4
Electric off-peak	6
Any central heating	6

7.1.2.2. Energy Use and Heat Loss-

Calculations of fuel use were made in the same way as for Lumsden, and mean corrected energy use per household was 161555MJ per annum, with around 31.5% of this being in the form of electricity, 39.5% coal, 3% smokeless fuel, 4% home cut wood, 7.5% bought wood, 5% bought peat, 6% home cut peat, 2% gas, 1.5% oil and 0.01% paraffin. There was no diesel generation of electricity. Thus coal and electricity use are higher in Cuminestown than in Lumsden, largely at the expense of smokeless fuel and wood.

Table 7.8. Percentages of Different Fuels Used, Cuminestown-

Fuel Type	%of Total Fuel Use
Coal	39.5
Electricity	31.5
Smokeless fuel	3.0
Purchased wood	7.5
Home cut wood	4.0
Oil	1.5
Home cut peat	6.0
Purchased peat	5.0
Gas	2.0
Paraffin	0.0

Fuel use per household varied from 27660MJ to 395518MJ, a larger range than in Lumsden, and the standard deviation was higher, reflecting a very large spread of fuel use.

As in Lumsden, most of those households consuming the least energy have no solid fuel burning appliances, and rely almost entirely on electricity for heating, and again the figures are positively skewed, with more extremes at the upper than at the lower end of the fuel use spectrum.

In the same way as for Lumsden, U values for different construction elements were used in conjunction with gross floor areas and estimated ventilation rates, to calculate the heat loss from individual dwellings for a hypothetical heating regime. Meteorological figures for Dyce, Aberdeen were used to assess degree days, but this time not adjusted for altitude for the more lowland sample area, so a slightly lower heating level is required for Cuminestown than was the case in Lumsden.

The figure for energy needs/energy use x 100 for Cuminestown was 72.36%, higher than in Lumsden by around 2.5%, whilst mean energy use is about 8% lower in Cuminestown, reflecting both Lumsden's higher location and slightly poorer housing quality.

When both energy use and energy need variables were divided by gross floor area, houses in Cuminestown were shown to use some 1800MJ per m2 gross floor area, with

Lumsden slightly higher at 1860MJ. Energy requirement in Cuminestown is 1230MJ per m2, in Lumsden 1298MJ per m2. Energy needs divided by energy use per m2, multiplied by 100 is 68.3% for Cuminestown and 69.8% in Lumsden, therefore both villages perform very much the same per m2 of gross floor area.

Again, the range of values for useful energy use was very large, indeed even larger than in Lumsden, ranging from 14.7 to 200%, with some houses using 7 times more energy than they would appear to need, others only half their requirement for the hypothetical heating regime. The latter category is largely made up of very large, under-occupied old houses where only a portion is heated.

How far personal heating habits may influence results is exhibited by the dwelling using 7 times more energy than is required for a generous level of heating. This house uses more energy than any other in Cuminestown, yet is a small (65m2), newly renovated bungalow with a high standard of insulation, only two, retired occupants, and a new, ostensibly efficient, solid fuel burning stove. Their excessive energy use can presumably be explained by a desire for high temperatures, coupled to a tendency to leave all doors and windows open. Although such extremes emphasise the randomness introduced by the 'human factor', it is felt that statistical significance remains good due to the sample size, which tends to iron out such eccentricities.

The same potential errors caused by non-heating fuel use apply as for Lumsden, and again the low total size of this sector means that heating can remain the main focus of attention. The same calculation can be done as for Lumsden to assess the percentage used for non space heating purposes, and 83.9% of energy use is estimated to be in space heating. Removing the non space heating energy load changes the useful energy figure from 72.36% up to 81.21%.

Although domestic energy use per household is lower in Cuminestown than in Lumsden, it would still seem to be excessive based on the hypothetical heating regime.

With 33% of houses occupied by retired people, 2% by the unemployed, and 30% of the remainder having non-working women, 65% of houses may be occupied during the day time on most days, a larger proportion than in Lumsden, which may reduce the energy requirement in Cuminestown somewhat. Thirty five percent of houses are thus likely to be unoccupied for a considerable part of the heating season.

As in Lumsden, those without central heating typically use only one point source of heat, which in 50% of cases is an open fire, normally burning coal as the main fuel source, and again, those houses using only electricity tend to use considerably less energy than the others.

In Cuminestown, 12% of houses have solid fuel stoves, with 7.8% having oil or gas central heating, making a total of 20% of houses with 'improved' fossil fuel burners. Many of the houses with open fires may have good, efficient grates and flues, and there must certainly be a large range of efficiencies for solid fuel open fires, but a majority, though a smaller majority than in Lumsden, have low efficiency fuel conversion systems, perhaps going down to 10 or 15% in some cases.

Again the lack of a relationship between fuel use and the type of solid fuel burning appliance can be explained by the fact that it is the professional and self-employed respondents who tend to install expensive solid fuel stoves for central heating purposes, and they also tend to expect a higher level of heating throughout their houses.

Recalculating fuel use based on conversion efficiencies of 90% for electricity, 80% for closed fossil fuel stoves running central heating, and 30% for solid fuel burnt on open fires, produces a figure of 135%, i.e. only 65% of the energy needed to fulfil the hypothetical heating regime, is actually used.

Since no council dwellings have closed stoves, the advantages which could be accrued by the installation of more efficient solid fuel burning appliances in Cuminestown are even greater than for Lumsden. If many people could provide their existing level of heating by burning less fuel, local resource use, presently at around 18% of total energy use, could increase in proportion to the imported percentage, thus increasing local energy autonomy considerably.

Adjusting the figure for energy use efficiency to 70% for households presently using open fires, to reflect the potential savings to be generated by the installation of more efficient appliances, gives a figure of 79.0%, for useful energy. By contrast, adjusting construction figures to reflect the position were all houses to have 100mm of loft insulation (fibreglass), gives a figure of 65.8, assuming that inefficient open fires are still used.

7.1.2.3. Energy Use in Transport-

As in Lumsden, the Cuminestown survey only included travel to place of employment, recording travel mode under the same 4 categories.

Mean number of miles travelled each way per day for heads of household was 5.7, exactly the same as in Lumsden, but representing a slightly lower energy use of 35.6MJ each way per day, due to differences in travel mode, particularly the fact that more people work locally, and thus can walk to work.

Total energy used in travel per annum for all household members was 24786MJ per household, a lower figure than in Lumsden, and again around 15% of household energy use, in spite of the considerably larger number of both workers and school children in Cuminestown. Energy use is lower however due to greater local employment and schooling, together with the rather shorter distance to secondary schooling in Cuminestown (Turriff), than in Lumsden (Huntly).

Again, adding a figure representing two return journeys per household per week to Cuminestown for outlying residents having cars gives 832MJ extra per household, so that total necessary local travel energy use is 25617MJ per household. Again, despite shorter distances than in Lumsden, this travel can be considered to be below minimum requirement.

Indeed, looking at the travel to work of car owning heads of household, at around 14 miles per day, 2800 miles per annum, it can be seen that actual travel is likely to be much greater. Average figures for vehicle miles per year are normally taken to be about 10000 to 12000 (8), so that travel to work may represent only about 25% of the actual energy used. 10000 miles represents 1350 litres of petrol, at 47MJ per litre. This is 68000MJ per car, a much higher proportion of domestic energy use, and a figure which could probably be dramatically reduced by voluntary constraint.

7.2. Energy Use Patterns, Agricultural-

7.2.1. Lumsden-

Considering capital on the farm, and firstly mechanical plant, fuel use on plant appears to be some 20 litres/hectare/annum on the farms for which this figure was available, though it proved to be a difficult variable to ascertain, and only a minority of farms could produce it off hand. This gives an energy consumption of 20 x 47MJ/litre = 940MJ/hectare/annum.

In terms of buildings, there are some 1.2 square metres of buildings per hectare of land, though this total figure is somewhat irrelevant in the absence of statistics on fuel use in buildings. On all the farms, buildings were mainly machinery and hay stores, and unheated stock wintering. Only two farms had silos, and the only heated building on the farms surveyed was a small pig unit. Small amounts of occasional lighting are the only energy use involved, so that farm buildings in this area have little significance for energy consumption or the energy resource.

There are no grain driers in this predominantly pastoral area, where much arable land is given over to potatoes and turnips.

Most farms operate a system of using 120kg of NPK fertiliser per hectare, needing 5470MJ in its manufacture, and for the 32% (700 hectares) arable land this represents84 tonnes, or 3829000MJ for the whole survey area (9).

With 1000 sheep, 800 cattle, 50 poultry, 25 pigs and 12 horses in the sampled farms, this is supplemented by some 960 tonnes of manure (10), representing a potential 14378713MJ of fertiliser value. (Since these figures cannot be measured, they are assessed from published material (11)). These figures represent the whole 27km2 of the survey area. The majority of the manure, other than perhaps that from sheep (2000000MJ), is currently well used, although most is randomly spread by animals in the field, rather than being controlled spreading of slurry.

Turning to attitudinal questions, many of these produced little response from the farmers involved in the survey, largely through lack of interest in issues, but also because of a perceived repetition with the domestic survey.

Only one farmer felt that chemical fertiliser use and the intensiveness of farming might decrease, and that mixed farming might return to areas which have increasingly gone over to monoculture, the rest being united in their opposition to this proposition. One other person felt that organic farming would grow in importance, one felt that the number of field operations would decrease, whilst no-one thought that the number of small plots would increase, or that friction between farmers and conservationists would change. Few strong opinions were held on any of these issues, many of the suggestions seeming impossible or irrelevant to farmers, reflecting a high level of conservatism, a basic unwillingness to change and a belief in present farming systems.

Although the sample in the farm survey has been in no way comprehensive, it does reflect a fair cross-section of tenure types and farm sizes, and whilst more might be done in the future to ensure a fuller coverage, the basic problem of farm boundaries not fitting in with survey areas, and management units not being central to the farms geographically, still exists, so that the population as sampled is probably as representative as it will ever be.

It might however be worth bearing in mind for future surveys the possibility of biassing the survey in a rather elitist manner, by trying to sample more of the larger landowners, to get a fuller coverage of land, much of which has potential as an energy resource.

7.2.2. Cuminestown-

On farm fuel use in Cuminestown, as in Lumsden, was largely restricted to mechanical plant. Ten respondents were able to give a figure for diesel used, which averaged 74 litres per hectare, representing 3525 MJ/hectare/annum, 7,050,000MJ for the survey area, and around 25% of total domestic energy use for the area, (adjusted to include non sampled homes). This is nearly 4 times more energy per hectare than that consumed in Lumsden, as might be expected in a predominantly arable area.

In terms of buildings, there are some 8 square metres of building area per hectare of land, again a larger amount than in Lumsden, as a result of the lack of less productive hill land. Energy use in these buildings is also greater, particularly since four farms in the sample operate grain driers. Since one of these is electric, and its energy use is incorporated into the farm house bill, and another has electric, oil and solid fuel driers, and no accurate fuel figures are available, accurate assessment of energy use in grain drying is difficult.

One farm uses a gas drier consuming some 818kg of gas per annum, representing 32720MJ, or 500MJ per hectare of arable land, 1/7th of the amount used in mechanical plant. Another farm with a diesel grain drier consumes 4500 litres/annum, including mechanical plant. Making an allowance for mechanical plant of 3525MJ/ha, this leaves 270MJ/ha for grain drying. Interpolating the perhaps more reliable 500MJ/ha to all arable land in the area (75% of total land), gives a total energy use figure for grain drying of 1500 x 500 = 750,000MJ, a relatively small amount compared to the 7 million MJ used in mechanical plant.

Other building energy use tends to be more sporadic and not as easy to make statistical generalisations about, as it relies on the non-land related enterprises of individual farmers. Thus one farm in the sample has a pig house for 25 sows, one a poultry house for 5000 birds, one a dairy distribution business and one a large building with refrigeration facilities for potatoes. All of these enterprises are run using electricity on the same meter as the dwelling, and although the electricity bills for these farms are very large, it is not possible to separate out the amount used for agricultural purposes.

The only other large energy input to consider is fertilisers, and to a lesser extent, pesticides. Most farms operate a system of using 120kg/hectare of NPK fertiliser on arable land, and with 608 cattle, 282 sheep, 25 pigs and 5500 poultry on farms for which figures were available, this is supplemented by some 676 tonnes of manure (dry weight), representing a potential 10138058MJ of fertiliser value (12).

This then represents 5470MJ of NPK fertiliser per hectare, 10940000MJ total for the area. It is assumed that, given the mixed nature of the farming pattern, good use is already made of the organic fertiliser resource, though this sector is considered again in section 8.

7.3. Energy Use Comparisons-

Table 7.9. gives details of overall energy use within the two main survey areas, with figures being adjusted to cover the entire sample area, rather than merely the sampled dwellings and farms.

In both main survey areas, domestic energy use is greater than all other sectors put together, and imported chemical fertilisers are the greatest agricultural input. Even if travelling is expanded to include all journeys, not merely essential ones, domestic space heating still remains the largest single sector. Although the dominance of this sector might be expected on a national scale, it is perhaps somewhat surprising in predominantly farming areas with low population densities.

For both areas a comparison between total delivered domestic energy and actual useful energy demonstrates the value of being able to conserve energy by more efficient conversion, on total energy use in the area.

Table 7.9. Summary of Energy Use.

	MJ/Annum Lumsden	MJ/Annum Cuminestown
Domestic energy use (delivered to house, MJ)	22199616	28364367
Needs/use x 100, %	69.83	72.36
Mean delivered energy per household.	175699	161556
Domestic energy use (adjusted for low appliance efficiency)	10840553	15667523
Heating component (%)	89.10	83.90
Non heating component (%)	10.90	16.10
Transportation energy/household	28009	24786
Transportation energy use,	4215023	5175308
Total adjusted for non-work journeys.	4289472	5378545
Agricultural machinery energy use per hectare	940	3525
Total ag. machinery use	2538000	7050000
Agricultural buildings/grain drying, (MJ/hectare)	000	500
Total agricultural building use	000	750000
Imported fertilisers/arable ha	5470	5470
Imported fertilisers, total.	3829000	10940000
Pesticides, total.	35000	75000
Total agricultural energy use per hectare	6460	9545
Total agricultural energy use	6402000	18815000
Total energy use, all sectors per household.	246305	275954
TOTAL ENERGY USE, ALL SECTORS	32811088	52557912

Outside the frame of reference of the survey, energy use is likely to be considerably greater in Cuminestown than in Lumsden, due to the number of retail outlets and small businesses in the former. Yet within the surveys, Lumsden exhibits higher energy useage per household in both domestic and transportational sectors, whilst Cuminestown, as might be expected, has much higher agricultural energy consumption per hectare, and for the area as a whole, despite the larger area covered in the Lumsden survey. The higher population of the Cuminestown survey area means that both domestic and transportational energy are higher than in Lumsden, when aggregated for the areas as a whole.

The factors leading to a higher household energy consumption in Lumsden are; the higher proportion of non-working people at home during weekdays, the somewhat poorer condition of the housing stock, particularly in the private rented sector, the slightly larger houses, and the slightly poorer climatic conditions, coupled to the fact that more houses are in exposed positions outside the village itself.

Lumsden also makes rather better use of local and free energy resources than does Cuminestown, with the local resource making up some 23% of domestic energy use in the former, compared to 18% in the latter, and the free resource making up 11% and 8% of the total in the respective areas. Perhaps surprisingly, the use of home-cut peat is higher in Cuminestown, although local availability would appear to be lower, whilst it is timber which makes up most of Lumsden's free and local resource use. The statistical significance of these figures is somewhat dubious however, since the figures are heavily influenced by only a few houses making maximum use of peat and wood supplies.

The Dunecht survey did not produce sufficient energy use data to work out total household energy use, with valid, complete observations for only 7 cases, but it is likely that the use of free resources, with no peat supplies and most timber controlled by the estate, is low, whilst the use of the local resource, with most people purchasing wood from the estate, is high.

Correlation between energy use and housing standards proved surprisingly difficult, and personal habits of the occupants, in terms of heating regimes and ventilation conditions, seem to make a considerable difference to the results. Yet one cannot conclude from this that such measures as insulating dwellings are fruitless, for they may allow occupants a far greater degree of comfort for the same amount of energy. One simple, if seemingly patronisingly obvious measure, may be to stress ventilation levels, both in terms of draught proofing structures and changing personal habits, as major forces in heat loss.

Compared to domestic energy use, transportation and agricultural energy use, as measured, show fewer opportunities for savings. Although many car owners may be able to restrict their travel, or use more economical vehicles, socially speaking there appears to be a transportation shortfall, rather than an excess, with 27% of households in Lumsden, and 20% of households in Cuminestown having no car, and are therefore restricted to a bus service which, particularly in Lumsden, is largely limited to essential services such as journeys to and from school. Although the normal arguments on the provision of public transport, post buses, minibuses and travelling services, apply, it is unlikely that such provision could make any difference to energy use by encouraging present car owners to make more use of public services, unless the level of provision was to be increased many times over.

Nationally, domestic energy use makes up some 25% of total energy use, passenger transport 12.5%, and agriculture only 1% (13). In the survey areas agriculture obviously makes up a much higher proportion of total energy use, whilst transportation energy use, though expected to be high in rural areas, is actualy only around 50% of the national average compared to domestic energy use. This again confirms that the essential journeys considered are likely to make up only a fraction of the total energy used in transport.

It is beyond the remit of this project to suggest the complete changes in agricultural systems which might be necessary to conserve energy in the farming sector. A pastoral system such as in Lumsden certainly reduces the amount of imported fossil fuel and fertiliser energy compared to more arable Cuminestown et Cuminestown's system of production makes more efficient use of the incident solar energy, and when this is taken into account, may be a more efficient agricultural form.

Aside perhaps from the special case of intensive animal rearing, which in the case of pig rearing for instance, is ostentatiously wasteful of energy, savings must be made within the existing agricultural pattern. As such, in mixed farming areas where good use is made of available organic fertiliser resources, and there are few uses of energy in farm buildings, opportunities for savings seem minimal, and linked to such factors as the technology level of agricultural machinery. The use of local resources and renewables in grain drying is one potential area of saving, though currently only a small proportion of energy use in Cuminestown, and not a factor at all in Lumsden.

The agricultural sector, as section 8 demonstrates, can make far greater contributions to the energy resource than it can to energy saving.

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8. ENERGY RESOURCE PATTERNS-

8.1. Domestic Resources (All Areas)-

8.1.1. Introduction-

Although the energy resources of Cuminestown and Lumsden are primarily agricultural in nature, aside from the universal resources of solar and wind power, there are some small energy resources available in the domestic sector.

Unnecessary energy use might be considered to be a resource in itself, and the saving of it to be a positive usage of that resource. Yet these energy uses have been considered in Section 7, aside from the potential savings to be made through building design, i.e. passive solar design.

8.1.2. Passive Solar Design-

Section 2.3, on energy economics, has demonstrated, for one passive solar energy project, a saving of 1314 kWh/annum (4730 MJ) for single bedroom flats over similar conventional flats constructed to minimum building regulations standards. Average gross floor areas of dwellings in the two main survey areas are almost double that of these flats, so that potential savings to be made by building new houses in this way might amount to 8000MJ/annum, which represents only 5% of total energy use. Additionally, energy payback times for the additional energy required in construction are long, and though useful savings might be made by introducing these techniques into new housing, the replacement period for the entire housing stock is necessarily a very long one, and savings are dwarfed by the savings which could be made in fuel conversion efficiency.

8.1.3. Human Labour-

Within the dwelling unit is a convenient place to consider the role of human labour as an energy source.

Section 2.2. concluded that the contribution which can be made by human labour, particularly within agriculture, when it is considered purely as a source of energy, is minimal, with a reasonably fit manual worker having the useful output of a 100W light bulb. Obviously however, the availability of human labour is important in so far as respondent's ability to make use of other resources, such as wood and peat, is concerned.

The actual unemployed labour resource in both Cuminestown and Lumsden is quite small, at 3.22 and 1.57% of the population respectively, representing, in energy terms, 7200MJ and 3500MJ/annum, yet the total labour resource may be much larger.

The current willingness of the employed sector of society to spend more time on energy related activities can be measured by the number of people presently cutting peat and gaining their own supplies of fire wood. There are 19 families in Lumsden cutting peat, 13 in Cuminestown, and 35 families in each area cutting significant amounts of wood themselves, not including those who buy in large logs and cut them up before use. For a large majority of these people, the free resource is a major component of their fuel use. These quite small numbers partly reflect availability, with peat hags being allotted historically to only certain houses and, particularly in Lumsden, estate dominance over both peat and wood supplies, together with the estate owners' reluctance to see these resources used.

Were access to these fuels to be improved, the human labour may well be available to make use of them.

Cross-tabulating confidence in the future of peat as a fuel source against the age of respondents produces the perhaps surprising result that it is the younger people who are more in favour of this fuel. In age groups under 45, for both areas aggregated, 75% of people felt that peat would be a fuel of the future, whereas in age groups over 45, the figure was only 48%. Perhaps the older people's reticence about peat cutting is based on the disillusionment of experience, but nevertheless it is encouraging to find this confidence, albeit not backed up in practice, amongst the younger householders, in a traditional fuel source.

It should be noted however, that a slightly higher proportion of the older than the younger age groups actually cut peat. Extending the comparison by a cross-tabulation with occupation does not produce such a clear response, neither those in traditional local occupations, nor the professionals and self-employed sectors, seem to show any greater leaning towards peat as a fuel source.

Appendix 12 shows maps of local peat resources for the two areas.

So there would appear to be a considerable willingness, in theory at least, to apply available human labour to the gathering of fuel supplies; a willingness which springs largely from identification with a perceived historically more independant culture, rather than from a more general interest in energy per se. It is difficult to say how far this armchair philosophy would actually be displayed in reality, were the means to gain peat and wood to be made available, but it seems fair to give the benefit of the doubt to those expressing an interest.

One interesting development was foiled by the estate included in the sample in Lumsden, which for two years let peat hags to an individual cutting with simple, tractor mounted equipment. However, this lease was withdrawn on the grounds that it was "not worthwhile", to the estate owners.

8.1.4. Domestic Wastes-

As stated in section 2.2, national resources of waste materials stand at 210PJ/annum, together with 20PJ/annum of sewage. This converts to 400MJ of sewage per capita per annum, or 149240MJ in Lumsden, 228240MJ in Cuminestown. This represents less than 1% of domestic energy use in Cuminestown, and 0.7% in Lumsden.

The easiest way of utilising this small energy resource is probably to spread it on the land, a process which is not advisable without more advanced means of processing, such as activated sludge treatment, than are available to individual or small groups of dwellings.

In terms of other domestic wastes, the figure of 4000MJ per capita per annum relates to all wastes including industrial wastes, and cannot be directly applied to the rural domestic sector, where levels of wastes will be much smaller. In addition, the large number of houses with solid fuel heating already utilise much of their clean, easily converted waste, in the shape of newspapers and paper packaging, for lighting fires, and it is estimated that the domestic waste not presently used is unlikely to be much greater that the sewage resource. This waste is also much more difficult to use as fertiliser, and the optimum use is for most of the dry, clean waste to be burnt, perhaps by collection from homes without solid fuel fires, and redistribution to those with fires.

Even so, the difference which such a policy would make would be at best marginal, and a high estimate of the available resource would put it at the same level as sewage, 149240MJ in Lumsden, 228240MJ in Cuminestown.

8.2. Agricultural Energy Resources, Lumsden-

8.2.1. Introduction-

Since the agricultural system represents the main difference between the two principal survey areas, the agricultural energy resource will be dealt with seperately for each area.

As with the domestic sector, potential savings in energy use could be considered to be an energy resource, though since most of these have been considered in the previous section, the only one that remains relates to passive solar design. Since energy use in buildings, aside from grain drying, is sporadic and particular to certain farms in both areas, it cannot be generalised about enough to explore the resource. In Lumsden indeed, building energy use is virtually non-existent.

8.2.2. The Food Resource-

Obviously the most economically important energy output from agriculture in almost any area is food, both crops and animal produce, the latter being the more important, economically at least, in Lumsden. Average grain production per hectare of arable land is 4 tonnes/hectare, 2 tonnes in the average year in the rotation, representing some 80000MJ/ ha/annum, 72000000MJ for the Lumsden area, with its 900 hectares of rotational arable land (1). With an estimated 67% of barley in Scotland being either retained on farms or sold to other farms for animal feed (2), this leaves 33%, 24000000MJ, exported from the system. Lumsden's production of 750 beef cattle, the milk from 60 dairy cows, 1000 lambs, and pigs from 25 sows, make up an additional energy content of 24543340MJ/annum (Calculated on the basis of 10000kcal, 41.83MJ per kilogram),making a total agricultural production of 48543340MJ/annum, compared to 6405000MJ in agricultural energy use (3).

8.2.3. Cropping Wastes-

Straw production in the Lumsden survey, for the 10 farms for which figures were available, was 171 tonnes. 144 tonnes of this are used for animal bedding and feed, whilst farms in the sample buy an additional 122 tonnes of straw. So there is in fact a shortfall of 95 tonnes of straw which, although perhaps reflecting a bad year in this case, means that straw cannot be considered as a resource in Lumsden.

The 95 tonnes shortfall represents an energy use of some 1710000MJ, at 18000MJ/tonne (4), an energy requirement around 65% of agricultural machinery energy use, and therefore not inconsiderable. Having been used as bedding, straw may then be spread as fertiliser, so providing some, albeit reduced, energy value, but this has already been considered in the section on energy use.

Other cropping wastes, particularly the wet wastes from the large amounts of potatoes produced in Lumsden, may be presently underutilised, but since the sampled area is as large as the survey area, although not conforming to the same boundaries, adding this resource to the total resources of the area would unnaturally inflate them.

The best use for these wastes would probably be in an anaerobic digester, though the seasonal nature of the waste would maximise necessary capital expenditure, whilst fuel output would be low, and storage and use systems are expensive.

8.2.4. The Timber Resource-

Probably the largest underutilised agricultural fuel resource in Lumsden is the timber resource. Currently 1476300MJ of home cut wood are consumed in surveyed Lumsden homes, largely cut on land within the survey area, whilst 2231100MJ of bought wood are used, which although relatively local, originates outside the immediate survey area. Together these represent around 15% of domestic energy use. The total resource, however, is considerably larger.

Within the sample there are some three hectares of woodland used for fuel, two hectares of deciduous woodland not utilised for fuel, and around 100 hectares of coniferous forest attached to the sampled estate. Since woodland and forestry tends to be concentrated on the large estates, much of it is not included in the sample. Aside from the sampled farms, one estate has some 50 hectares of unmanaged deciduous woodland, and another 100 hectares.

Production of timber by trees in commercial forestry is around 12 tonnes of dry matter per hectare per annum, for most species, though differences in volume may be great. For the perhaps rather less productive forestry of Lumsden, 10 tonnes per hectare is taken for coniferous forest, 6 tonnes for deciduous woodland. All these resources in Lumsden are presently lying idle, and if trees were to be thinned at the growth rate, an annual production of 45000000MJ is possible, around double present household energy use in the area.

Winning this amount of fuel might be difficult without clear felling, yet certainly considerable amounts of fuel could be taken by organised individuals, making a large difference to the local fuel bill.

8.2.5. The Peat Resource-

The peat resource around Lumsden is very large considering the low number of users and potential users. It consists of around 20 hectares of low lying, wet peat, situated around half a mile from the village, and though popularly said to be useless as fuel, used by several respondents, and hill peat on the 'Cabrach', outside the actual survey area, but largely on land owned by the large estate in the sample.

The latter resource covers at least 200 hectares. Assuming a peat depth of only 0.5m, this then represents a total of 1000000m3 of peat, about 500000 tonnes dry weight. At 20000 MJ/tonne, the total resource is thus 11000 million MJ. Even if this resource is treated somewhat artificially as a fully renewable one, and the depletion time is assumed to be 2000 years to allow for regeneration, this represents 5500000MJ per annum, some 15% total annual fuel use for all purposes (6). If a depletion time of 100 years is taken, then the annual resource is 110000000 MJ per annum. The real limiting factor is not the actual resource size, but the ability to gain the fuel.

Currently, extracting peat from the lowland source near the village has been reduced to the level of poaching by one major landowner, despite historic rights of access, whilst the situation on the large estate included in the sample, aside from the one experimental lease previously mentioned, is now roughly the same.

8.3. Agricultural Energy Resources, Cuminestown-

8.3.1. The Food Resource-

Food output in Cuminestown is greater, in terms of energy content, than that of Lumsden, reflecting the greater emphasis on crops than on animal produce, as well as the much greater energy input to agriculture.

Average grain production per hectare of rotational arable land is 4 tonnes, representing 80000MJ/annum/hectare, 120000000MJ for the area as a whole, with an estimated 1500 hectares of arable land (7). With an estimated 67% of barley kept on farms or sold to other farms for animal feed, this leaves 40000000 MJ sold off farms for purposes other than animal feed (8).

Annual animal production of 550 beef cattle, 300 lambs, pigs from 25 sows and the eggs from 5447 poultry makes up an additional energy content of 12301019MJ (9). Assuming similar patterns of production on farms not surveyed, this gives 24602038MJ for the whole area. Animal and crop production makes up a 'farm gate' energy output of 64602038MJ, 3269MJ/hectare, compared to 18815000MJ of agricultural energy use, i.e. a net food energy production of 45787038MJ.

8.3.2. Cropping Wastes-

Straw production in the Cuminestown sample was 1834 tonnes, 1050 tonnes of this being produced by one farm. 173 tonnes of straw are bought by sample farms, and 1604 tonnes are used for bedding and feed on sample farms. With 230 tonnes sold, this leaves an excess of production over requirement of 57 tonnes, about 3% of total production, a rather small amount, suggesting that this cushion may be needed against years of only marginally lower harvests.

However, 45 hectares of straw are burnt in the field, at 3.6 tonnes/hectare for barley straw (10), around 162 tonnes altogether, or 10% of the total resource. So to available total of 219 tonnes, extrapolated for the whole area to 438 tonnes, at 18000MJ/dry tonne, represents an energy resource of

7884000MJ, or about 110% of agricultural machinery energy use.

One farm in the area, though not one that it proved possible to include in the sample, has installed a small straw burning stove, largely for domestic use, and this already absorbs some of the resource. Straw burnt in the field is not entirely wasted however, for it provides some immediate fertiliser value, but the vast majority of the energy content is wasted by this process. (11)

8.3.3. The Timber Resource-

The timber resource in Cuminestown, though not as large as in Lumsden, does provide significant opportunities for local energy resource use. Currently, 640100MJ of home cut wood are used in sampled homes, together with 1191400MJ of purchased fuel wood which, though more or less local, comes largely from outside the immediate survey area. This extrapolates to a total wood fuel consumption of 3296700MJ for the area as a whole, around 12% of total domestic fuel use. Yet the total resource is much larger than this.

There are only 11 hectares of mixed deciduous woodland in the sample, of which only 2 hectares are currently used for fuel. Yet large stands of timber were not included in the successful sample.

Within the survey area there are actually another 30 hectares of presently unused and under used deciduous woodland, with a potential productive capacity of 3240000MJ, and a forestry commission plantation of 100 hectares, which could produce 18000000MJ. Obviously however, the Forestry Commission plantation is already productive, or shortly will be, (this plantation is currently 15 years old), and though thinnings and small branches and roots left in may constitute a significant resource in future, the nature of the operation makes this not a continuous resource, and the percentage of material currently used is not known. If only say 10% of this resource could be tapped however, together with the annual production of the underutilised deciduous woodland, 5040000MJ would become available, which would provide nearly 20% of current domestic usage.

8.3.4. The Peat Resource-

Home cut peat use is, perhaps surprisingly, higher in Cuminestown than in Lumsden, at 967500MJ for the sample, 1741500MJ for the area as a whole; i.e. around 7% of the total domestic energy use. Mean usage of commercially supplied peat is some 4 times greater in Cuminestown than in Lumsden, largely as a result of the relative proximity of the two large commercial peat cutting operations around New Pitsligo.

However, the potential for increasing peat consumption by home cutting in Cuminestown is less than in Lumsden, due to the scarcity of peat resources within and immediately around the survey area.

Some 20 hectares of peat deposits are situated near Cuminestown, but outside the actual survey area. This represents 100000 tonnes, 2000 million MJ. Thus the annual peat resource at the unrealistically long depletion time of 2000 years, is 1000000 MJ per annum (12). At a depletion time of 100 years, the resource becomes 20000000 MJ per annum.

8.4. The Non-Agricultural Renewable Energy Resource-

8.4.1. Water Power-

It is perhaps surprising that diffusion of ideas on renewables has gone so far that, aside from the straw burning installation already described, the two main areas contain examples of a new wind generator, three solar water heating systems and a large private hydro-electric scheme, along with a wind turbine retailer (albeit only selling small windchargers for electric fences as a very minor part of a larger business).

Yet the only one of these renewables for which one can meaningfully talk of the total resource, is water power.

Lumsden is in a larger catchment area than Cuminestown's flatter landscape, and contains the only large stream in the survey areas. Scope for individuals to take advantage of water power is extremely limited, since major streams and the land around them tend to remain in the hands of estates, and the existence of fishing rights and other alternative uses tend to make usage for water power more problematical.

The extent of the inertia affecting estates in this matter is strongly evidenced in the case of the largest farm unit in the sample in Lumsden. This is the largest block of land in the survey, and incorporates a tenanted farm and around 10 let houses, as well as the 1732 hectares managed as the home farm. On this estate a major hydro-electric scheme was installed by the grandfather of the present incumbent around the turn of the century, to provide electric lighting for various houses and farms in the area, as well as local street lighting.

At the time, this installation was obviously extremely advanced, and gave the estate electric power generations before similar rural communities could boast it. The hydro-electric plant was still the only form of electric power in the vicinity until the late 1960's.

Yet even given the existence of generating plant and water storage capacity, and the potentially high availability of capital on an estate of this size, creating the perfect conditions for the use of such renewables, the estate, though professing an interest in private hydro-electric power, are unwilling or unable to find the money for the refurbishment of the existing plant.

A guide to the size of the available resource can be got by looking at the catchment areas and average stream heads of both areas. Catchment areas of all streams passing through the survey areas were taken, together with the maximum average head, i.e. average height of the start of streams, minus minimum height within the areas. The southern corner of the Lumsden area contains a large river, the Don, but this is omitted, since it is unlikely and indeed unreasonable to expect that its catchment area, encompassing a large area of Grampian, should be dedicated to the provision of electricity to Lumsden.

Lumsden streams have a catchment area of 110km2, at average maximum heads of 200m. Flow from this catchment area is likely to be around 1.1m3/sec minimum, therefore 6.4 x 1.1 x 200 x 3.6 = 5069MJ/hour, 44402688MJ/annum. In Cuminestown, catchment areas total 60km2, making flow 0.6m3/sec, and average maximum head is 50m, thus 6.4 x 0.6 x 50 x 3.6 x 24 x 365 = 6054912MJ/annum (13).

Yet the economics and energetics of hydro-electric power schemes, as discussed in section 2.3, are often not favourable even for larger schemes, whilst total utilisation of all runoff from the two areas would obviously be impossible. If say half the potential flow were to be used at a quarter the maximum head, these figures would become 5550336MJ and 756864MJ respectively for the two areas. Thus the hill area of Lumsden has considerably greater potential than has Cuminestown for water power, but though the potential resources are large, technical and access problems limit this dramatically, whilst the amount of financial input needed compared to energy produced, particularly for the smallest schemes, may be prohibitive.

8.4.2. The Wind and Solar Resources-

The total wind, and particularly solar resource, in both survey areas, is immense, in terms of total wind power available and total incident solar radiation, at around 3348.8MJ/annum per cm2 for solar, and 131MJ/annum per m2 for wind (14). Yet the idea of harnessing these diffuse resources to such an extent is patently preposterous, whilst solar radiation is already used at optimum, if low, efficiency in farming. Yet these two resources are more open to use by more individuals than is water power, and anyone owning their own home, given sufficient capital, could potentially install such a system.

In terms of solar power, one house in Lumsden and two in Cuminestown have solar roof panels. The recent installations in Cuminestown, purchased by the present occupants, are popular with them, and rough estimates put the percentage of hot water requirement supplied at 50%. By contrast, the installation in Lumsden was installed by a previous owner of the house, and has now ceased to work. Since the manufacturer has gone out of business and the present incumbants show little or no interest in the system, it is unlikely that it will ever work again, although only about 6 years old.

A more realistic way of assessing the maximum possible use of the resource is to suggest a scenario in which all houses in the area installed 5m2 of solar panels, which could provide hot water up to half their needs. (Attempting to supply a greater proportion means that much is wasted and the economics suffer). This would cost, at present prices, around £2000 per house, £300580 in Lumsden, £419920 in Cuminestown, for an energy saving of 5468MJ (15) per household per annum, 821846MJ in Lumsden, 1148061MJ in Cuminestown. Energy costs of capital could have a payback time of some 5 years (see Section 2.3), economic payback times are however unlikely to be less than the life of the equipment. Mass production of panels could, and indeed already has for many systems, brought this cost down considerably, but energy costs of capital are unlikely to reflect this downward trend.

It is less valid to take such a generalised scenario for wind power, which requires more space and is not so easily applied to small domestic usage, being sporadic and limited to electricity. A fairly far-fetched maximum usage scenario might be for all farms in the two areas to be able to replace half of their electricity usage with wind power, amounting to a total of 424200MJ/annum for Lumsden, 983200MJ for Cuminestown.

One farm in the Lumsden area, which remained unsurveyed, does employ wind power for pumping, though the exploits of these retired, incomer part-time farmers are treated with some scepticism by other members of the agricultural community, who consider that only those with a high level of capital available, and not too great a concern over losing money, could consider such a scheme seriously.

When it comes to renewable energy sources, one would perhaps imagine that middle class incomers, taking up their rurality often as a form of rather idealised 'escape', would have been more in favour of wind and solar power than other groups, yet no particular correlation between either age or occupation, and confidence in the prospects for renewables, can be gleaned, except that retired people have slightly lower confidence in these forms, often coupled to considerably less knowledge of them than other groups.

The populace is split on the issues of wind and solar power almost evenly between the 'don't knows', those in favour and those against, though with slightly higher confidence in solar than in wind. Other sources are for the most part not known about, the issue of methane generation from waste, for instance, typically just produces incredulity amongst respondents.

8.5. Comparisons of the Energy Resource-

Table 8.1. presents a summary of the rural energy resources of Lumsden and Cuminestown as described in Sections 8.1 to 8.4.

When the utilised food resource is removed from the total, to leave the spare fuel resources, only Lumsden, with larger reserves of timber and peat than Cuminestown, has a local energy resource size greater than energy usage, although even in Cuminestown, resource size is over half domestic consumption. Although many of the resource figures represent rather coarse estimates, they are able to suggest orders of magnitude, and can certainly demonstrate that resources are considerable compared to use, and many times current local resource use. It would of course be impossible to employ all of these resources, or perhaps even any of them 100%, yet the potential for increasing local energy autonomy can be clearly seen.

Table 8.1. Summary of the Rural Energy Resource.

	Lumsden (MJ/annum)	Cuminestown (MJ/annum)
Passive solar house design (all houses)	1200000	1600000
Human labour (unemployed)	3600	7200
Sewage	149240	228240
Domestic waste	149240	228240
Total domestic resource	1502030	2063680
Passive solar farm building design	Sample too small to generalise	
Food crops	80000000	120000000
Animal products	24543340	24602038
Excess straw	-1710000	7884000
Timber	45000000	6228000
(minus current use)	-1476300	-640100
Peat (2000 year depletion)	5500000	1000000
Peat (100 year depletion)	110000000	20000000
Total agricultural resource	256357000	162306000
Hydro power	5550336	756864
Active solar	821846	1148061
Wind	424200	983200
Total renewables resource	6796382	2888125
TOTAL ENERGY RESOURCE	264655000	167257000
TOTAL ENERGY USE	32811088	52557912

By far the easiest resource to tap is the excess straw, present only in Cuminestown, for here farmers already have the equipment to harvest and bale the fuel. Conversion, however, is not so easy. Straw burning stoves (and particularly those designed to take the newer, large round bales), are generally too large for ordinary domestic situations, and require a higher level of organisation to use their energy. In the few, small energy using farm buildings in Cuminestown, much of the electricity is used for non-replacable purposes such as lighting, for which a straw burning stove is useless. Additionally, much of the current excess production is already used by the existing installation on one farm, though most is still burnt in the field. Perhaps very small straw burning stoves for several, very close together, owner occupied homes, present the best opportunity for the use of this resource.

Much easier to burn on existing fires, but harder to harvest by mechanical means, are the timber and peat resources. Although the timber resource is extremely large, in Lumsden in particular, the nature of it, largely thinnings from existing woodland, makes it difficult to harvest in large quantities.

There are basically two distinct ways in which the timber resource might be harvested; either by owners' encouragement of casual felling by as many individuals as possible, or a small commercial enterprise (one or two persons), carrying out more organised harvesting. The capital necessary for the latter scheme would be quite small, consisting of perhaps a chainsaw and a small tractor and trailer, whilst production of say 6 million MJ could gross around £12000, representing some 300 tonnes of timber annually. Such an enterprise would not necessarily be restricted to the immediate survey areas.

The same type of organisation might be applied to the winning of the peat resource. Since many people in rural areas own wood cutting equipment such as chain saws, there may be little advantage in carrying out a professional operation, but mechanical cutting of peat is rather more specialised, though small, ordinary tractor mounted devices for cutting in traditional hags, as opposed to stripping large areas, are now available. Such an operation has been reported as having been mounted in Lumsden without success, but what caused the failure is not clear. The experiment may not have worked merely due to the resistance of the estate owning the peat resource, and their apparent reluctance to have any kind of economic activities taking place.

In spite of these opportunities, using the local energy resource looks in many ways not as attractive as optimising savings in present use, and most particularly the savings which could be made by employing small, efficient solid fuel burning stoves in the domestic environment.

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9. THE FUTURE OF RURAL ENERGY RESOURCES AND USE-

9.1. The Local Survey and the Wider Context; The Ability to Make Generalisations About Rural Areas from the Specifics of Survey Areas-

9.1.1. Agricultural Indicators of Comparability-

The main features in which the survey areas were specifically designed to differ were agricultural form and topography, so that the survey results can be said to represent a wide range of types of area due to their differences in form.

Figure 9.1 (1) is a broad breakdown of agricultural regions in Britain, which demonstrates that the types of agriculture practised in the North East of Scotland broadly fit into the agricultural categories of large areas of the country. In reality however, livestock rearing differs considerably from area to area, from specialist dairy areas to rough grazing for sheep, to an area of mixed farming with barley production, such as around Cuminestown.

Looking at the climatic limitations on land use within these broad farming areas is able to bring out land suitability rather more. Figure 9.2 (2) puts both Cuminestown and Dunecht in areas of 'slight' climatic limitation, and Lumsden in an area of 'severe' climatic limitation.

Figure 9.1. FARMING REGIONS IN BRITAIN (1)

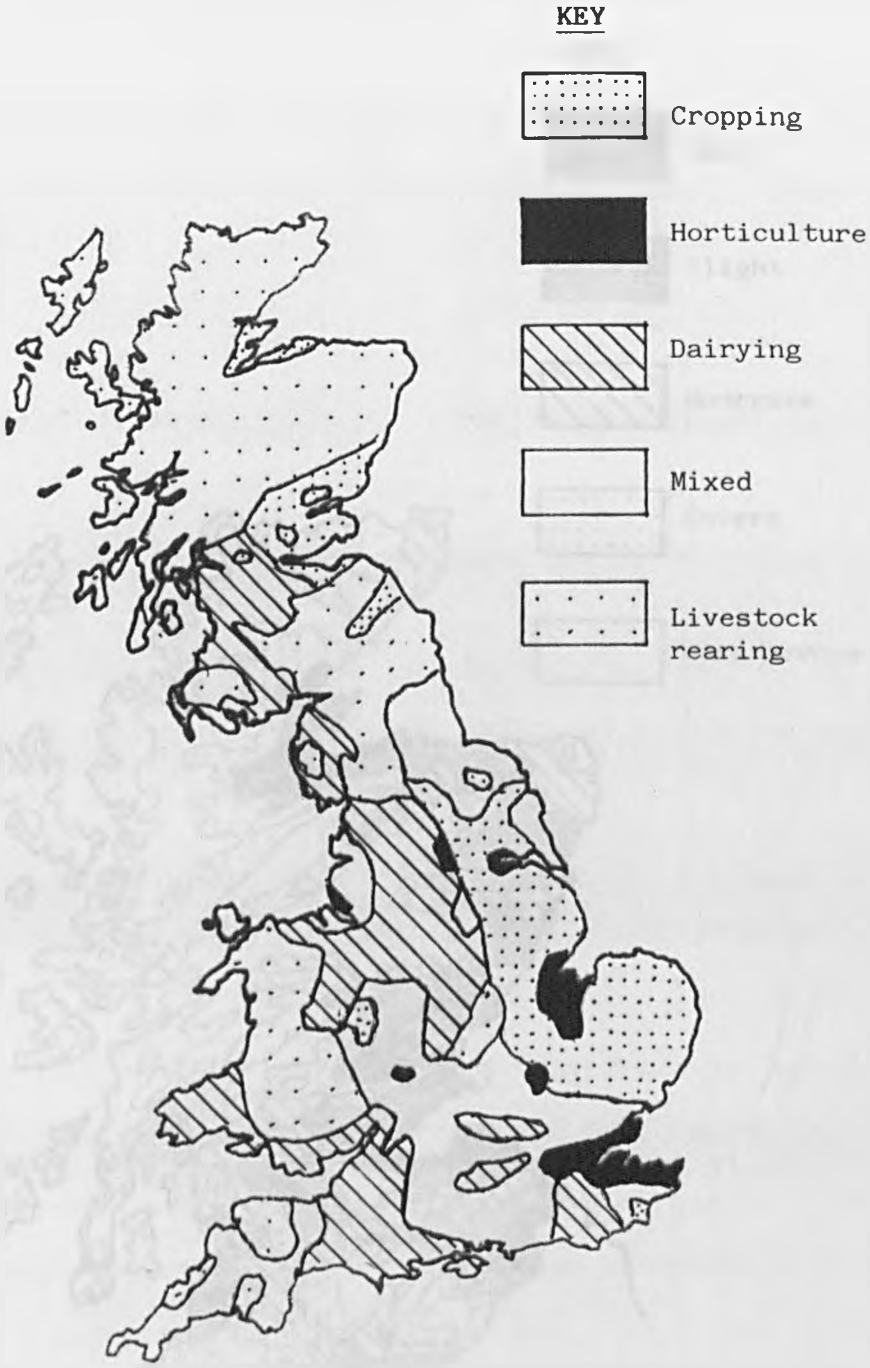
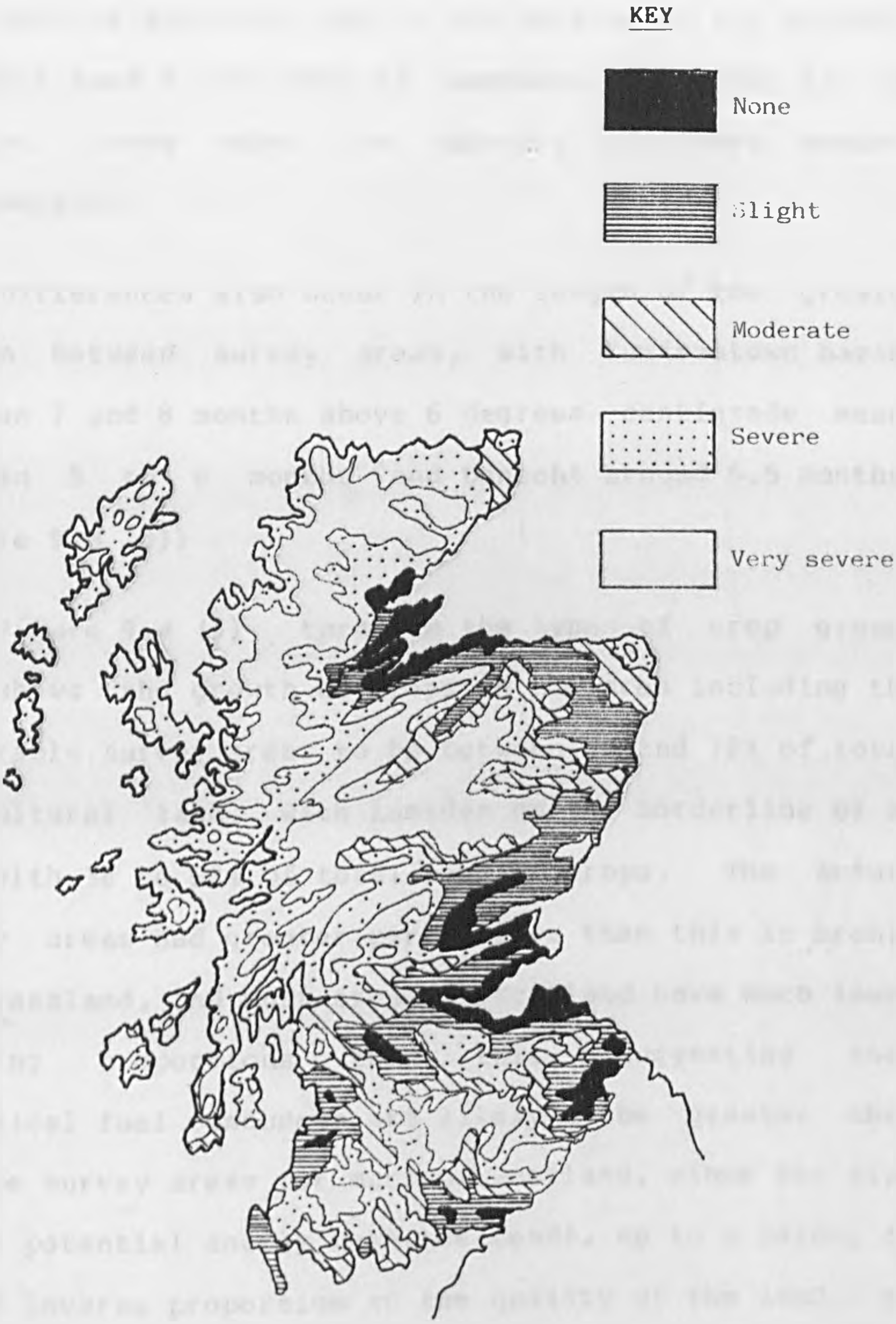


Figure 9.2. CLIMATIC LIMITATIONS ON AGRICULTURAL LAND USE IN SCOTLAND (2)



The first category covers quite large stretches of Eastern and Central Scotland, whilst the latter encompasses larger areas in the more favourable strips of the West of Scotland, and in the uplands of the Borders. The hill land to the west of Lumsden, included in the sample, comes under the category of 'very severe' limitations.

Differences also occur in the length of the growing season between survey areas, with Cuminestown having between 7 and 8 months above 6 degrees centigrade mean, Lumsden 5 to 6 months and Dunecht around 6.5 months. (Figure 9.3 (3))

Figure 9.4 (4) turns to the types of crop grown, and shows the growth of crops in the area including the two arable survey areas to be between 50 and 70% of total agricultural land, with Lumsden on the borderline of an area with 30 to 50% of total land in crops. The actual survey areas had greater percentages than this in arable and grassland, and most areas of Scotland have much lower cropping proportions than this, suggesting that biological fuel resources are likely to be greater than in the survey areas for much of Scotland, since the size of the potential energy resource tends, up to a point, to be in inverse proportion to the quality of the land. In this respect, Lumsden is far closer to a Scottish 'national average' than the other areas, particularly with regard to its large areas of hill land. The other survey areas have more in common with areas further south

Figure 9.3. LENGTH OF GROWING SEASON DEFINED BY THE NUMBER OF MONTHS WITH A MEAN TEMPERATURE ABOVE 42.8°F (3)

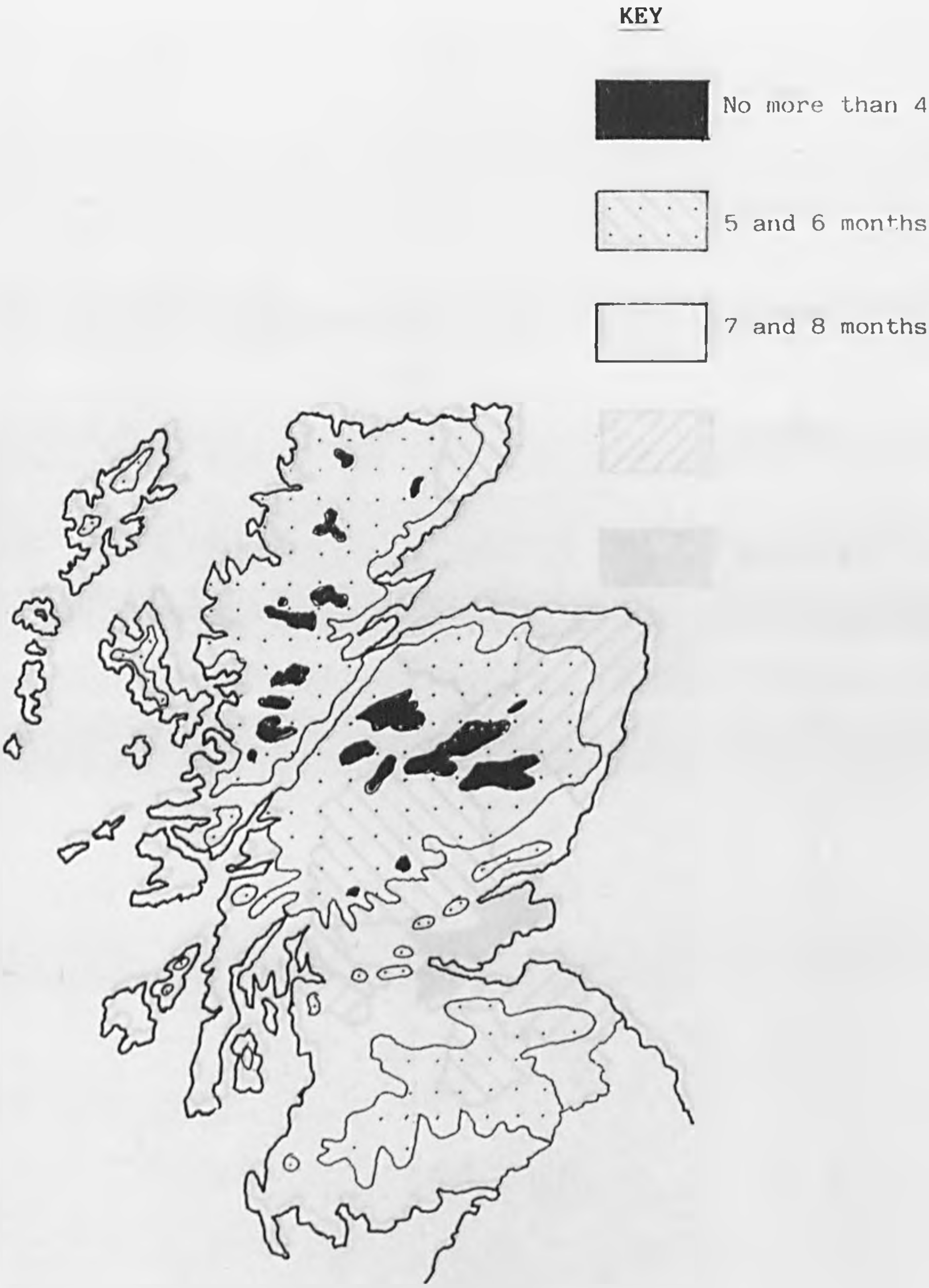
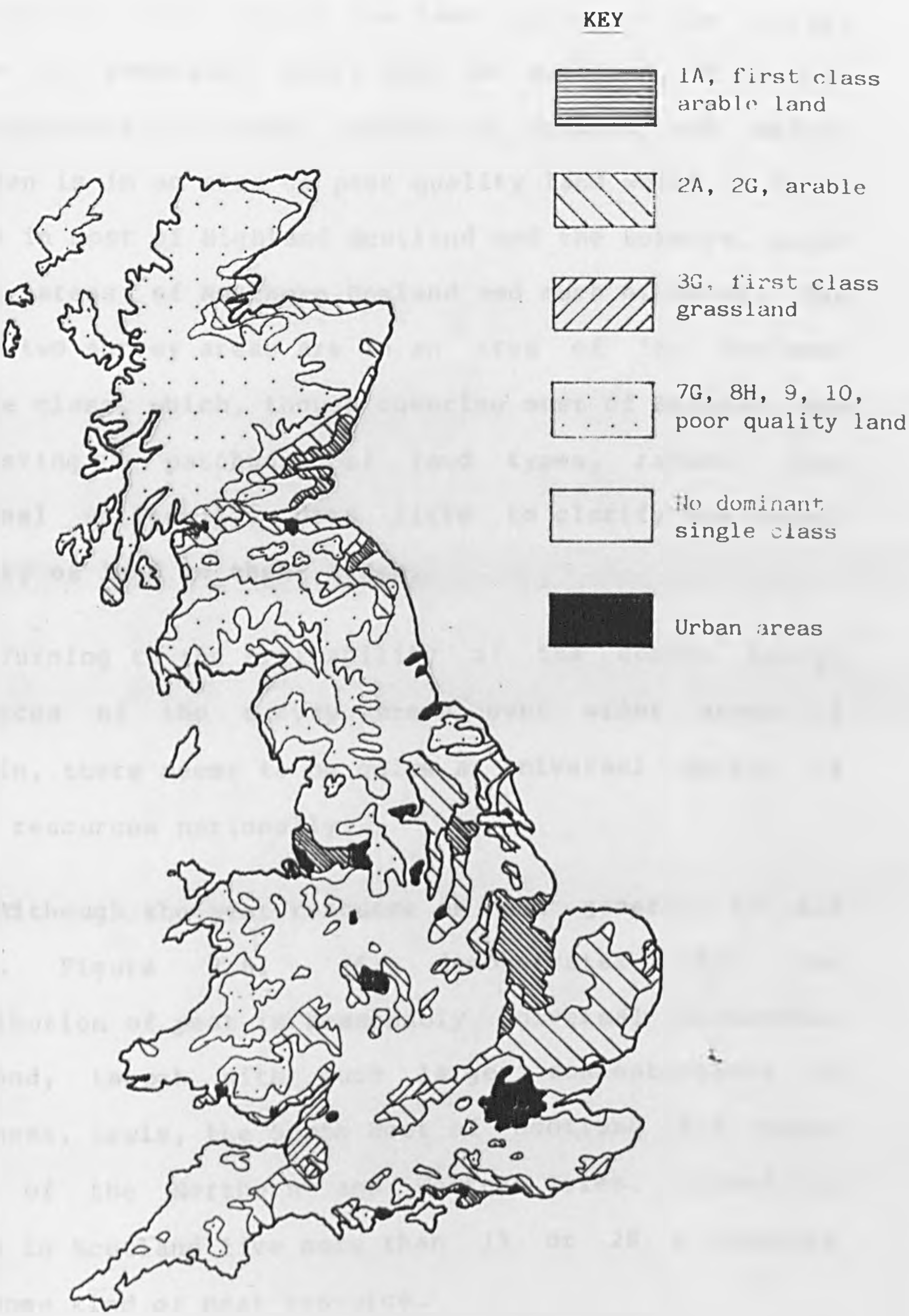


Figure 9.4 CROPS AND GRASS AS A PERCENTAGE OF TOTAL AGRICULTURAL AREA BY COUNTY IN SCOTLAND (4)

Figure 9.5. SCHEMATIC LAND CLASSIFICATION (5)



than they do with much of the rest of Scotland.

The land quality and agricultural form of England and Wales is expanded on by Figure 9.5 (5). This demonstrates that, whilst the land quality of the survey areas is generally quite good for Scotland, it is more representative of larger areas of England and Wales. Lumsden is in an area of poor quality land which is to be found in most of Highland Scotland and the Borders, quite large areas of Northern England and much of Wales. The other two survey areas are in an area of 'no dominant single class, which, though covering most of Britain, and suggesting a patchwork of land types, rather than regional uniformity, does litle to clarify the actual quality of land in these areas.

Turning to the availability of the common energy resources of the survey areas over wider areas of Britain, there seems to be quite a universal spread of these resources nationally.

Although the peat resource is not general to all areas, Figure 9.6. (6) demonstrates that the distribution of peat is reasonably universal throughout Scotland, though with much larger concentrations in Caithness, Lewis, the South West of Scotland and other areas of the Northern and Western Isles. Indeed few people in Scotland live more than 15 or 20 kilometres from some kind of peat resource.

Figure 9.6. DISTRIBUTION OF PEATLANDS IN SCOTLAND (6)

(Areas of peat deposits shown in black)

Figure 9.7. EXISTING AREAS OF COMMERCIAL FORESTRY IN BRITAIN (7)

(Areas of forest shown in black)

This resource, standing at 821000 hectares, 11% of the total land area, amounts to some 2400 million tonnes of peat (dry weight (14)), with around 30 or 40% of this being capable of exploitation for fuel, is much greater than that in the rest of the U.K. where only a few rural areas can draw on a local peat resource.

Aforestation is also more widespread in Scotland than it is in other areas of the U.K., as is the potential for further commercial forestry, due to the large amounts of land of low productive value to agriculture. Figure 9.7 (7) shows areas of major forest in the U.K., yet this map considers the areas of commercial forestry, rather than the small areas of shelter belt and woodland considered as fuel resources in the survey areas. Most rural areas can be considered to be similar to Cuminestown in this matter, with limited amounts of woodland, (ignoring the nearby Forestry Commission plantation), rather than Lumsden with its greater amounts of forestry.

Table 9.1 shows the distribution of woodland in the U.K., and it can be seen that the areas of woodland in the samples were rather low for the North East of Scotland.

Table 9.1. Percentage Tree Cover for Different Regions of the U.K.- (15)

Area	Tree Cover % (Forest, Woodland and Scrub)
North-East England	7
North-West England	6
East England	5
South East England	13
South-West England	7
North Wales	11
South Wales	10
North Scotland	8
East Scotland	13
West Scotland	16
South Scotland	10

The higher figures for tree cover in Scotland than in England are a product of the larger number of productive forests, and the sample areas can be considered to be representative of most rural areas in terms of the extent of the timber fuel resource.

9.1.2. Social and Housing Indicators of Comparability-

Figure 9.8 (8) shows population densities for Britain, and the low population density to be found in the areas under study is also the case in most of the rest of Scotland aside from the central belt, the extreme North of England and much of inland Wales. Expanding this area from areas with under 20 people per square kilometre to include areas with between 20 and 40/km2, brings in parts of the South West, most of the rest of Wales and larger areas of Northern England, including the Lake District and much of Yorkshire. This represents over half of the land area of Britain, though obviously quite a small proportion of its population.

Lumsden, with a population density of 14.2/km2, falls into the former category, Cuminestown has a population density of 28.5/km2, and falls into the latter category.

Figure 9.9 (9) shows the proportion of population over 60, and differs slightly from the statistics used in the surveys, which divided the population in terms of retirement age, i.e. over 65 for men. But even with this disparity, which would tend to lower the proportion in the highest age groups in the samples, the study areas both have a higher retired population than the national average of 18.6%.

Both areas also have a higher proportion of old people than the average for Grampian region, with Cuminestown, at 19.81%, being similar to the Highlands and Islands, the North East of England, South Wales and the Hampshire/Dorset area, and Lumsden, at 22.83%, falling into the category occupied by North and Central Wales, the South West of England, East Anglia and parts of the Scottish Borders. These differences are relatively small and could vary considerably with local conditions, but they do show a generally higher proportion of elderly than the national average in all

Figure 9.8. POPULATION DENSITY (8)

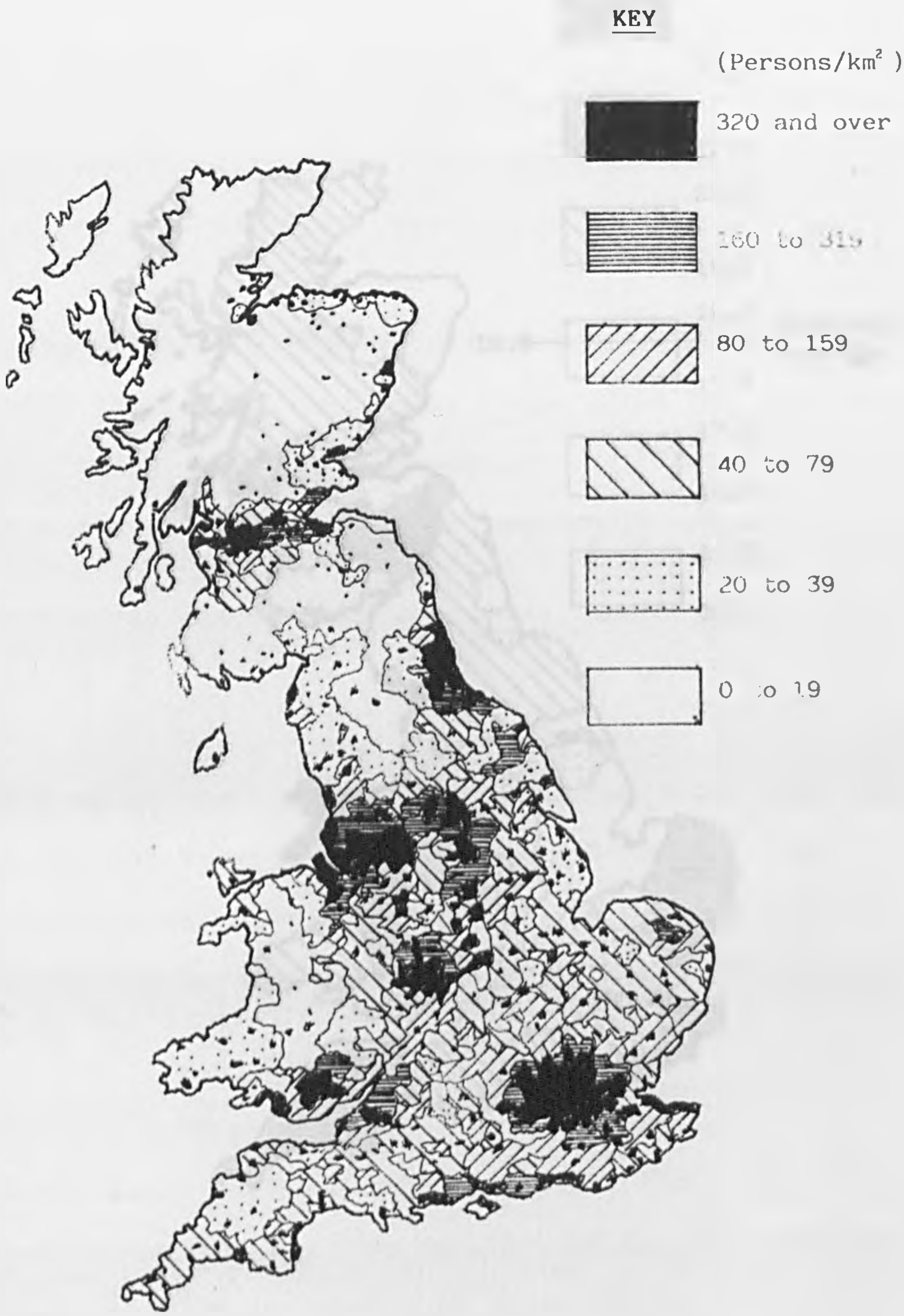
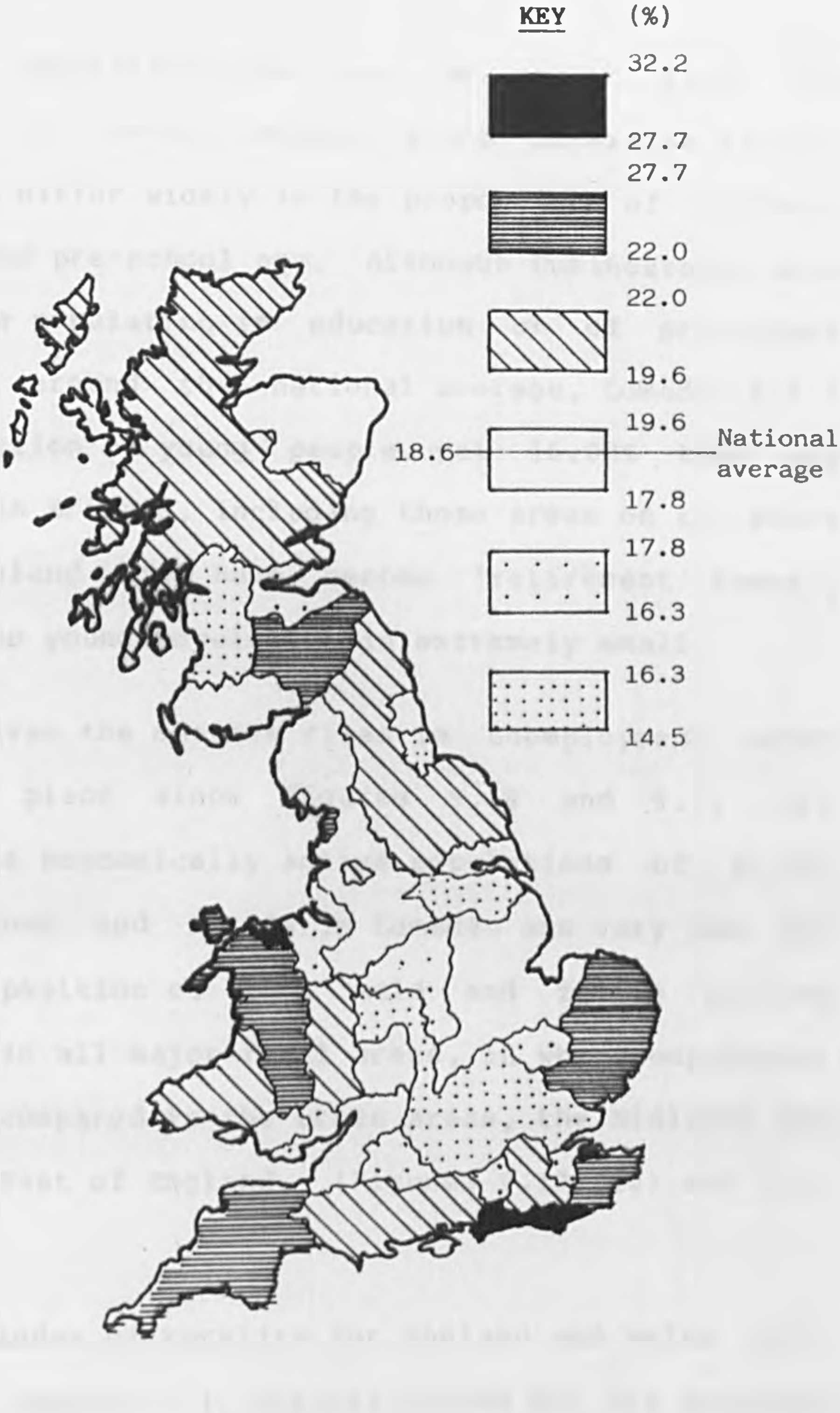


Figure 9.9. PERCENTAGES OF PERSONS AGED 60 AND OVER (9)



the major rural areas, which is consistent with the survey results.

Fewer generalisations can be made from the proportions of young people, since otherwise similar rural areas differ widely in the proportion of children at school and pre-school age. Although Cuminestown, with 26.8% of the population in education or of pre-school age, falls around the national average, Lumsden has a lower proportion of young people, at 16.82% than any major area in Britain, including those areas on the South coast of England which have become 'retirement towns', and where the young population is extremely small.

Even given the massive rises in unemployment which have taken place since figures 9.10 and 9.11 were compiled, the economically active populations of 32.42% in Cuminestown and 32.74% in Lumsden are very low, and reflect the position of both male and female working populations in all major rural areas, in which employment remains low compared to the urban areas, the Midlands and the South East of England. (Figures 9.10 (10) and 9.11 (11))

Clokes index of rurality for England and Wales (12), discussed in Section 2.1, and criticised for its tendency to define rurality in terms of deprivation, and then drawing from this the conclusion that rural areas suffer from deprivation, is reproduced in Figure 9.12 (13). The index is assessed with regard to the variables listed in Table 9.2.

Table 9.2. Variables Used in Clokes Index of Rurality for England and Wales-

	Variable Name	Census Data
1.	Population density	Population/acre
2.	Population change	% Change 1951-61, 61-71
3.	Population over 65	% Total population
4.	Population men age 15-45	% Total population
5.	Pop. women age 15-45	% Total population
6.	Occupancy rate	% Population at 1.5/room
7.	Occupancy rate	Households/dwelling
8.	Household amenities	% Households with exclusive use of: (a) Hot water (b) Fixed bath (c) Inside wc
9.	Occupational structure	% In socio-economic groups (a) Farmers-employers and managers (b) Farmers own account (c) Agricultural workers
10.	Commuting out pattern	% Residents in employment working outside the rural district
11.	In-migration	% Population resident for less than 5 years
12.	Out-migration	% Population moved out in last year
13.	In/out migration balance	% In/out migrants
14.	Distance from nearest urban centre of 5000 population	
15.	Ditto 100000 pop.	
16.	Ditto 200000 pop.	

For all the variables in the above table the survey areas conform to Cloke's intermediate or extreme rurality categories, except 7, households per dwelling, (which was a constant 1 for the survey areas), 12, outmigration and 2, population change, which were not recorded. The possession of basic household amenities, aside from a few specific instances, is suggested by Cloke as being no

Figure 9.10. ECONOMICALLY ACTIVE POPULATION, MALE (10)

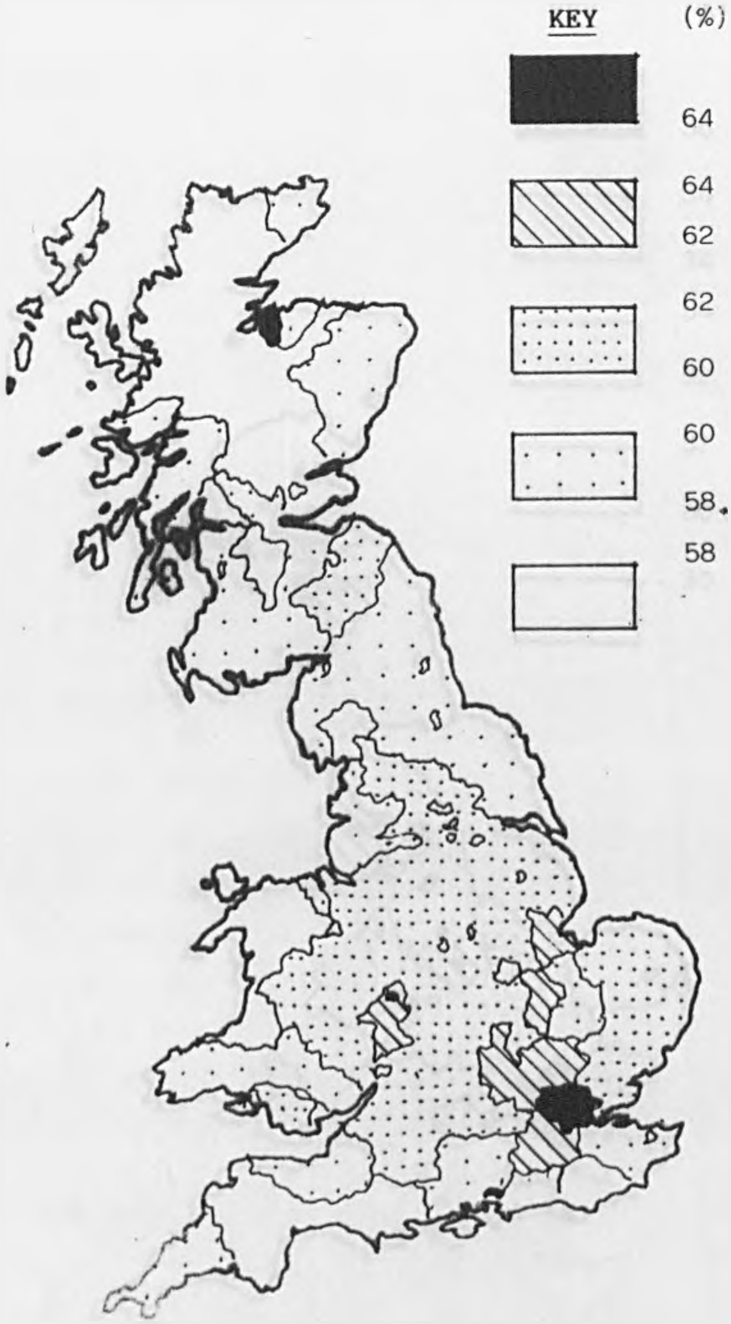


Figure 9.11. ECONOMICALLY ACTIVE POPULATION, FEMALE (11)

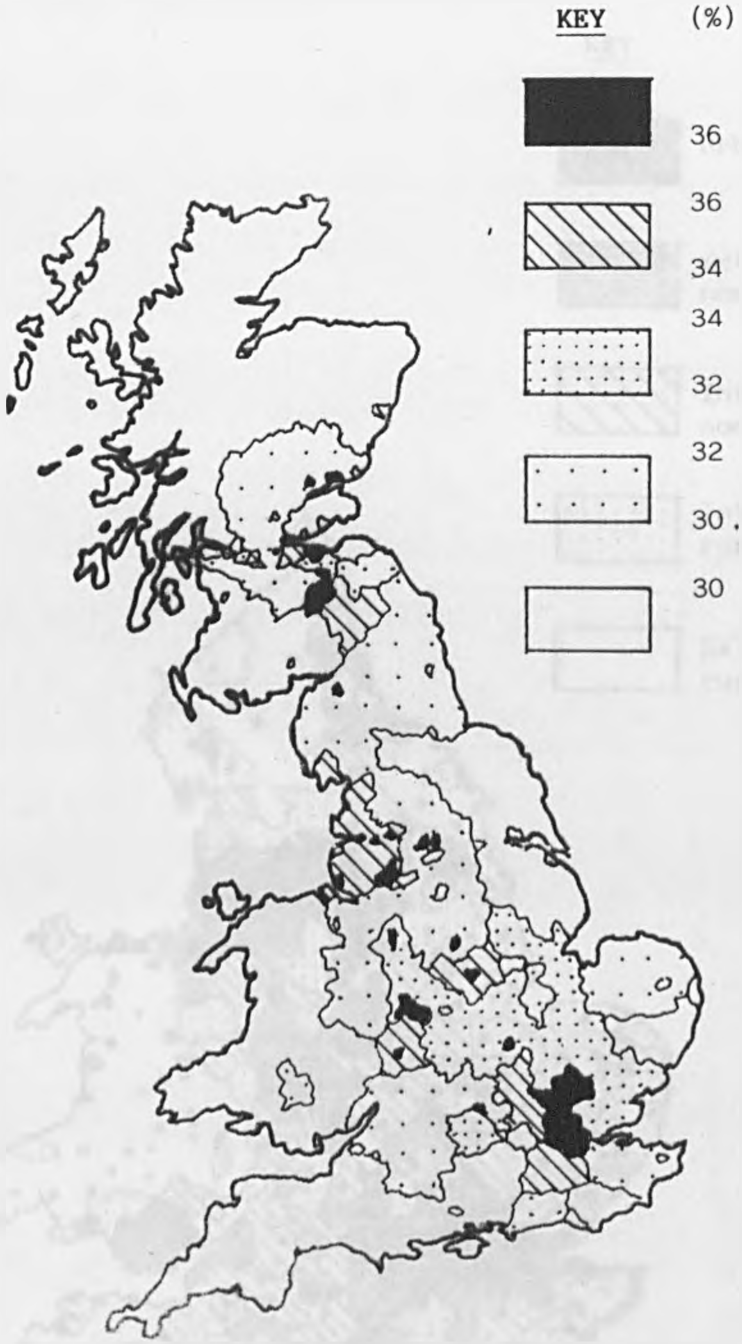
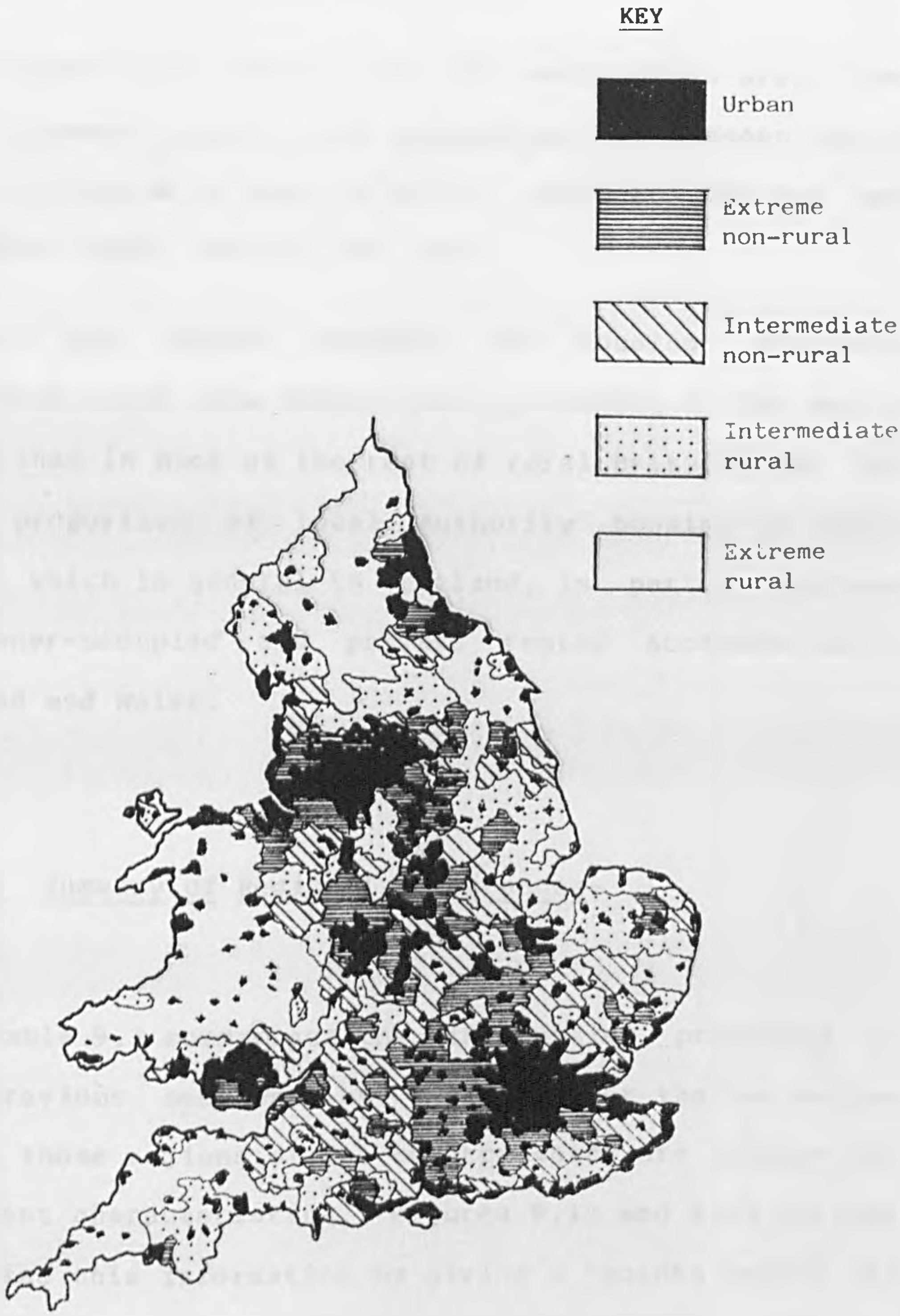


Figure 9.12. SPATIAL VARIATIONS IN RURALITY IN ENGLAND AND WALES (13)



longer such an important variable, due to improvements in past years (16), and indeed the survey areas demonstrate these improvements, with only a very few cases now lacking the basic amenities.

Figure 9.12 removes even very small urban areas from the category rural, and Cuminestown and Lumsden can be seen to conform to most of Wales, Northern England and the South West, outside the towns.

In one respect however, the housing standards variables might show better quality housing in the survey areas than in much of the rest of rural Britain, for the high proportion of Local Authority housing in sample areas, which is general to Scotland, is partly replaced by owner-occupied and private rented accomodation in England and Wales.

9.1.3. Summary of Regional Differences-

Table 9.3 summarises the information presented in the previous sections by listing, for the two survey areas, those regions of the country which are similar for different characteristics. Figures 9.13 and 9.14 further summarise this information by giving a 'points score' to different regions based on how many of the different characteristics are similar to those of the survey areas.

The regional divisions used in Figures 9.13 and 9.14 are not literal, and do not necessarily follow the divisions used in the preceeding Figures, which differ widely from characteristic to characteristic, but merely broadly indicate that much of the area within each region has characteristics similar to the survey areas.

Table 9.3. Regions of Britain Having Similar Characteristics to the Survey Areas-

	Characteristic	Areas similar to Lumsden	Areas similar to Cuminestown
9.1	Farming regions	Scottish Highlands, Mid Wales, Upland Borders.	North-East Scotland, Borders, Northern England, South Wales, South West England.
9.2	Climatic limits	Scottish Highlands, Upland Borders.	North East Scotland, Borders, Fife.
9.3	Growing season	Scottish Highlands, Upland Borders.	North East Scotland, Central Belt, Coastal strip in West Scotland.
9.4	Percentage crops and grass	Moray, Dundee, part Central Belt, Most of Borders.	Grampian, Caithness, Perth, East Borders.
9.5	Land classification	Scottish Highlands, Upland Borders, North West England, North and Central Wales, Peak District.	North East Scotland, Central Belt, North-East and most of Central England.
9.6	Peat deposits	Scotland except Caithness and Northern and Western Isles. Limited parts of upland England and Wales.	
9.7	Afforestation	Scotland except Western and Northern Isles, North-East England, Wales	
	Table 9.1. Woodland	Scotland except far north, Wales, South-East England.	

9.8	*Population density*	*Scotland except Central Belt, North Central England, Central Wales.*	*Coastal Eastern Scotland, N.W. England, S.W. Wales, parts of N.E. England, Central S.W. England.*
9.9	Ageing population	North and Central Wales, S.W. England, East Anglia, Eastern Borders.	Highlands and Islands, N.E. England, South Wales, Hants/Dorset.
9.10	Male employment	Both samples much lower than other low areas, low employment areas Highlands and Islands, West Wales, S.W. England, North England, West Borders, South Wales, South West England.	
9.11	Female employment	Low employment areas Scotland, Wales, Northern England, South-West England.	
9.12	Index of Rurality	Wales, North England except Lakes, most of S.W. England, parts of East Central England.	

Figure 9.13 SUMMARY OF REGIONAL CHARACTERISTICS, SIMILARITIES TO LUMSDEN

(Numbers represent the number of different characteristics, as illustrated in Figures 9.1 to 9.12, in which the various regions are similar to Lumsden. There are 11 characteristics for Scotland, 8 for England and Wales.)

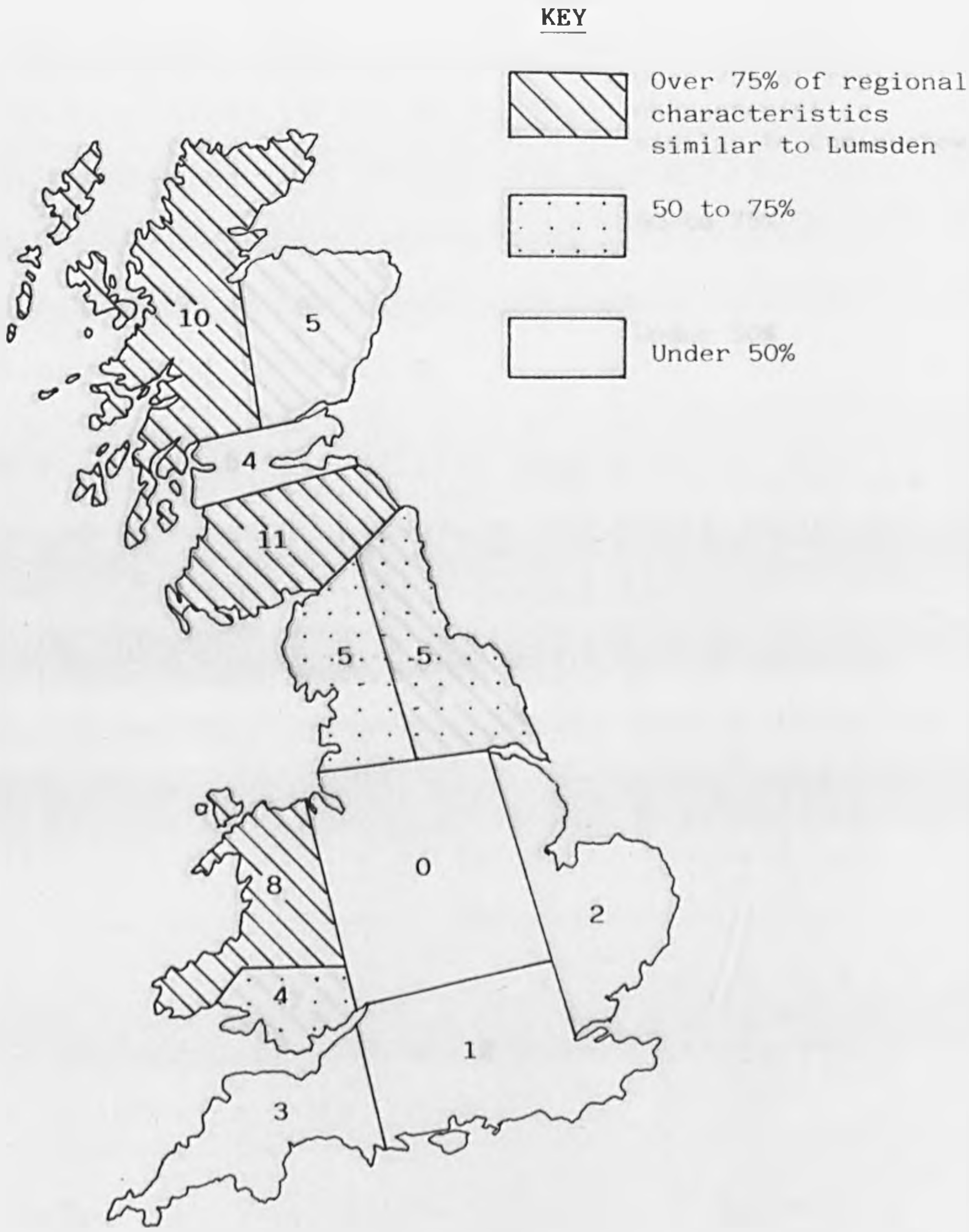
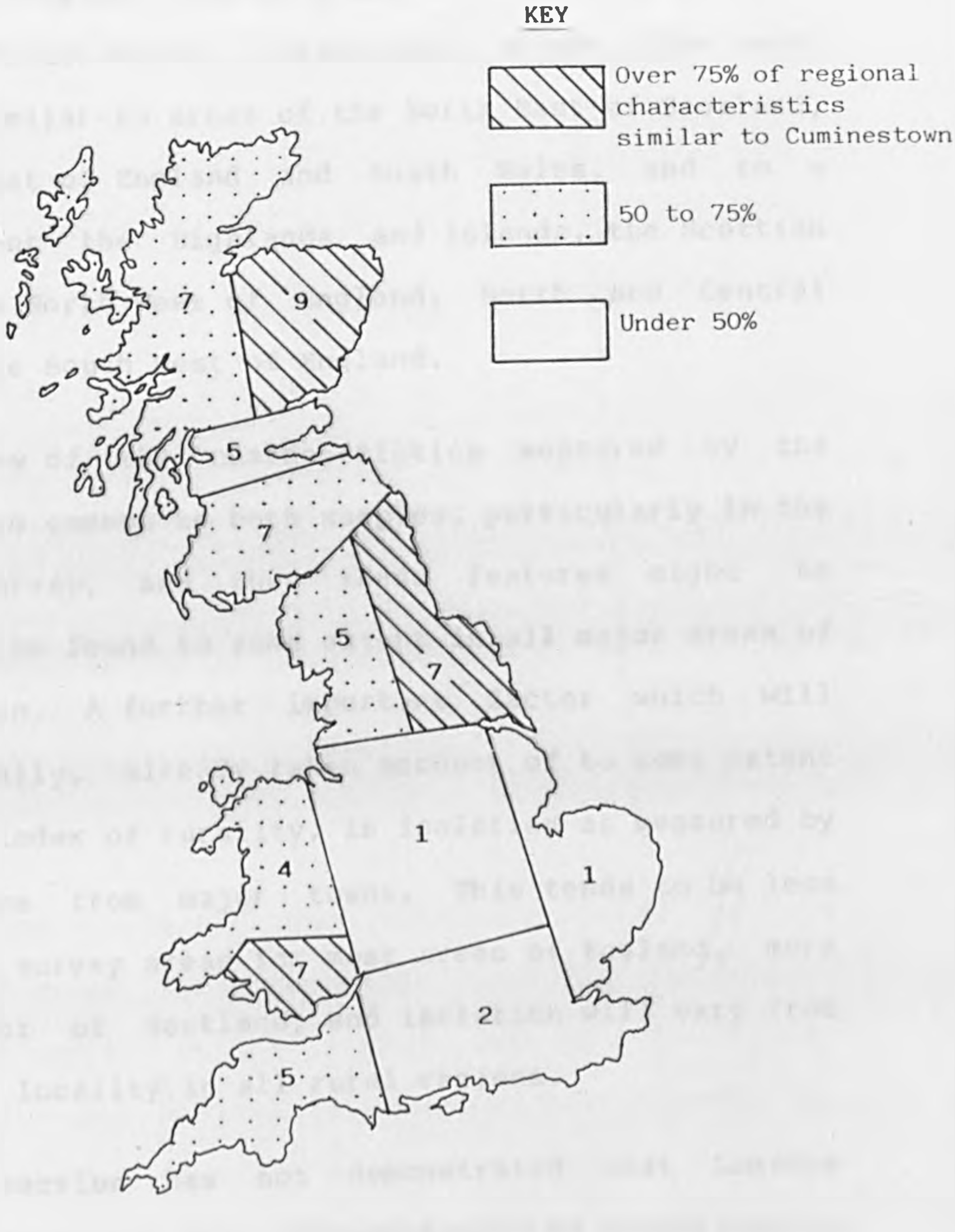


Figure 9.14 SUMMARY OF REGIONAL CHARACTERISTICS, SIMILARITIES TO CUMINESTOWN

(numbers represent the number of different characteristics, as illustrated in Figures 9.1 to 9.12, in which the various regions are similar to Cuminestown. There are 11 characteristics for Scotland, 8 for England and Wales)



As might be expected, Figures 9.13 and 9.14 show that the Lumsden survey area is most similar to areas in the Highlands and Islands, the Scottish Borders and North and Central Wales, and to a lesser extent the North of England and South Wales. Cuminestown, on the other hand, is most similar to areas of the North East of Scotland, the North East of England and South Wales, and to a lesser extent the Highlands and Islands, the Scottish Borders, the North West of England, North and Central Wales and the South West of England.

Yet many of the characteristics measured by the surveys were common to both samples, particularly in the domestic survey, and thus these features might be expected to be found to some extent in all major areas of rural Britain. A further important factor which will differ locally, already taken account of to some extent in Cloke's index of rurality, is isolation as measured by the distance from major towns. This tends to be less than in the survey areas for most areas of England, more in the west of Scotland, and isolation will vary from locality to locality in all rural regions.

This section has not demonstrated that Lumsden and/or Cuminestown are representative of conditions in whole major regions of the U.K., but that many individual localities in these regions bear a close relationship to these survey areas in many of their characteristics. Since this study has dealt with a system which is defined as being basic to rurality, containing only domestic and agricultural sectors, generalisations based on the results of the local surveys can be made for many areas of rural Britain.

9.2. The Delphi Survey and Rural Energy Resource and Use Patterns-

This section draws on the hypothetical 'most likely future' generated in the Delphi survey, and conclusions from the local level rural energy resource and use survey, looking at how these present patterns are likely to alter over the next 50 years.

9.2.1. Social Conditions and Housing-

The rather top heavy age structure found in the survey areas seems likely to change little in the next 50 years. Although the Delphi survey sees a continually ageing population, brought on partly by past trends, the envisaged repopulation of rural areas should negate this effect in theory, at least in Cuminestown and Dunecht type areas, though in practice land ownership patterns in Dunecht would appear to legislate against this. The most remote of rural areas are envisaged as suffering from small amounts of continued depopulation, and this might apply to Lumsden type areas, though the borderlines of these 'extremely remote' areas are not defined. It may be however, that a return to 'family' based economic structures will lead to a lower percentage of old people living alone than is presently the case, particularly in Lumsden and Dunecht, the former having 43% of its houses occupied by only one or two retired people at present.

Any repopulation is however likely to affect the current parochiality of regional and local origins, and if the envisaged influx comes mainly from professional and self-employed categories, knowledge of such matters as renewable energies, and the capital necessary to employ them, are likely also to rise.

Changes in employment structure envisaged by the final Delphi scenario are likely to add to this increase in the numbers of self-employed, and whilst unemployment is unlikely to rise above the present fairly low figures, larger numbers of retired people and reductions in working hours will both increase the available 'human labour resource' and the number of dependant adults.

It is not clear specifically how tenure types would change under the scenario, but with decreasing central involvement in services, it would seem likely that higher levels of owner-occupation will result. Thus greater individual control over housing standards, house insulation, fuel use and fuel burning equipment will be vested in occupiers. Thus Lumsden would grow more like Cuminestown in this respect. The availability of capital is obviously an important factor in housing standards, yet the current low rate of take up of available grants for home insulation and improvements in the survey areas, for instance, is likely to change given the greater public awareness and practice of energy conservation measures suggested by the scenario. The same would apply to the use of better fuel conversion systems (see Section 9.2.3.), particularly given the current correlation between such standards and education levels.

Employment in agriculture, in terms of the numbers of people involved, is likely to change, with the suggested large increase in food production on small plots. Thus more people will be producing food on their own small garden plots.

In terms of attitudes, the current confidence in and acceptance of 'modern comforts', coupled to an equal confidence in the ability to do without outside support (Section 9.2.5.), is not incompatible with the scenario view of parallel increases both in interest in 'DIY' type 'self-sufficient' activities, and technology which is impervious to such methods. There seems to be a kind of begrudging air to the acceptance of change which fuels this 'self-sufficient' approach in the face of welcomed improvements in technology.

9.2.2. Agricultural Patterns and Land Ownership-

Probably the greatest single effect on the nature of individual survey areas, the ownership and control of land, seems unlikely to change much under the Delphi scenario, except in isolated individual cases. The scenario envisages little pressure to break up estate ownership, whilst no more land, particularly in the hill areas, is likely to be ploughed. However, areas where absentee landlordism and lack of economic usage of estates is rife, such as Lumsden, are likely to see improvements, depending on the attitudes of individual landlords, in the running of these estates. This should lead to greater access to timber and peat resources, and possibly more food production and jobs in agriculture where this is possible. Small amounts of land are likely to pass into the hands of more individuals for food production with economic pressure from incomers.

Existing proportions of arable to other types of land are unlikely to change from the present picture in the long term, though fluctuations in economic conditions and policy on subsidies will cause short term variations. Better use of hill land, such as in Lumsden for livestock production, perhaps including deer farming, is likely. Estate control over the timber and peat resources is likely to continue.

Agricultural employment, presently running at around one worker per 66 hectares in Cuminestown, one per 135 hectares in Lumsden and one per 70 hectares in Dunecht, is likely to grow somewhat according to the Delphi scenario, largely due to increases in the number of small plots, whilst hours per worker will drop.

The very low ratios of input to output of energy in the agriculture of the survey areas are likely to drop even more, with a 25% drop in agricultural machinery energy use and a fall to 95kg/hectare/annum in chemical fertiliser use, producing an overall 20% drop in agricultural energy use.

In terms of the attitudes of farmers to change, most see a slowing down in the improvement of hill land, which is consistent with the scenario, whilst they have a high confidence in modern farming methods in general, whilst seeing perhaps an enforced reduction in chemical fertiliser input. Perceptions amongst farmers do not admit to much future change, and the changes envisaged by them are not as great as the changes envisaged by the scenario.

9.2.3. Domestic Energy Use-

The patterns of relatively large amounts of local and free energy resources used in the survey areas is likely to be accentuated under the scenario, with all areas falling more in line with Dunecht, with its 26.5% of energy use (aside from electricity) in local timber. The high use made of solid fuel fires is unlikely to change much, and indeed this is likely to increase with rises in oil and gas prices. Greater public awareness of energy conservation will lead to more efficient fuel conversion apparatus, better insulation standards and lower ventilation levels generally, bringing down the ratio of energy delivered to useful energy considerably.

It has been shown (Sections 7.1 and 7.2), that measures to increase fuel conversion efficiency could reduce fuel use by around 22%, so that if 25% of present energy use came from local sources, this could become over 30% of future energy use, without having recourse to the insulation of dwellings. Similar savings could be made by 100% loft insulation, which would push the local resource used up to close to 50% of the total, excluding electricity use.

There is likely to be, however, a slight counter tendency to increase fuel consumption, due to ageing population structures and fewer working hours leading to more hours spent at home, accentuated by more access to information from the home and economic life being based more around the family.

The higher use of electricity forecast by the scenario, and the attendant savings to be made by micro-electronic control devices, are likely to have less impact in these rural areas of high solid fuel use than in urban areas, though electricity will be of considerable importance in some houses for heating, and in all for the increasing number of appliances and communication devices.

Heating standards seem likely to rise, given the demands for central heating by the younger residents, particularly when coupled to the envisaged rise in 'DIY' type activities.

Transportation energy use is unlikely to drop below the very low estimates, based largely on journeys to work, used in the surveys, but the journeys to work element will drop for the individual, with fewer working hours and more non-physical means of contact, whilst staying more or less static in total, with an influx of people from outside living in rural areas. Those in the remotest areas will suffer considerably from increases in vehicle fuel prices, and eventually from reductions in the number of private cars, though improvements in mass transit, non-physical communication and travelling services will offset this effect somewhat.

9.2.4. Agricultural Energy Use-

Many of the agricultural energy use changes mooted in the Delphi scenario are already standard practice in the areas subject to local survey. Thus the suggested return in specialised farming areas to more mixed farming is unnecessary in the survey areas, with their traditional pattern of mixed farming, whilst farming intensivity, with low building energy use and extensive animal rearing, is already quite low in these areas. With more extensive animal rearing, the preponderance of barley fed beef is likely to drop in comparison to hill animal production with minimal harvested feedstuffs. Certainly purchased animal feedstuffs will not rise above their present very low level.

Food production is likely to be 'internalised' rather more than at present, with a higher degree of on-farm processing and a general reduction in levels of packaging, and where possible there will be diversification into more different types of food production.

The difference between areas such as Cuminestown and areas such as Lumsden is likely to remain, with Cuminestown making better use of incident solar radiation, but Lumsden using less energy in total. Opportunities for energy saving in agricultural production in these types of areas are fairly minor.

9.2.5. Energy Resources-

In spite of the ageing population, the 'human labour resource' is likely to increase, due both to incomers and to reductions in working hours. If the 20% reduction in working hours occurs, then the present relatively low unemployed resource would be swelled many times over by the spare hours gained. Such a resource could then be applied to the gaining of energy resources.

Better use is likely to be made of the timber resource in all areas, though in Dunecht this is already quite advanced, whilst the same would apply to the use of the peat resource. The Delphi scenario would suggest that the way is likely to open for both casual gaining of these resources by individuals, and perhaps small businesses set up for the local gaining and distribution of fuels.

It seems certain that the straw resource will not continue to be burnt in the field, for with a spare resource only existing in one of the three survey areas, and then only as a small proportion of production, with use already being made of this resource by one farmer, surpluses are likely to be absorbed very quickly, at least in these mixed farming areas.

Control over all land based resources is likely to remain dependant on the ownership of land, but if the changes mooted in Section 2.3. come about, and there is a partial move away from profit maximisation and towards the support of communities, there are some grounds for hope that access to resources will grow in all areas.

The confidence placed by the scenario in short rotation coppiced woodland as an energy source is likely to lead to more of this type of fuel being grown in areas such as Lumsden, where the amount of surplus hill land is large, as are existing timber resources, more so than in more lowland areas.

The suggestion of the scenario that 15% of electricity use in remote rural areas will come from non-biofuel renewables by 2034 seems to be well within the resource suggested by Section 8.5, which outlines a resource of between 20 and 30% of total electricity use.

The higher confidence in both wind and solar power, as well as more traditional small hydro plants, on the part of farmers in the surveys, is largely backed up by the Delphi, as is the lack of confidence in such renewables as methane generation from waste, though part of the confidence of farmers in these matters is undoubtedly due to the lack of knowledge on other resources.

It is perhaps surprising that the diffusion of renewables technologies has progressed so far already that the areas surveyed have three examples of solar water heating, a wind generator, a supplier of wind generators, a hydro plant and a straw burning stove, and this must bode well for the growth of these technologies in the future.

Other energy resources and energy saving techniques favoured by the Delphi survey are confirmed in the field, such as the importance of insulation standards and passive solar design in housing, reductions in intensivity in farming and reductions in chemical inputs. Overall, the assertion that energy saving is more likely to be successful than the use of the energy resource would seem to be confirmed by the local survey.

The high confidence demonstrated in the local survey in the ability of small areas to be self-sufficient in fuel sources may be a misplaced one, in as much as respondents typically overlook the importance of such things as vehicle fuel, yet such confidence can only add to the likelihood that the mooted changes towards a fuller use of local energy resources will indeed take place.

9.2.6. Conclusions-

All in all, it would seem that perhaps the use of local resources is not as attractive an option as savings in existing energy use, and particularly changes in conversion appliances, such as the introduction of solid fuel stoves. It seems unlikely that energy autonomy in rural areas can ever be complete, but advances in this direction are possible, and whilst rural areas are at least potentially autonomous in energy, urban areas can never be, at least not in small local areas. Section 5.3.1. suggested that the prerequisites for a more autonomous system are; the existance of an untapped resource, technical ability, willingness on the part of individuals to tap the resource, and access to that resource. The surveys have shown that the resources exist, technical ability has been shown to exist in most cases. The local survey has demonstrated willingness amongst individuals in the communities, at least in theory, and only access to the resources is restricted, and given the propositions of the Delphi scenario, this too should increase in future.

In terms of potential means of contributing to local energy autonomy, the Delphi survey seems to back up the local survey results. Obviously the 50 year scenario is impossible to check by reference to the local survey, but its points seem mainly to be compatible with the present conditions and attitudes of the local areas surveyed, and the changes which are already taking place.

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10. CONCLUSIONS AND RECOMMENDATIONS-

10.1. The Hypothesis-

As stated in Section 1, the hypothesis that was presented for testing by this project was that;

> "There exists considerable potential for a greater degree of rural energy autonomy, especially through the medium of increasing integration between agricultural/forestry and domestic sectors, to make better use of rural energy resources."

For the most part it seems that this hypothesis has been proven to be true, and that considerable potential exists to redress the balance between rural and urban areas, in terms of the present expense of supplying fuels to the former, and the greater energy requirement per household in rural areas.

Energy is very central to rurality, as demonstrated by the definition of rurality in Section 2.1.3., where rural areas are shown to be inevitable producers of energy, and whilst rural areas are at least potentially energy autonomous, localised urban areas can never be.

10.2. The Influence of Land Holding Patterns-

Aside from the variables which were planned to vary from the outset, probably the most sweeping differences which affected the rural areas under study were their land ownership patterns.

Thus Dunecht, with very strong control by one estate and, to a lesser extent, the adjacent estate owned by a relation of the owner of Dunecht Estate, exhibits very different characteristics from the other two areas. Many material variables in Dunecht, such as the presence of central heating, the use of solid fuel closed stoves and insulation of housing, correlate very strongly with occupation, and this is a function of landlord control over houses and jobs in the area. Non material variables such as attitudes to various issues bear no such obvious correlation.

The standards of private rented accomodation in Lumsden and Cuminestown also exhibit this bias towards professional and self-employed occupations, but the lower number of this type of housing makes this bias less of a problem.

In the field of using the energy resource, the estate control and organisation of Dunecht contrasts sharply with the apathy and decay of Lumsden and the more diverse land ownership of Cuminestown. Although the Delphi scenario suggests a future change to more concerned landlords, individual owners cannot be relied on to change, and areas such as Cuminestown, with land in the hands of more people, are likely to be more homogenous in following trends.

10.3. Housing and Social Conditions-

As stated in Section 10.11, housing conditions remain poor in rural areas, although those standards are unable to explain all disparities in fuel use. The insulation standard of houses is generally poor, again dependant on tenure type, with private rented accomodation having the worst standards. Amongst this group some anomalies arise in standards encouraged by local authority grant aiding, such as the full double glazing of otherwise poor quality private rented accomodation in Lumsden.

A certain parochiality in local and regional origins is evident amongst respondents, a situation which seems likely to change somewhat in all but the most remote rural areas in the future.

A particular feature of these rural areas, discussed further in Section 10.6, is the preponderance of solid fuel open fires as the main form of heating in homes, a feature which would not be expected in urban areas, and which offers considerable potential for improvement.

The ageing population structure at present, though expected to continue nationally, will not go through such pronounced growth in rural areas, where it is already high, due to the influence of future rural in-migration, led by the suggested increase in low volume new industry to some rural areas, and increases in non-physical communication processes. If the population structure becomes younger this will induce both new building, with necessarily higher insulation standards, and rehabilitation of the presently old housing stock.

10.4. Agricultural Patterns-

Relatively few changes in agricultural pattern are envisaged by the Delphi scenario, or indeed admitted as possibilities in the local survey, for the kinds of mixed farming areas considered, though agricultural energy use is expected to drop somewhat, but again not as much as in areas of either crop or livestock monoculture.

Planned differences in farming pattern were shown to be the case in the local survey, and to some extent the differences in unit size, particularly between Lumsden hill areas and Cuminestown arable land, were also to be expected. There was found to be a perhaps surprising number of very small holdings, often practising a single, not necessarily economic, form of production (in terms of the ability to provide realistic livelihoods from the land), such as renting out grazing, selling hay standing and rearing ponies.

It seems likely that the way in which agricultural form will develop in the future will be more towards the forms found in the survey areas, mixed farming with only minimal amounts of intensive animal rearing, though the production of barley for animal feed is likely to drop.

10.5. Current Energy Use-

Although largely useless in terms of its ability to map regional fuel supply, the survey of suppliers (Section 4), did highlight the discrepancy between suppliers of different types of fuel. Thus, whilst oil is supplied exclusively by a small number of agents of multinational companies, fuelwood is supplied by a wide variety of companies and individuals, some of whom are untraceable, and may only be supplying fuel on a casual basis.

The largest agricultural energy use in both main areas was chemical fertiliser but, perhaps surprisingly for quite sparsely populated rural areas, domestic energy use was higher than agricultural energy use in both areas. Only when the energy uses internal to the system, particularly animal wastes used as fertiliser, are considered, does agricultural energy use rise above domestic use.

There seems to be a large difference between delivered and useful domestic fuel, all of which could not be explained by housing standards, but is the result of low efficiency in fuel conversion, differences in heating levels and ventilation standards. This gap is particularly evident with regard to solid fuel use.

As might have been expected, the hill area of Lumsden had a higher domestic fuel use than did lowland Cuminestown, due to altitude, exposure and poorer housing conditions in the former, whilst the latter exhibited greater agricultural fuel use.

In households, Lumsden with a mean annual fuel use of 175699MJ, and Cuminestown at 161556MJ, both use much more fuel than the national average of 101200MJ per household. Solid fuel in rural areas taking the place of natural gas, which is the main fuel in use in households nationally.

Although energy use in these rural homes in the North East of Scotland will always be higher than the national average, there is much room for saving in fuel use, particularly through information diffusion on insulation and ventilation standards and fuel conversion equipment.

Due to the minimal transport level considered by the local surveys, few savings are envisaged in the already low energy use of this sector, measured at only half of the national average for local travel.

10.6. Means of Fuel Conversion-

The suggestion that energy analysis, as opposed to monetary analysis, may come into its own in future as more people move at least partially away from a purely economic stance on energy matters, is partly borne out by attitudes in the local survey to local fuel use and renewables amongst some respondents. However it is clear that energy as a unit of accounting is not perfect, for it obscures differences between the quality of different energy sources, whilst marginal values of successive units of energy, as pointed out in Section 2.3.3, may drop. It is also clear that supposedly free resources are rarely free, either in monetary or energetics terms, when the cost of capital equipment is considered.

Section 2.3.3. assessed various projects for the harnessing of different renewable energy sources. The energetics and economics of wind energy conversion appeared to be rather poor, though the economics at least may now be becoming more favourable (1). Although wind energy conversion has already gained a small foothold in the survey areas, it would seem only to be valid at present when the value of a small number of kilowatts of electricity is perceived as being very high, and where no alternatives are available.

Photovoltaics are generally felt to have little future in Britain, except again in circumstances where a small amount of energy has a high value. Solar water heating, under the influence of strenuous sales campaigns, is already spreading in rural areas, but again their economics, and particularly problems caused by failure of equipment and the transience of manufacturing and distributing companies, do not make such systems attractive propositions at present.

Simple conversion techniques, specifically straightforward burning, seem to be streets ahead of other, more technically complex methods of gaining energy from biomass. The surveys only considered the use of existing biomass, and there is not much of a case for producing biofuels in preference to food on any but the most marginal land. One of the main recommendations of the survey has been the encouragement of improved biofuel conversion systems, in the form of simple and cheap wood and peat burning stoves, often of quite low capacity, to improve the efficiency of this process.

Indeed, the low present conversion efficiency of biofuels means that, contrary to popular belief, electricity use for heating, energetically speaking, may in many cases be more efficient than burning fuels on solid fuel open fires.

Hydro-electric schemes, though well proven, are site specific to a high degree, and both their energetics and economics vary widely with the suitability of the site. Given a good site however, it looks amongst the best of the renewables, in spite of the evidence presented by the closing down of the one hydro-power scheme in existence in the survey areas.

10.7. The Energy Resource-

The energy resources of the areas under study, conservatively assessed though they are, are considerable, yet only in Lumsden do 'annual' resources exceed energy use in the domestic and agricultural sectors, and the timber resource, if fully utilised, would make up the majority of this renewable potential. Yet in the other main survey area resources make up more than half of use, and could be employed more than they are at present.

The only real domestic energy resource, if it can be called that, with a use potential, is the human work resource. This is low in energy terms, but indispensable in tapping the other rural energy resources. Agricultural energy resources are much more significant than domestic energy resources, and indeed agriculture can make more contributions to energy resources than it can to energy savings, in contrast to the domestic sector.

The easiest resources to utilise, aside from the low volume, marginal resource of straw, are generally the traditional fuels which are already in use to some extent, namely wood and peat. Although the peat resource is sporadic, in as much as it only exists within certain areas, the timber resource, in one form or another, exists within almost all rural areas. It is felt that, except in extremely marginal agricultural areas, most of the timber resource in the forseeable future will come from existing plantations of deciduous shelterbelts and woodland.

10.8. Current Energy Resource Use-

The current use of local energy resources in the survey areas is 26.5% of total non-electric fuel use in Dunecht, 8.6% of total energy use (including electricity) in Cuminestown, and 13.3% in Lumsden. This is all made up of peat and wood, with marginal amounts of solar water heating in the samples which cannot be separated from other energy sources.

In the agricultural sector, local resource use is insignificant, unless one counts the large savings in chemical fertiliser use made by the use of animal wastes. Small amounts of excess straw not used for animal feed and bedding, and of wind power, are also used within the survey areas, but not on sampled farms.

At present only in the pilot area is local resource use high enough to make up a larger proportion of total use than could be saved by very simple direct conservation methods.

10.9. Likely Future Extent of Rural Energy Resource Use-

It seems likely that the future holds a greater emphasis on energy conservation for most people, and a consequent lowering in fuel use, together with a continued departure from the traditional 1:1 relationship between energy use and GNP. Many people will prefer to use local resources and some will be prepared to do so even where they are not the cheapest option.

The 15% of electricity use deriving from renewables in remote rural areas suggested by the Delphi scenario is quite possible even just considering domestic solar panels and windpower on farms, without including any larger local installations.

The timber and peat resources are quite large enough for Cuminestown and Lumsden type areas to reach the 26.5% of present energy use derived from local resources in Dunecht, and with around a 20% saving in total energy use, this would mean that Lumsden dwellings would consume on average around 140000MJ, of which about 43750MJ would be in local resources. In Cuminestown the equivalent figures would be 128000MJ and 40000MJ, meaning a reduction of imported energy of 58750MJ per household in Lumsden and 61000MJ in Cuminestown, or around a third of current use. The generation of 15% of rural electricity from renewables would have a much more marginal effect than this.

The high confidence amongst respondents in the local survey in their own ability to be self-sufficient in fuel backs up this projection of the future.

10.10. The Ability to Extrapolate to the Wider Rural Environment-

Section 9.1, in assessing similarities and differences between both Lumsden and Cuminestown, has demonstrated that, although no hard boundaries can be drawn around areas which are identical to one or both of the survey areas, many of the characteristics of much of Britain's rural land are similar to those of the survey areas.

Particularly when the rural system under consideration, as defined in Section 2, is limited to a simplified set of factors which can be said to be universal to most rural areas, then the conclusions generated by study in the sample areas hold good at least for large areas of Northern and Borders Scotland, most of

Wales and parts of Northern England.

Whilst the survey areas differed considerably in their agricultural characteristics, and in the other regions of the country which most resembled them, their social, housing and energy use characteristics were more homogenous. It is in this field particularly where the conclusions and recommendations presented here have the most relevance for other areas of rural Britain.

10.11. Recommendations on Policy to Increase Conservation and Resource Use-

Although there are a considerable, and growing, number of provisions to encourage fuel saving (2), few deal with the special case of rural areas and their different needs. Most of these measures deal with domestic energy use, and more specifically with the problems of insulation against heat loss. Although this is an important area, anomalies were discovered in the survey areas, such as the private landlord who has taken advantage of a grant for double glazing to increase the value of his properties, whilst the general standard of these houses remains amongst the worst found in the surveys, with an excessive ventilation level and no other insulation.

It is important however, to get across information on energy saving and use, particularly to the high proportion of elderly people in the rural areas, on such things as ventilation levels and insulation, and on an area of fuel use often overlooked, fuel conversion efficiency. Particularly if the use of local resources is to rise, the development of, and dissemination of information on, wood and peat burning stoves of simple, cheap design, but high efficiency, could be especially important.

On the subject of rural energy resources, as opposed to use, most research has concentrated on renewables such as wind and solar, yet these techniques are really not yet ready for distribution by 'hard-sell' companies to people who may not have bottomless pockets to delve into.

It may be more practical to exploit the apparent willingness and desire on the part of many people to be energy self-sufficient within their local areas, by such measures as supporting small fuel businesses such as woodland management and peat cutting, both of which could make a large impact on the energy autonomy of an area, with relatively little expenditure.

A serious impediment to such measures remains however, in some areas, the attitudes of landowners, and in the absence of the political will to change the land owning structure, access to resources is likely to remain a problem where those in control of the land do not wish it. The fact that the H.I.D.B., with powers to compulsorily purchase land for the application of such schemes, have only once exercised this right, is not encouraging.

Yet there is considerable potential for energy saving in these areas, and in the right land ownership conditions, considerable potential for the use of traditional local resources.

10.12. Final Word-

On the assumption that the future economic conditions suggested as being 'most likely' by the final Delphi scenario come about, the justification for looking at energy autonomy as an end seems not to rely entirely on a sort of international moral standpoint, but to make economic sense.

Although agriculture, as conventionally seen as food production, cannot, in the rural areas studied, make really significant contributions to domestic energy use, if agriculture is taken to mean land, and extensive managed or unmanaged extensive uses for that land, then very major effects on domestic energy use could be made. The equipment and capital of conventional agriculture can also assist this process greatly.

A combination of direct savings of energy and the use of this land based rural energy resource could do a lot to increase levels of autonomy in rural areas over a 50 year time horizon.

Notes and References, Section 10.

1. GALT, J. 1986, Personal communication.

2. Examples are Local Authority Structural Improvement Grants, and the designation of 1986 as Fuel Efficiency Year, with the attendant "Monergy" advertising campaigns.

APPENDICES.

APPENDIX 1, THREE D.O.E. SCENARIOS TO 2025.

Table 1 Scenario descriptions

Scenario 0: The Trends-Continued View
This scenario takes a 'trends-continued' view of the future by extrapolating middle-of-the-road views of likely social, economic, and technological developments in the medium term through to 2025. The real cost of energy raw materials in relation to other resources are assumed to remain at around their present levels until the early 1990s, after which they would begin to increase, though only slowly at first; early next century, world energy prices would rise above the cost of producing synthetic crude oil (from oil shales, tar sands, or coal). Conservation effects on energy utilisation are assumed to arise principally through the operation of the price mechanism, with modest reinforcement from government, but without any restrictive measures being imposed

Scenario 1: A Low-Growth View
In this scenario, low international economic growth is the dominant feature. It is assumed that, because of the consequent fall in demand for energy raw materials, world energy prices would rise more slowly than in Scenario 0. As a result of the depressed economic conditions in the United Kingdom, additional measures would be taken to reduce the total energy import bill both through the introduction of restrictive conservation measures and through the expansion of indigenous supplies of energy, particularly coal.

Scenario 2: A Limit-on-Nuclear View
This scenario assumes that no further thermal or fast reactors would be ordered after the completion in the mid-1980s of the proposed SGHWR programme, and that the cessation of the United Kingdom's nuclear fission programme would be parallelled in many other countries. International shortages of acceptable energy raw materials would develop, resulting in very high world energy prices and constraining the long term prospects for world economic growth. It is assumed that in the United Kingdom vigorous government measures would be introduced to reduce energy consumption.

Scenario 3: A High-Energy-Cost View
In this scenario, the dominant feature is an immediate sharp jump in world energy prices. Then, after a period of price stability until around the turn of the century, prices would begin to rise in line with Scenario 0. It is again assumed that government measures would be introduced to reinforce market pressures on energy consumers

Scenario 4: A Price-Transition View
The feature of this scenario is a multi-fold increase in world energy prices in the early 1990s, following a period during the 1980s in which energy prices had remained at their present levels. The scenario closely follows Scenario 0 up to the time of the price transition. Beyond that, there would be disruptive effects on international growth, which it is assumed would persist well into the next century

Scenario 5: A Self-Sufficiency View
The main themes of this scenario are self-sufficiency in hydrocarbons and a high contribution from nuclear energy. The scenario represents a view of the future in which the United Kingdom achieves permanent energy independence largely through an accelerated nuclear energy programme. Efforts would also be made to maintain a hydrocarbon self-sufficiency by expanding the coal industry and by extending production from the United Kingdom reserves of oil and natural gas. It is assumed that despite the substantially increased investment by the electricity supply sector and by the coal conversion industries, the United Kingdom's economic performance would not fall significantly below that in Scenario 0 until the early part of the next century

Scenario 6: A High-Growth View
The themes of this scenario are a buoyant international economy and high economic growth in the United Kingdom. It is assumed that the increased demand for energy would push up world energy prices faster than in Scenario 0, but insufficiently fast to interfere with economic growth. The United Kingdom's higher economic performance would give it the ability to expand its nuclear plant building industry at a particularly high rate.

Table 2 State-of-World Assumptions

State-of-World Variables	Scenario 0 Trends-Continued Scenario	1 Low-Growth Scenario	2 Limit-on-Nuclear Scenario	3 High-Energy-Cost Scenario	4 Price-Transition Scenario	5 Self-Sufficiency Scenario	6 High-Growth Scenario
(1) UK Economic Growth (GDP average annual)	Central view	Depressed	Reduced	Reduced Slightly	Central view to 1990, then reduced	Close to Central view	Buoyant
1975–1990	3%	2%	2½%	2½%	3%	3%	4½%
1990–2000	3%	1½%	2½%	2½%	2%	3%	4%
2000–2010	2½%	1%	2%	2½%	2%	2½%	3½%
2010–2025	2%	½%	1½%	2%	2%	1½%	3%
(2) World Economic Growth	Central view, 1–1½% above UK growth	Depressed ½–1% above UK growth	Low, ½–1% above UK growth	Reduced, ½–1% above UK growth	Central view to 1990 then reduced	Central view, 1–1½% above UK growth	Buoyant, 1½–2% above UK growth
(3) World Prices of Energy Raw materials	Rising slowly until 1990s then faster, exceeding cost of syncrude soon after 2000	Slightly below Scenario 0 levels	Rising rapidly from early 1980s onwards	Sharply higher, doubling immediately, stabilising until 2000, then as in Scenario 0	Stable until 1990, then jumping well above Scenario 3 levels	Similar to Scenario 0 levels	Rising somewhat faster than Scenario 0
(4) UK Internal Energy Prices (in relation to world prices)	Present relationship	High	Slightly higher than present relationship	Present relationship	Present relationship until 1990, then high	High	Present relationship
(5) Energy Conservation Effects	Present expectations	High but delayed by low economic activity	Very high, well above present expectations	Very high well above present expectations	Present expectations to 1990, then very high	Higher than on Scenario 0	Present expectations but accelerated by high economic activity
(6) Premium on Self-Sufficiency	Present policy	Present policy	Present policy	Present policy	Present policy	Very high	Present policy
(7) Nuclear Plant Building Programme	Up to a maximum of 50–60GW(e) installed in year 2000	Up to a maximum 40–50GW(e) installed in year 2000	Programme halted after SGHWRs commissioned in mid 1980s	Up to a maximum of 50–60GW(e) installed in year 2000	Up to a maximum of 50–60GW(e) installed in year 2000	Up to a maximum of 90–100GW(e) installed in year 2000	Up to a maximum 100–[illegible]GW(e) installed in year 2000
(8) Prospects of Energy from Alternative Sources	Present expectations	Below present expectations	Very high, well above present expectations	Above present expectations	Present expectations	Present expectations	Present expectations
(9) Coal Production	Present plans and expectations	Slightly above present plans and expectations	Well above present plans and expectations	Above present plans and expectations	Present plans to 1990, then rising above present expectations	Above present plans and expectations	Present plans and expectations

Notes. (1) The same demographic assumptions are common to all scenarios, namely: total population would slowly rise but not exceed the 1975 level by more than 10 per cent in 2025; however, the total productive workforce is not expected to increase significantly over this period.

(2) Structural shifts within the economy are assumed to have only a second order effect on energy consumption. Industrial output has been assumed to rise at a rate of 0.25 percentage points above the GDP rate on all scenarios.

SCENARIO 0 — THE TRENDS-CONTINUED VIEW

SCENARIO DESCRIPTION

This scenario takes a 'trends-continued' view of the future by extrapolating middle-of-the-road views of likely social, economic, and technological developments in the medium term through to 2025. The real costs of energy raw materials in relation to other resources are assumed to remain at around their present levels until the early 1990s, after which they would begin to increase, though only slowly at first; early next century, world energy prices would rise above the cost of producing synthetic crude oil (from oil shales, tar sands or coal). Conservation effects on energy utilisation are assumed to arise principally through the operation of the price mechanism, with modest reinforcement from government, but without any restrictive measures being imposed.

SPECIFIC ASSUMPTIONS

Economic Factors: A central view of the United Kingdom and world rates of economic growth is assumed. The United Kingdom economy (as measured by GDP) would expand at an annual average rate of 3 per cent up to the end of the century, falling toward 2 per cent by 2020. The world economy would expand at rates of 1–1½ percentage points higher than the United Kingdom's rates.

Energy Prices: The world price of energy raw materials would rise slowly until the 1990s, and faster thereafter. Shortages of naturally-occurring hydrocarbon liquids and gases would push their world price above the cost of substitutes early next century. Within the United Kingdom, energy prices to consumers would be held at or slightly above their present relationship to world energy prices.

Primary Energy Availability: Annual production of coal would rise toward 150 million tons (including 10–15 million tons of open cast) in the 1990s and hold at that level for the long term. As the world price of hydrocarbons increased later this century, techniques would be adopted to enhance the recovery from oil and natural gas reservoirs; also discoveries which would not be considered commercial under today's conditions would be exploited. It is further assumed that by the turn of the century, modest quantities of oil would be produced from areas yet to be designated.

The United Kingdom would have the technical and industrial resources to sustain a nuclear building programme geared to the installation of up to 50–60 GW(e) by the year 2000. Fast reactor technology would be proved and available for large-scale application before the end of the century. Renewable resources and waste materials would be developed as potential sources of energy, but would be introduced commercially only where economically attractive (in the light of the successful nuclear programme assumed in this scenario).

Conversion and Distribution: Electricity would not regain its present share of the inland energy market (nearly 12 per cent on a heat supplied basis) until the early 1990s, as some existing users switch to natural gas or to lower grade fuels. Combined heat and power plants and district heating schemes would be introduced where the economics appeared to be favourable.

Technologies to produce substitute natural gas from oil or coal and synthetic hydrocarbon liquids from coal would be available for introduction, if required, before the end of the century. It will be assumed in this scenario that coal-based SNG would be a more resource-efficient means of delivering energy for space and water heating than would coal-based electricity.

Utilisation: The existing pattern of energy need (in terms of 'useful' energy consumption) would broadly continue, but with some quantitative reductions due to the operation of the price mechanism, modestly reinforced by government measures. In addition, there would be steady improvements in domestic, commercial, and industrial end-use efficiencies, and in transportation efficiencies.

MAIN FEATURES

Primary Energy (Million tons coal equivalent)	1975	1990	2000	2010	2025
Indigenous Non-Nuclear Supplies					
Coal	120-127	135-145	130-150	130-150	130-150
Oil	2- 3	200-240	175-215	60-110	10- 30
Natural Gas	52- 53	75- 95	40- 50	15- 25	small
Alternatives	2- 3	4- 7	7- 30	10- 50	15-100
Total Indigenous Energy	183-185	420-480	370-430	230-320	170-260
Nuclear Energy	10- 11	40- 50	110-130	270-300	480-530
Balance of Supplies	145-150	(50)-(20)	40- 90	130-200	140-220
Total Primary Energy Consumption	340-345	450-470	570-600	690-740	860-940

Notes: The figures for total primary energy consumption have been calculated with a sectoral model using 1975 as a base. The figures include consumption of energy raw materials as chemical feedstocks and by ships bunkering at United Kingdom ports. The 1975 data are provisional and temperature adjusted.

SCENARIO 0 — THE TRENDS-CONTINUED VIEW

TECHNOLOGY IMPACTS

nary Energy Technologies

Coal: With deep-mined coal production stabilised at less than 150 million tons a year, it should be sufficient to extend those existing technologies which improve working conditions and raise the efficiency of deep mining. Wholly new extraction technologies (for example, in-situ gasification) are unlikely to be available on our 50 year horizon, but would probably not be required to maintain these production rates into the more distant future. However, new coal utilisation technologies will be needed in the medium term, in particular, techniques to utilise low-grade coals (for example, fluidised combustion) if substantial reserves of economically recoverable low-grade coals were shown to be present.

Oil and Natural Gas: The exploitation of our reserves of oil and natural gas at Continental Shelf depths (up to 200 metres) would benefit from the introduction of improved and new techniques in offshore resource evaluation; in the design, construction and installation of offshore structures and pipelines; and in underwater working, inspection and maintenance. Satisfactory deep sea (over 300 metres) engineering technologies and production systems will be called for by the mid 1980s. Enhanced recovery techniques to increase the recoverability of oil and gas in place may have become applicable by the late 1980s.

Nuclear Fission: A total of 50–60 GW(e) of nuclear plant could be accommodated by the electricity supply industry in the year 2000 and would generate about 60 per cent of the United Kingdom's electricity. Installed capacity would reach 120–140 GW(e) in 2010. Since a similar expansion in nuclear plant is to be expected throughout the developed world, the uranium supply position could (unless there are unexpectedly large new discoveries) have become sufficiently tight to require that fast reactors make a major contribution during the first decade of the next century. The direct application of nuclear heat is unlikely to make a significant impact before 2025.

Alternative Sources. Renewable sources – wave power, solar heat, tidal power, wind power, geothermal heat – even if successfully developed in the near future, would collectively contribute rather less than 40 mtcepa by the year 2000. The two technologies which, on this scenario, show most promise of making an impact this century would be wave power (up to 15 mtcepa) and solar heat (up to 4 mtcepa). Recovery of energy from wastes would also make a small impact, perhaps 5 mtcepa by the year 2000. However, of all the alternative sources only fusion power could become a dominant new source of energy, although that is most unlikely to occur before 2025.

Energy Conversion and Distribution Technologies

Electricity: Most new power stations would be nuclear; any new fossil-fuelled stations would tend to be based on 'low-risk' technology and hence be close replicas of existing plant. Major developments on energy storage systems would be welcome to smooth the diurnal demand pattern and to increase the utilisation of nuclear stations during off-peak periods. Combined heat and power plant would be increasingly favoured where there is a steady local demand for the heat, by the turn of the century. CHP plant may effect an energy saving of around 5 mtcepa, largely from industrial applications.

Gas: Base-load SNG plants based initially on feedstocks of heavy oil and later on coal, would be introduced from the 1990s onwards to compensate for the rundown in natural gas supplies. If the gas supply industry were to contract to a base size related to the premium markets held in the early 1990s the United Kingdom could be converting to SNG well over 50 million tons of coal a year by the year 2025.

District Heating: District heating schemes incorporating combined heat and power plants would make only a small contribution during the medium term. However, as gas supplies run down, district heating, perhaps involving nuclear combined heat and power plant, could expand to supply say 5–10 per cent of the United Kingdom's space and hot water requirements in the year 2025.

Synthetic Hydrocarbon Liquids: Apart from special requirements such as for certain aromatic chemicals synthetic hydrocarbon liquids would not be required by the United Kingdom before the next century. However, in the year 2025, the United Kingdom would consume a total of over 150 mtcepa of hydrocarbon liquids for transport fuels and for chemical feedstocks and by that date a significant proportion of those premium liquids could be coal-derived though not necessarily from coal conversion plant located in the United Kingdom.

Utilisation Technologies

Overall Impact: In response to the higher energy prices technologies which reduce the consumption of useful energy and which improve the efficiency of energy utilisation would be developed and introduced. By the year 2000 the consumption of useful energy would be some 10–15 per cent below what it would have otherwise reached without the escalation of energy prices. A further 10 per cent reduction would progressively accumulate during the early part of the next century.

Buildings: In buildings the major technology impacts are expected from the development of buildings of low energy consumption the more widespread adoption of energy management techniques and, more specifically for existing building stock, from insulation technologies, solar heat and possibly from the use of heat pumps. Together these could reduce useful energy consumption in buildings by over 10 per cent below what it would have otherwise reached in the year 2000 and by a further nearly 10 per cent during the early part of the next century.

Industry: Apart from the short-term effects of good housekeeping, which should reduce energy consumption in industry by up to 10 per cent, technologies to improve the energy efficiencies of processes and to reduce the energy content of products would be introduced to provide a reduction of at least a further 30 per cent in the specific consumption of energy in industry (on a heat supplied basis) by the early part of the next century.

Transport: In the transport sector, engine and motor vehicle design alone would have reduced specific fuel consumption by 10 per cent by the year 2000. Battery vehicles and alternative transport fuels are not expected to make a significant impact this century.

SCENARIO 1 — A LOW-GROWTH VIEW

SCENARIO DESCRIPTION

this scenario, low international economic growth is the dominant feature. It is assumed that, because of the consequent fall in demand for energy raw materials, world energy prices would rise more slowly than in scenario 0. As a result of the depressed economic conditions in the United Kingdom, additional measures would be taken to reduce the total energy import bill both through the introduction of restrictive conservation measures and through the expansion of indigenous supplies of energy, particularly coal.

SPECIFIC ASSUMPTIONS

Economic Factors: World economic growth would be depressed, averaging a little over 2 per cent a year up to the end of the century and somewhat less next century. As a consequence, the United Kingdom economy (as measured by GDP) would expand at an annual average rate of 2 per cent up to the early 1990s, falling off to around 1 per cent by the year 2000 and to perhaps as low as ½ per cent by 2000.

Energy Prices: The depressed demand for energy raw materials would cause the rise in world energy prices to lag behind those projected in scenario 0. Within the United Kingdom, energy prices to consumers would be held above their present relationship to world energy prices.

Primary Energy Availability: The poorer prospects for employment in the manufacturing industry would enable the United Kingdom to devote additional human resources to coal production such that deep-mined coal production would exceed 150 million tons a year early next century. Depletion rates of natural gas and oil would be controlled to extend into the late 1990s the period over which natural gas would cover premium gas markets, and to well into the first decade of the next century the period of self-sufficiency in oil. As the world price of hydrocarbons increased later this century, techniques would be adopted to enhance the recovery from oil and natural gas reservoirs; also discoveries which would not be considered commercial under today's conditions would be exploited. It is further assumed that, by the turn of the century, modest quantities of oil would be produced from areas yet to be designated.

Despite the poor economic performance the United Kingdom would still have the technical and industrial resources to sustain a nuclear building programme such that thermal nuclear stations could account for around 60 per cent of electricity production by the year 2000, provided that this would not entail constructing more than 4 GW(e) a year in the late 1990s and provided that other markets could be found for the coal thus displaced. Renewable resources and waste materials would be developed as sources of energy, but would be introduced commercially only where economically attractive.

Conversion and Distribution: Electricity would not regain its present share of the inland energy market (nearly 12 per cent on a heat supplied basis) until the late 1990s, as some existing end-users switch initially to natural gas and subsequently to supplies of lower grade energy. The operation of combined heat and power plants and the introduction of district heating schemes would be encouraged wherever the economics appeared to be favourable.

Technologies to produce substitute natural gas from oil or coal and synthetic hydrocarbon liquids from coal would be available for introduction, if required, before the end of the century. It will be assumed in this scenario that coal-based SNG would be a more resource-efficient means of delivering energy for space and water heating than would coal based electricity.

Utilisation: The existing pattern of energy need (in terms of "useful" energy consumption) would broadly continue, but with substantial quantitative reductions due to the conservation measures and to the higher consumer prices of energy. In addition there would be major improvements in domestic, commercial, and industrial end-use efficiencies, and in transportation efficiencies.

MAIN FEATURES

Primary Energy (Million tons coal equivalent)	1975	1990	2000	2010	2025
Indigenous Non-Nuclear Supplies					
Coal	126-127	135-145	150-170	160-180	170-200
Oil	2- 3	150-180	150-180	70-120	30- 70
Natural Gas	52- 53	65- 80	45- 60	20- 35	5- 10
Alternatives	2- 3	4- 7	7- 20	10- 35	15- 60
Total Indigenous Energy	183-185	360-400	370-410	280-350	240-320
Nuclear Energy	10- 11	30- 40	70- 90	110-130	140-160
Balance of Supplies	145-150	(40)-(20)	(50)-(30)	0- 40	20- 80
Total Primary Energy Consumption	340-345	380-390	420-440	440-470	460-500

Notes: The figures for total primary energy consumption have been calculated with a sectoral model using 1975 as a base. The figures include consumption of energy raw materials as chemical feedstocks and by ships bunkering at United Kingdom ports. The 1975 data are provisional and temperature adjusted.

SCENARIO 1	A LOW-GROWTH VIEW

TECHNOLOGY IMPACTS

[Pri]mary Energy Technologies

[Co]al: If deep-mined coal production is to be increased to 160–180 million tons a year largely by expanding the work force, it would be sufficient only to extend those existing technologies which improve working conditions and raise the efficiency of deep mining. Wholly new extraction technologies (for example, in-situ gasification) are unlikely to be available on our 50 year horizon, but in any event might not be required even if these production rates were to be maintained indefinitely, provided of course that the manpower was available. New coal utilisation technologies would need to be introduced in the medium term, in particular, techniques to utilise low-grade coals (for example, fluidised combustion) if substantial reserves of economically recoverable low-grade coals were shown to be present.

Oil and Natural Gas: The exploitation of our reserves of oil and natural gas at Continental Shelf depths (up to 200 metres) would benefit from the introduction of improved and new techniques in offshore resource evaluation; in the design, construction and installation of offshore structures and pipelines; and in underwater working, inspection and maintenance. Satisfactory deep sea (over 300 metres) engineering technologies and production systems will be called for by the early 1990s. Enhanced recovery techniques to increase the recoverability of oil and gas in place may have become applicable by the late 1980s.

Nuclear Fission: Unless we are again to become major importers of fossil fuels in the early part of the next century, the nuclear building programme would need to have installed a total of around 30 GW(e) of plant by the year 2000, and about double that amount by the year 2010. Since a similar expansion in nuclear plant would be expected throughout the developed world, the uranium supply position could (unless there are unexpectedly large new discoveries) have become sufficiently tight to require that the fast reactors make a major contribution no later than the second decade of the next century. The direct application of nuclear heat would be unlikely to make a significant impact on our 50 year time-horizon.

Alternative Sources: Renewable sources – wave power, solar heat, tidal power, wind power, geothermal heat – even if successfully developed in the near future, would collectively contribute rather less than 40 mtcepa by the turn of the century. However, in the face of a low growth in energy consumption and relatively stable energy prices, the only technology which, on this scenario would show promise of making an impact this century is solar heat (up to 4 mtcepa). Recovery of energy from wastes and the bio-conversion of wastes could also make a small impact, perhaps 4 mtcepa by the year 2000. Of all the alternative sources, only fusion power could become a dominant new source of energy, but that is most unlikely to occur before 2025.

Energy Conversion and Distribution Technologies

Electricity: Probably all new power stations would be nuclear; any new fossil fuelled stations would tend to be based on 'low-risk' technology and hence be close replicas of existing plant. Major developments on energy storage systems would be welcome to smooth the diurnal demand pattern and to increase the utilisation of nuclear stations during off-peak periods. Combined heat and power plant would be increasingly favoured where there is a steady local demand for the heat: by the turn of the century, CHP plant may effect an energy saving of up to 5 mtcepa, largely in industrial applications.

Gas: Base-load SNG plants, based initially on feedstocks of heavy oil and later on coal, would be introduced from the 1990s onwards to compensate for the run-down in natural gas supplies. If the gas supply industry were to contract to a base size related to the premium markets held in the 1990s, the United Kingdom could be converting coal to SNG at the rate of up to 50 million tons a year by the year 2025.

District Heat: District heating schemes, incorporating combined heat and power plants, would make only a small contribution during the medium term, since the investment capital is unlikely to be available to build up the networks. However, as gas supplies run down, district heating, perhaps involving nuclear combined heat and power plant, could expand to supply say 5–10 per cent of the United Kingdom's space and hot water requirements by the year 2025.

Synthetic Hydrocarbon Liquids: Apart from special requirements, such as for certain aromatic chemicals, synthetic hydrocarbon liquids would not be required by the United Kingdom until well into the next century. In the year 2025, the United Kingdom would be consuming a total of around 100 mtcepa of hydrocarbon liquids for transport fuels and for chemical feedstocks, and by that date a small proportion of these premium liquids could be coal-derived, though not necessarily from coal conversion plant located in the United Kingdom.

Utilisation Technologies

Overall Impact: In response to high energy prices and conservation measures, technologies which reduce the consumption of useful energy and which improve the efficiency of energy utilisation would be pursued. By the year 2000, the consumption of useful energy might be over 15 per cent below what it would have otherwise reached. There would be a further 10 per cent reduction during the early part of the next century.

Buildings: In buildings, the major technology impacts are expected from the development of buildings of low energy consumption, the more widespread adoption of energy management techniques, and, more specifically, for existing building stock from insulation technologies, solar heat, and from the use of heat pumps. Together these could reduce useful energy consumption in buildings by 15 per cent below what it would have otherwise reached in the year 2000 and by a further 10 per cent in the early part of the next century.

Industry: Apart from the short-term effects of good housekeeping, which should reduce energy consumption in industry by 10 per cent, technologies to improve the energy efficiencies of processes and to reduce the energy content of products would be introduced to provide a reduction of a further 25 per cent in the specific energy consumption of industry (on a heat supplied basis) by the early part of the next century.

Transport: In the transport sector, engine and motor vehicle design would have reduced specific fuel consumption by 15–20 per cent by the year 2000. Battery vehicles and alternative transport fuels would not be expected to make a significant impact on our 50 year time horizon.

SCENARIO 6 A HIGH GROWTH VIE

SCENARIO DESCRIPTION

The themes of this scenario are a buoyant international economy and high economic growth in the United Kingdom. It is assumed that the increase demand for energy would push up world energy prices faster than in Scenario 0, but insufficiently fast to interfere with economic growth. The United Kingdom's higher economic performance would give it the ability to expand its nuclear plant building industry at a particularly high rate.

SPECIFIC ASSUMPTIONS

Economic Factors: The United Kingdom economy (as measured by GDP) would expand at an annual average rate of over 4 per cent up to the enc of the century, falling toward 3 per cent by 2010. The world economy would expand at rates of 1½-2 percentage points higher than the United Kingdom's rates.

Energy Prices: The world price of energy raw materials would rise somewhat faster than in Scenario 0. Shortage of naturally-occurring hydrocarbon liquids and gases would push their world price above the cost of substitutes early next century. Within the Unitec Kingdom, energy prices to consumers would be held at or slightly above their present relationship to world energy prices.

Primary Energy Availability: Annual production of coal would rise towards 150 million tons (including 10-15 million tons of open-cast) in the 1990s and because of manpower constraints would hold at that level for the long-term. As the world price of hydrocarbons increased late this century, techniques would be adopted to enhance the recovery from oil and natural gas reservoirs, also discoveries which would not be considered commercial under today's conditions would be exploited. It is further assumed that by the turn of the century, modest quantities of oil would be produced from areas yet to be designated.

With the buoyant economic conditions, the United Kingdom could have the technical and industrial resources to sustain a nuclear building programme geared to the commissioning of around 5 GW(e) a year of new nuclear plant in 1990, 10 GW(e) a year at the turn of the century, and 15 GW(e) a year by 2010. It is assumed that fast reactor technology would be available for introduction in the mid 1990s. The direct application of nuclear heat from high temperature reactors would become technically feasible soon after the turn of the century.

Renewable resources and waste materials would be developed as sources of energy, but would be introduced commercially only where economically attractive (in the light of the successful nuclear programme assumed in this scenario).

Conversion and Distribution: In the medium term, electricity's share of the inland energy market would remain at its present level (nearly 12 per cent on a heat supplied basis) until the nuclear building programme gathered speed in the early 1990s. Combined heat and power plants and district heating schemes would be introduced where the economics appeared to be favourable.

Technologies to produce substitute natural gas from oil or coal and synthetic hydrocarbon liquids from coal would be available for introduction, if required, before the end of the century. It will be assumed in this scenario that coal-based SNG would be a more resource-efficient means of delivering energy for space and water heating than would coal-based electricity.

Utilisation: The existing pattern of energy need (in terms of 'useful' energy consumption) would broadly continue, but with some quantitative reductions due to the higher price of energy. In addition there would be steady improvements in domestic, commercial, and industrial end-use efficiencies and in transportation efficiencies.

MAIN FEATURES

Primary Energy (Million tons coal equivalent)	1975	1990	2000	2010	2025
Indigenous Non-Nuclear Supplies					
Coal	120-127	135-145	130-150	130-150	130-150
Oil	2- 3	200-240	175-220	70-110	20- 40
Natural Gas	52- 53	75- 95	40- 50	15- 25	5- 10
Alternatives	2- 3	4- 7	7- 30	10- 50	15-100
Total Indigenous Energy	183-185	420-480	370-430	240-320	190-280
Nuclear Energy	10- 11	60- 80	210-240	450-500	820-890
Balance of Supplies	145-150	(20)- 20	100-140	180-230	200-280
Total Primary Energy Consumption	340-345	510-530	730-760	940-1000	1270-1390

Notes: The figures for total primary energy consumption have been calculated with a sectoral model using 1975 as a base. The figures include consumption of energy raw materials as chemical feedstocks and by ships bunkering at United Kingdom ports. The 1975 data are provisional and temperature adjusted.

SCENARIO 6 — A HIGH-GROWTH VIEW

TECHNOLOGY IMPACTS

ary Energy Technologies

Coal: With deep-mined coal production stabilised at less than 150 million tons a year, it should be sufficient to extend those existing technologies which improve working conditions and raise the efficiency of deep mining. Wholly new extraction technologies (for example, in-situ gasification) are unlikely to be available on our 50 year horizon, but would probably not be required to maintain these production rates into the more distant future. However, new coal utilisation technologies will be needed in the medium term, in particular, techniques to utilise low-grade coals (for example, fluidised combustion) if substantial reserves of economically recoverable low-grade coals were shown to be present.

Oil and Natural Gas: The exploitation of our reserves of oil and natural gas at Continental Shelf depths (up to 200 metres) would benefit from the introduction of improved and new techniques in offshore resource evaluation; in the design, construction and installation of offshore structures and pipelines; and in underwater working, inspection and maintenance. Satisfactory deep sea (over 300 metres) engineering technologies and production systems will be called for by the mid 1980s. Enhanced recovery techniques to increase the recoverability of oil and gas in place may have become applicable by the late 1980s.

Nuclear Fission: On this scenario, the energy market would have no difficulty in absorbing the power from 25–30 GW(e) of installed nuclear plant in 1990, 100–110 GW(e) in the year 2000, and as much as 200–350 GW(e) in 2010. Since a similar expansion in nuclear plant would be expected throughout the developed world, the uranium supply position could (unless there are unexpectedly large new discoveries) have become sufficiently tight to require that fast reactors make a major contribution before the turn of the century. The direct application of nuclear heat is unlikely to make a significant impact before the year 2000, but by 2025 perhaps 10–20 per cent of industrial process energy could come from this source.

Alternative Sources: Renewable sources – wave power, solar heat, tidal power, wind power, geothermal heat – even if successfully developed in the near future, would collectively contribute rather less than 40 mtcepa by the year 2000. The two technologies which show most promise of making an impact this century would be wave power (up to 15 mtcepa) and solar heat (up to 4 mtcepa). Recovery of energy from wastes and the bioconversion of wastes could also make a small impact, perhaps 5 mtcepa by the year 2000. However, of all the alternative sources only fusion power could become a dominant new source of energy, although that is unlikely to occur within our 50 year time horizon.

Energy Conversion and Distribution Technologies

Electricity: Practically all new power stations would be nuclear; any new fossil-fuelled stations would tend to be based on 'low-risk' technology and hence be close replicas of existing plant. In order to support the operations of an expanding electricity supply industry, steady improvements will be called for in most items of plant and equipment, particularly transmission equipment. Major developments on energy storage systems would be necessary before the year 2000 to smooth the diurnal demand pattern and to increase the utilisation of nuclear stations during off-peak periods. Combined heat and power plant would be increasingly favoured where there is a steady local demand for the heat; by the year 2000, CHP plant may effect an energy saving of over 5 mtcepa, largely in industrial applications.

Gas: Base-load SNG plants, based initially on oil feedstocks and later on coal, would be introduced from the 1990s onwards to ease the run-down of the gas supply industry. At its maximum impact, the production of SNG might require some 30–40 million tons a year of coal as feedstock. In the long term, remaining gas consumers would be switched to electricity or district heat.

District heat: District heating schemes, incorporating combined heat and power plants, would make only a small contribution during the medium term. However, as gas supplies run down, district heating, perhaps involving nuclear combined heat and power plant, could expand to supply say 5–10 per cent of the United Kingdom's space and hot water requirements in the year 2025.

Synthetic Hydrocarbon Liquids: Apart from special requirements, such as for certain aromatic chemicals, synthetic hydrocarbon liquids would not be required by the United Kingdom until perhaps around the turn of the century. However, by the year 2010, the United Kingdom would be consuming a total of over 200 mtcepa of hydrocarbon liquids for transport fuels and for chemical feedstocks, and by that date a significant proportion of these premium liquids could be coal derived, though not necessarily from coal conversion plant located in the United Kingdom.

Utilisation Technologies

Overall Impact: In response to the higher energy prices, technologies which reduce the consumption of useful energy and which improve the efficiency of energy utilisation would be developed and introduced. By the year 2000 the consumption of useful energy would be nearly 15 per cent below what it would have otherwise reached without the escalation of energy prices. There would be a further 10 per cent reduction during the early part of the next century.

Buildings: In buildings, the major technology impacts are expected from the development of buildings of low energy consumption, the more widespread adoption of energy management techniques and, more specifically for existing building stock, from insulation technologies, solar heat, and possibly from the use of heat pumps. Together these could reduce useful energy consumption in buildings by 15 per cent below what it would have otherwise reached in the year 2000, and by a further 10 per cent in the early part of the next century.

Industry: Apart from the short-term effects of good housekeeping, which should reduce energy consumption in industry by over 10 per cent, technologies to improve the energy efficiencies of processes and to reduce the energy content of products would be introduced to provide a reduction of a further 40–45 per cent in the specific energy consumption in industry (on a heat supplied basis) by the early part of the next century.

Transport: In the transport sector, engine and motor vehicle design alone would have reduced specific fuel consumption by 10–15 per cent by the year 2000. Battery vehicles and alternative transport fuels are not expected to make a significant impact this century, but by 2025 electric traction could account for over one-fifth of all road movements.

APPENDIX 2, LISTS OF 'DELPHI' PARTICIPANTS.

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B. First Round Respondents.

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D. Numbers of Respondents in Different Specialisms for the Three Rounds.

SPECIALISM	ROUND 1	ROUND 2	ROUND 3
Rural Specialists	17	8	6
Rural Generalists	17	7	5
Energy Specialists	21	6	3
Energy Generalists	15	5	3
Others	9	0	0

APPENDIX 3, THE 'DELPHI' QUESTIONNAIRES.

A. The First Round.

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ROBERT GORDON'S INSTITUTE OF TECHNOLOGY

HEAD OF SCHOOL
S. H. BAXTER, ARICS, MRSH, CIAgrE

RURAL ENERGY DELPHI SURVEY, ROBERT GORDON'S INSTITUTE OF TECHNOLOGY AND THE ROYAL INSTITUTION OF CHARTERED SURVEYORS.

Dear Sir,

An ongoing project here at the School of Surveying, sponsored by the R.I.C.S. has been involved in socio-economic research into the characteristics of energy use in rural areas of the U.K. and elsewhere, and the prospects for the future. As a part of this research we are conducting a several stage postal 'Delphi' survey of experts in the various specialisms touching on this field, which we would be grateful if you felt able to take part in.

Enclosed in the first round of this survey are a list of the people we have asked to take part, a description of the research and it's methodology, an introduction to the first round survey, and a survey form for you to complete if you feel able.

Although this survey is presented in 'questionnaire' form, we recognise that your ideas and comments may not happily fit this format, and would be grateful for your responses in whatever form you feel to be appropriate.

If you wish to collaborate with colleagues, or feel that someone else in your organisation is better able to contribute, please feel free to pass this literature on, though we would be grateful if you could note the name of whoever might be called upon to provide responses.

The anonymity of your individual responses is assured, since no names will be attached to specific responses in feedback. The second round of this three round process will follow as soon as possible after enough responses have been recieved.

We look forward with interest to your ideas and comments, and hope that you will find this process of communication between different specialisms of some interest yourself,

Yours sincerely,

SCHOOL OF SURVEYING
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Tel. 0224 33247

ROBERT GORDON'S INSTITUTE OF TECHNOLOGY

HEAD OF SCHOOL:
S H BAXTER, FRICS, FIAS, MRSH, CIAgrE

RURAL ENERGY DELPHI SURVEY ROBERT GORDON'S INSTITUTE OF TECHNOLOGY AND THE ROYAL INSTITUTION OF CHARTERED SURVEYORS

Dear

I enclose a copy of an outline of an interdisciplinary survey of rural and energy experts on the subject of the future of rural energy use. which we are carrying out here at the School of Surveying

Since your organisation is intimately connected with aspects of this field we would be grateful for your advice as to which person(s) in or connected with your organisation, you feel might best be able to help us The documentation to the first round of this survey will be sent out once we have been able to complete the list of suitable correspondents

As the survey includes a wide range of different specialisms which perhaps do not often communicate together on such a broad conceptual topic we hope it may be of some interest to you

I look forward to hearing from you

Yours sincerely,

RURAL ENERGY AND THE FUTURE

SURVEY ROUND ONE

INTRODUCTION

This first round of the 'Delphi' survey is divided into two basic sections, firstly a hypothetical future is mapped out in full, with various of it's aspects represented on 'cusp catastrophe' diagrams for illustration. Elements of this fifty year projection are then separated, and your comments are invited as to the likelihood and desirability of each event.

Obviously elements cannot legitimately be viewed entirely in isolation, so your suggestions are also encouraged on the scenario as a whole. All comments will be carefully noted, and round two feedback will adjust, or possibly wholly replace, the scenario based on these comments.

The second section presents a set of possible ways in which local rural energy autonomy might be increased, and an assessment is asked for as to their likelihood, possible importance and desirability. Your comments might well include challenges as to the desirability or feasibility of thinking in terms of autonomy at all. This list is by no means complete, and is merely presented as a starting point for criticism and addition.

A SCENARIO FOR THE NEXT FIFTY YEARS

1.0 INTERNATIONALLY

On the international scene, it is suggested initially that there are to be no major shifts in the nature of present power blocks, though America will tend to gain the ascendancy, particularly through her relations with China. Threatened world or continental scale wars, conventional or thermonuclear, do not occur, and the pattern of contained military activity in poor countries of the world from time to time is sustained.

Although third world countries do see growth, the poorest areas are practically indistinguishable from today in their conditions, apart from their increased populations. Some economic power however, particularly in the more basic manufacturing industries, shifts to some third world countries, patricularly in Latin America and South East Asia, many of whom are able to achieve this growth whilst taking control of their own affairs, at the expense of the established developed nations, and gain considerable material benefit. Many O.P.E.C. countries consolidate their indusrial structure and become major forces in manufacturing, and by the end of the fifty year period their very expensive oil exports are absorbed more by plastics and chemical industries than for use as fuel.

Outside of these countries, and particularly in the capitalist first world, growth remains low, at one to two percent, throughout the period, as the traditional manufacturing economic base of these countries collapses. In spite of eventual oil substitutions, world energy pricres rise, generally in a series of politically inspired jumps, faster than any other commodity except food.

2.0 EUROPE

As a political and economic unit, the E.E.C. grows in importance, partly in response to economic threats from the developed third world. E.E.C. politics become more of an issue, as Brussels becomes more 'real' to people as a centre of power. Eventually, European elections and political issues enjoy equal status with domestic affairs.

As a result of this trend, Europe begins to be thought of as an area of regions, rather than nations, and individuals identify with their regional status, based on economic and natural conditions, less than with their nation.

3.0 NATIONALLY

Britain averages a lower rate of growth than many other parts of Europe, at around 1%/annum, and by the end of the period philosophies of creating economic stability have replaced the perceived need for economic growth. Low employment is a continuing phenomenon, and there is a slow shift, though violently resisted in some quarters, towards the acceptance of the lack of full employment, and the need for social policy to be aimed towards leisure use. With the collapse of the traditional, basic manufacturing industries, emphasis sits more and more on the production and export of such commodities as software, research and information.

Politically, there is a considerable continued shift to the right for some time, within a more generally capitalist Europe. Goals within society shift away from the social level and concentrate more and more on the individual, with the progressive withdrawal of the state from many areas and the isolation of the production and life of the family.

The ageing of the conservative youth of the late 1970's and 80's reinforces the general new capitalism, which trend continues in spite of a slight left wing backlash around 2000 to 2005. There is a breakdown of political alignment based on class, though the classes continue tto exist in modified form, and there is the growth of a staid, conservative working class, offset by a more socialist branch within the middle classes. The continued nuclear threat results in generations of resigned fatalism, which emerges through egotistical self interest of the individual, and some religious ressurgence, rather than concerned social behaviour such as pressure grups.

4.0 U.K. ENERGY

Energy prices in the U.K. are much higher than the world average due to economic policy in Europe and at home. The encouragement of the coal industry, and research into coal using technology, leads eventually to considerable replacement of oil, and ultimately to the elevation of coal to the present position of oil, with taxation and other conserving strategies rplacing the encouragement to consume.

The priority for energy conservation amongst individuals grows considerably, though wih state money restricted, this is reflected mainly in the growth of relatively low-tech means of saving on 'traditional' patterns of use. There is some tendency towards localisation, as in urban district heating schemes, but basically energy supply developes on its existing pattern. In spite of Government wishes, the anti-nuclear lobby has some early effect, and keeps down the developmen of fission reactors to a 20GW capacity by 2000. Resistance slowly dies out, however, due to the accident free history of the industry, whilst commercial fusion energy is available at the end of the 50 year period.

There is a high emphasis on self-sufficiency nationally and, to a lesser extent, on a European scale, so that U.K. oilfields are quickly depleted, with a dramatic drop of production after 2000, and a period of very high energy costs in the transition to coal. Because of this transition, grid electricity grows in importance, with a doubling in power station efficiency, from 30% to 60% conversion. Renewed inner city smog problems after 2000 result in restrictions on the individual use of low grade coal, and the present return to open fires is not allowed to continue.

Little stae funding for renewables mean that they are restricted to relatively slow growth and low-tech applications, though their identification with individualism and self-sufficiency lend thm an appeal for individuals (still particularly the middle classes), who employ them on the small scale. Following a considerable lowering in price, and technical innovations in electricity storage, photovoltaics become the major renewable source after 2000.

5.0 U.K. RURAL

The decline of the existing structure of urban industry, the growing impportance of information technology, and increasing stress on individualism, mean that more and more marginal rural areas are 'recolonised', largely by middle class urbanites.

Although there is little positive rural policy, pressure on rural areas for commuting, retirement, and new lifestyles in the atmosphere of continued high un and underemployment, is encouraged through the progressive dismantling of planning controls. New rural infrastructure in response to this growing demand is at a minimum. The perceived isolation of outlying areas goes down, whilst the individual's willingness to be isolated rises, so that he appeal of marginal rural areas for permanent settlement rises for many people.

Planning controls remain relatively strong in 'green belt' areas around towns, so that rural area population growth is caused more by genuine migration than by urban spread. Friction between indigenous and incomer populattion, in spite of (or perhaps because of), the latter's interest in agriculture and rural community, rises, and becomes a more political issue, but trends are always towards the moulding of rural areas o the requirements of the incomer[illegible]

Small, particularly high-tech, high va[illegible] industries, locate in favourable rural areas, but ve[illegible] [illegible]arginal areas remain low in wage type employment.

Many more people adopt lifestyles involving more than one source of income, including both part-time jobs and self-employment in small enterprises involving the whole of households, thus a kind of 'household economy' begins to take over from widespread wage labour as the main source of income.

More than in urban areas, rural areas adopt the small-scale use of renewable energy sources, particularly biofuels, causing land pressure and a conflict of interest in many cases between food and fuel, on much the same lines as presentt day agriculturee/forestry conflicts.

The low growth state means the growth in importance of rehab in domesic building, including the use of local materials to convert existing farm buildings to dwellings, with material and energy costs providing the main impetus towards this growth, rather than the present emphasis on planning policy.

Public transport and transport infrastructure declines considerably, and whilst this need is not met by private transport, forms of communication other than physical movement, which are not so much a function of distance, tend to equalise the position of the rural areas.

All in all, self-sufficiency, both for reasons of economics and ideology, becomes a priority in food, energy and most other goods.

6.0 U.K. AGRICULTURE

There is little change in landowning patterns over the period, as a reaction to industrialised farming halts the growth of farm size, though large estates remain largely in the same hands and continue to dominate the life of more isolated areas. With the relaxation of planning controls, there is less discrepancy between prices for agricultural and building land, and land prices generally remain high. A general change in atitudes encourages the productive use of land, and the decline in validity of the 'sporting estate' image makes many previously bad estate owners manage their land rather better.

Early on, environmental groups have some effect in altering farming practices, causing the decline of chemical fertilizer and pesticide use, the growth of 'organic farming', use of rotations and mixed farming. E.E.C. agricultural policy shifts away [illegible] direct subsidy and tries to encourage 'good farming practices' and balanced food production, generating a battery of fixed, inflexible regulations which most small farmers employ computers to evaluate.

Outside of very strongly delineated conservation araes, like the NationalParks, (considerably restricted in size), environmental concern becomes restricted to concerns on the esthetics of landscape, which factor becomes more and more synonomous with 'good farming practices', rather than strict preservation. Within nNational Park areas, including several in Scotland, however, conservation is rigid and unbending and operates greatly to the detriment of the farming.

Agricultural energy use decreases due to rising prices, though with emphasis on food production for export, (particularly to the 'cheap labour', industrialising secors of the third world), more land comes under the plough. Energy efficiency increases through the rationalisation and reduction of field operations, and through increased machinery efficiency, with small tractors and very little use of large, specialised machinery such as combines.

Although farms remain quite large, and areas under cultivation grow, there is a considerable growth of small-scale, allotment type of rural production by both incomers and the indigenous population, as sideline income to the household economy. both this factor, and the deindustrialisation of many farming practices, contribute to a return to productive activity on the land which, including part time labour, has reached 25% of the workforce by 2034.

FIFTY YEAR SCENARIO - QUESTIONNAIRE.

P'ease comment on the 'ike'ihood of occurrence of the fo''owing events, taken from the preceding descriptive scenario.

1. INTERNATIONAL-	% Like'ihood	% Desirabi'ity	A'ternatives	Comments
1.1. No significant disarmament, but wor'd war, and a'' war within present'y deve'oped nations avoided.				
1.2. Main manufacturing base in present 'Third Wor'd' countries by 2034.				
1.3. No oi' used as fue' within 50 years.				
1.4. Wor'd economic growth be'ow 2% per annum, 2000 to 2034.				
1.5. Wor'd average energy prices rise 5% per annum for 50 years.				
Other Comments	/	/		

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2. EUROPE-				
2.1. General growth in importance of E.E.C.				
2.2. E.E.C. and national politics have equal importance to the individual by 2034.				
2.3. Other Comments.				
3. NATIONALLY-				
3.1. U.K. economic growth averages 1% per annum for 50 years.				
3.2. Economic stability replaces growth as a political aim by 2034.				
3.3. Un and 'under' employment (based on present 40 hour week standard), at 30% by 2000.				
3.4. Most 'social' policy concerned with leisure by 2034.				

FUTURE

3.5. Majority of G.N.P. in services by 2034.				
3.6. U.K. shifts continually to the right politically, by 2034, breadth of party structure fesembles American Republican/Democrat split.				
3.7. State withdraws from many areas of its present concern, particularly social provision etc. (suggest areas).				
3.8. Renewal of importance of 'family' for state and individuals.				
3.9. 'Family' becomes more isolated from 'community'.				
3.10. No political alignment by present 'class system' by 2034. (suggest other factors causing alignment).				
3.11. 'Pressure groups' disappear after 2000, self and egotism take the place of 'social awareness'.				
3.12. Other comments.	/	/		

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FUTURE

4. *U.K. ENERGY-*				
4.1. U.K. Energy prices consistent'y higher than wor'd average.				
4.2. Coa' is major rep'acement for oi'				
4.3. Energy saving menta'ity grows genera''y.				
4.4. Litt'e state money avai'ab'e for energy conservation research or practice.				
4.5. 20GW fission capacity by 2000.				
4.6. Fusion becomes commercia' by 2034.				
4.7. Much higher e'ectricity use, more or 'ess on existing grid pattern.				

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4.8. *Large drop in North Sea oil production in year 2000, coinciding with rapid rise in coa' prices (suggest other years).*				
4.9. Power station conversion efficiency doub'es over 50 years.				
4.10. Litt'e 'arge sca'e nationa' use of renewab'es.				
4.11. 20% of <u>rura'</u> domestic energy in renewab'es by 2034.				
4.12. Photovo'taics main source of renewab'es after 2000.				
4.13. Other comments.				
5. U.K. RURAL-				
5.1. Urban migration to countryside continues, 40% of popu'ation 'rura' 'by 2034.				

FUTURE

5.2. Total relaxation of planning control outside green belts and national parks by 2000.				
5.3. New rural infrastructure and services almost nil throughout period.				
5.4. Generally rising willingness of individuals to be isolated.				
5.5. Rising friction between incomers abd indigenous rural population for 20 years.				
5.6. Decline in % wage employment compared to part-time self-employment. Both have equal status after 2020.				
5.7. Small, high value industries locate in rural areas.				
5.8. Multiple occupations carried out by 40% of workforce by 2034.				

5.9. Considerab'e conf'ict between biofue's and agricu'ture.				
5.10. In spite of 'ack of p'anning contro's, rehab. is the most important sector of rura' bui'ding throughout the period.				
5.11. Dec'ine of rura' pub'ic transpprt to ½ existing 'eve'.				
5.12. No increase in present private vehic'e ownership per capita.				
5.13. Non-transport communication systems take over from 5.12 and 5.13.				
5.14. 'Se'f-sufficiency' becomes an important phi'osophy for most peop'e.				
5.15. Other comments.				

FUTURE

6. U.K. AGRICULTURE-				
6.1. No perceptible change in large estate ownership.				
6.2. Halt in growth of farm size by 1990.				
6.3. Gradual withdrawal of institutions from farm ownership.				
6.4. Great improvement in management of estates run presently exclusively for sport.				
6.5. Decline in use of chemical fertilizers and pesticides to ¼ of present quantities per hectare.				
6.6. Growth of organic farming, 30% of farms fully 'organic' by 2034.				
6.7. Return of mixed farming to most areas.				

FUTURE

6.8. C.A.P. becomes twice as difficult to interpret, network of extension agencies deal solely with this task.				
6.9. Concerns of 'environmentalists' and farmers coincide after 2000.				
6.10. Rigid conservation in 20 small national parks severely restricts farming.				
6.11. 50% decrease in <u>direct</u> agricultural energy use, (i.e. not in materials or capital), by 2034.				
6.12. Priority for food export, aimed at national self-sufficiency in food value, rather than in particular crops.				
6.13. 20% more land ploughed by 2034.				
6.14. Field operations/hectare reduced to ½ present number by 2034.				

FUTURE

6.15. *Average tractor size falls.*				
6.16. No specialised powered machinery such as combines by 2034.				
6.17. Number of food-producing plots under 10 acres rises 5 times by 2034.				
6.18. Including part-time workers, 25% of adults are actively engaged on the land by 2034.				
6.19. Other comments.				
7. GENERAL COMMENTS-				

FUTURE

ENERGY SAVING AND USING THE 'RURAL ENERGY RESOURCE' - QUESTIONNAIRE.

There follows a list of possibilities for energy saving, and for 'internalising' the energy system of rural areas. You are asked to consider what is the likely contribution of each of these ideas, by indicating the percentage of present energy use for their particular function, (shown in brackets after each item), that they might make up in 50 years time. You are also asked for your comments on the desirability, problems, advantages and details of the application of each idea, and most particularly, for your own ideas as to reducing rural areas' dependance on imported fuels. It is recognised that such a percentage assessment is not likely to be accurately calculated in any way, given the time span and the lack of rigid definition of each field, all we are really looking for is a rough approximation of your confidence in each item, and your views on its advantages and disadvantages.

	likely % present energy use made up by item	Advantages	Disadvantages	Comments
1. DOMESTIC ENERGY USE-				
1.1. Replacement of transport by non-physical forms of communication. (Energy in all rural transport)				
1.2. Use of mobile services. (Energy in rural transport)				
1.3. Energy saving vehicle design. (Energy in rural transport)				
1.4. Efficient vehicle use such as car sharing. (Energy in rural transport)				

FUTURE

1.5. Reducing space heat waste by insulating. (Domestic space heat).				
1.6. Reducing space heat waste through smaller and adjoining new houses. (Domestic space heat)				
1.7. Reducing domestic energy use merely by using less, e.g. heat and light. (All domestic energy).				
1.8. Voluntary rejection of many consumer goods presently imported into rural areas. (Fixed energy in production of goods)				
1.9. Use of heat pumps. (Domestic space heat).				
1.10. Use of individual and other small wind energy converters. (All domestic energy).				
1.11. Use of individual and other small hydro plants. (All domestic energy).				

1.12. Use of photovo`taic ce``s. (Domestic e`ectricity)				
1.13. Use of so`ar water heating. (Domestic hot water and space heat)				
1.14. Use of passive so`ar techniques in new housing. (Domestic space heat).				
1.15. Use of gas from anaerobic digestors with individua` househo`d's waste as feedstock. (Domestic space heat and cooking)				
2. ENERGY IN AGRICULTURE-				
2.1. Reducing chemica` ferti`izer and pesticide input by use of organic ferti`izer and changed management practices. (Energy in producing chemica` inputs)				
2.2. Reduction in intensiveness of `ivestock rearing (Tota` energy in food production).				

FUTURE

2.3. Move from livestock and feed to crops for human consumption. (Energy in food)				
2.4. Increase in farm machinery efficiency. (Energy in field operations)				
2.5. Use of waste machine heat, e.g. in crop drying (On farm energy use)				
2.6. Use of forest thinnings and timber left in after felling (Total rural energy use).				
2.7. Planting of forestry for fuel, coppicing. (Total rural energy use).				
2.8. Management of farm woodland and hedgerows for fuel. (Total rural energy use)				
2.9. Wet crop residues producing gas. (Total rural energy use)				

2.10. *Planting of catch crops. (Total rural energy use)*				
2.11. Use of animal wastes for gas (Total rural energy use)				
2.12. Use of straw burning stoves (Total rural energy use)				
2.13. Use of small wind energy converters (On farm energy use)				
2.14. Use of small hydro plants. (On farm energy use)				
2.15. Use of photovoltaic cells. (On farm energy use)				
2.16. Use of solar water heating. (Farm building heat)				

FUTURE

2.17. Use of passive solar techniques in farm buildings. (Farm building heat)				
3. DOMESTIC/AGRICULTURAL INTEGRATION-				
3.1. Replacing mechanical energy by human labour on the farm (Imported commercial farm energy)				
3.2. Reducing food packaging and processing, local products staying in local area. (Energy in food industry)				
3.3. Using existing farm buildings for new dwellings. Local resources rather than imported industrial. (Energy in house construction).				
3.4. Planned casual felling of firewood by individuals (Energy in domestic space heat)				
3.5. Reopened and new peat hags worked by individual families. (Domestic space heat)				

FUTURE

3.6. Biogas plants using human and animal wastes. (Energy for domestic heat and cooking)				
3.7. Straw burning in domestic stoves (Domestic space heat)				
3.8. Renewables in integrated projects, e.g. wind/diesel generation for domestic/ new food processing or refrigeration.(Total rural energy use).				

4. ADDITIONAL IDEAS/COMMENTS-

B. The Second Round.

20/06/1985

Dear

<u>Rural Energy Delphi Survey Robert Gordon s Institute of Technology and the Royal Institution of Chartered Surveyors</u>

Thank you for participating in the first round of our Delphi survey which has provided many very interesting responses

We enclose a copy of round two of the survey and would be very grateful if you could agree to participate again

This round consists of an amended fifty year scenario which goes over the points of the first round incorporating the responses of panelists to try to create a picture with which more people might agree more fully The second part of the documentation is a short series of lists of energy saving possibilities which require ranking in order of importance

Many respondents remarked on the time consuming length and complexity of the first round questionnaire and the approach of asking long lists of questions has been changed in this round to a more descriptive one merely asking for comments on the points with which people disagree

Once again thank you for your interesting first round responses we would be grateful for any comments you have on this round

Yours sincerely

H M Edge

DELPHI ROUND TWO, AMENDED SCENARIO.

INTRODUCTION-

The following scenario has been amended to take account of first round responses. We have attempted not merely to abide by majority opinion on issues, but to seek the underlying reasons behind any disagreement which there might be, and thereby to produce a scenario which incorporates most opinions. We hope that we have achieved this end without producing a watered down, meaningless compromise.

Could you please comment on any item of the scenario which you feel is not the most likely option, and on the scenario as a whole, in the spaces provided on the right hand side. At appropriate points the scenario is interspersed with new questions on issues where no rational conclusion could be drawn which incorporated all of the responses. (Comments can be directed at any point made in the scenario, and need not be restricted to the few questions contained within it.)

1.0 INTERNATIONAL-

The assumption is made that no world war, (or other major war involving the developed nations), occurs.

World economic growth averages around 2%/annum, and drops slightly after 2010, when population growth slows down in most developing countries as the long delayed result of cultural adaptation to rising life expectancy and lower infant mortality. The effects of low growth are offset in some countries by wealth redistribution, but starvation and malnutrition grow as problems throughout the period. The diffusion of new technologies remains selective by area and class, and they solve few of the problems of the poorest countries. Growth begins to be defined in terms of desirable activities in the solving of problems, whilst maximising gross products lowers in relative importance.

China, South East Asia and some countries of Latin America can be defined as parts of the capitalist 'First World' within 50 years, and these countries and the present developed countries still dominate world trade and the economies of the poorer countries. Africa in particular shows little general improvement in living conditions for it's populace, and although much of the more basic manufacturing resides in Third World countries due to the cheapness of labour,more sophisticated new manufacturing, as well as new service industries such as software production, remain within the first world.

Question- An alternative scenario might be the collapse of the First World and its economic system, perhaps through the greater organisation of Third World countries against economic domination by the richer countries, perhaps as a natural result of Third World development leaving no room for exploitation, or through internal problems in the First World, or through major war between the developed nations. Any of these possibilities would obviously change the entire nature of this scenario, could you please comment on the likelihood of a First World collapse of this kind?

Real energy prices rise 2%/annum on average, though after an initial 'oil glut', oil prices rise at 5%/annum after 2000. In some panic over such rises, some countries, notably the U.S.A., subsidise energy prices from time to time, but these market led price rises cannot be arrested, and most countries respond by the encouragement of energy conservation.

Oil substitutes such as Third World produced alcohol, achieve equal status with oil in terms of price and consumption by the end of the period, and these fuels are only used by the military, in aviation, and in a few small, outdated mass transit systems. Such a transformation is aided by a series of breakthroughs in the technology of electrical storage systems.

2.0 EUROPE-

The effects of the E.E.C. grow more far reaching and important to individuals within member countries, though this never goes so far as to surpass the autonomy of individual states, at least in the perceptions of ordinary people.

However, recent growing nationalistic trends, (such as those exhibitted by S.N.P., Plaid Cymru, the I.R.A. and the Basque seperatists), do not abate, and Europe is not a harmonious, benign entity, but one forced to become more important as a prerequisite of self preservation against other power blocks, in spite of opposition from many small, largely peripheral areas. Europe is seen increasingly by most of the Third World as an economically hostile 'rich man's club'.

3.0 NATIONALLY-

3.1 General-

After the year 2000, present arguments about the problems of unemployment begin to lose weight as government and the people are forced into accepting different employment structures. Such solutions as job sharing, short hours working in the home and multiple occupations, begin to bridge the gulf between the 'employed' and the 'unemployed, and to relieve the tedium of long hours in repetitive occupations. 'Work hours' per capita are reduced by some 20%, though such statistics become increasingly more difficult to measure, with people not merely being employed for a wage, but doing work for payment in kind, or work the value of which can only be measured in terms of the savings it generates to the individual.

Thus does 'self-sufficiency' become increasingly more important, not so much in terms of total personal or family autonomy in such matters as food supply, but by the replacement of some specialist wage labour by 'DIY' work at home. Such fields as cheap,recycled components in vehicle maintenance, and the growth of occupant labour in house construction and repair, are able to replace an additional 20% of wage labour. This trend is further encouraged by popular reaction against the increasing specialisation of those people involved in newer technologies such as computer hardware and software, and the fear of over-specialisation.

These changes in the structure of the labour market remove the last effective battle cry of conventional labour politics, the Labour party loses almost all of it's support and is replaced by a Liberal/S.D.P. type of party, whose strength grows, along with smaller nationalist parties, after the electoral reform brought about by it's first government. By the end of the period, Labour party politics are seen as being as far to the left as say, the National Front is to the right.

The State continually withdraws from many areas of it's present concern, particularly service provision which requires State finance, though without relinquishing control over these areas. Privatisation continues apace, with the Welfare State being continually dismantled, particularly as changes in the employment structure take place, though pensions do not suffer as much as other sectors, due to the delayed effects of present unemployment up to 50 years from now.

'Leisure' grows in importance, though it's definition becomes much changed to include the self-financing activities of many people. Leisure facilities are provided more by private than by public funds. Service industries, including non-manufacturing industries such as computer software development, continue to grow in importance compared to manufacturing in the U.K.

The status and representativeness of the standard 'nuclear family' continues to be eroded, it being replaced by wider definitions of family groups, often formed on economic grounds, and not necessarily composed of blood relatives. The economy becomes in many ways based on the activities of these small groups, which tend to restrict their 'social awareness' to within themselves, and grow more isolated and inward looking

<u>Question</u>- Conflict remains amongst respondents, between those who perceive economic growth as a necessary condition for sustainment and change in any society, and those who see the possibility of a healthy, dynamic society without the need for growth, do you see economic growth as a prerequisite of change, or even of stability? Please explain briefly.

3.2 U.K. Energy-

The use of coal increases throughout the period, whilst the use of oil drops. North Sea oil production peaks before 2000, reducing to almost nil by 2034, leaving some very small operations to the west of Shetland as the only U.K. production. The rise in coal use is most dramatic after 2020, as other sources of oil dry up, and oil is only consumed for highly specialised uses by 2034. Continued conservative politics means a relatively large share of the market for nuclear power, particularly fast breeder reactors, in the short term. Fusion does not become commercial by 2034, though there is still much expenditure on it's development, whilst with uranium reserves finite and becoming very expensive, fission is not seen as a permanent solution by anyone. Nuclear fission peaks as a power source around 2020, and therafter begins to run down with the closure of the older plants.

<u>Question</u>- Given that the present nuclear power station capacity, and new capacity planned to 1990 amounts to some 12.5 GW, what would be your estimate of the most likely peak capacity, and the year in which this is most likely to occur?

Conventional thermal electricity generation becomes more efficient throughout the 50 year period, reaching 45% efficiency for the actual generation, (not counting transmission losses). Combined Heat and Power scheme development however, takes the overall average efficiency of primary fuel use in thermal power stations up to 60%.

Electricity use rises slowly, though more quickly towards the end of the period, with the more general introduction of private electric vehicles. The grid system is also adapted towards the end of the period to accomodate fairly large wave and tidal schemes away from large centres of population.

In terms of renewables, breakthroughs in photovoltaic cell manufacture make it the most common alternative source worldwide after 2010, though it is of limited importance in the U.K. A few large schemes are generating electricity from renewables, (excluding large hydro plants), such as the Severn barrage, a major wave power scheme on the west coast of Scotland, and one large wind farm. Most other renewables schemes are small scale however, and largely restricted to the more remote rural areas of Wales, Scotland and parts of Northern England, where small-scale hydro, wind etc. make up some 20% of the total electricity consumed.

Most people's awareness and practice of energy conservation grows considerably as energy prices continue to rise, (a trend which continues, in a perhaps more educated form, the present predilection for hard sell tactics by double glazing companies etc.). Yet in spite of the greater political capital to be gained, energy conservation research and practice is largely restricted to the private sector, in common with many other fields. By the end of the period, micro-electronic control systems are able to save 30% of the energy used for most purposes.

3.3 U.K. Rural-

'Rural districts', as presently defined by the local authority areas, increase their share of total population from 23% to around 40% over 50 years. Only the most isolated of areas see any continued depopulation, whilst rural inmigration affects areas further and further away from present centres of population, largely as a result of changes in employment structure away from the industrial system first introduced in the last century, as detailed in section 3.1. (Obviously by the end of the period, this migration has changed the nature of many areas so that they can no longer reasonably be defined as truly rural).

Though there is attendant friction between incomers and the indigenous population, these definitions become slowly blurred, and friction arises even between the early and late 'newcomers, although no particularly serious problems are caused thereby.

Planning regulations in rural areas become progressively more 'conservative' and conservationalist. I.e. many general restrictions are totally removed, and the emphasis is more on extreme control within well defined areas of varying size, such as the conservation of historic buildings, villages and nature reserves, rather than on more general environmental control. Thus the strong pressure groups and lobbyists, mainly an elite with vested interests in such areas, win the day, and the capitalist market economy is given free rein over most of the rest of land.

As such planning controls are lifted in rural areas, and the need for face-to-face communication in business is reduced due to advances in information technology, many small, high value new industries tend to locate in the rural districts, largely on the grounds of providing a 'better environment' for employees and management. Initially this occurs around major centres of population, but eventually most areas see some influence from this movement.

There is a decline in the level of public service provision in relation to the amount of private and voluntary services, whilst in spite of the large influx of population into many areas, there are generally few more services provided than at present, reflecting new, more individualistic attitudes.

Rehabilitation remains a 'fashionable' and important sector in rural building for some time, particularly in areas where 'recolonisation' occurs later. This predilection for rehab is encouraged both by an irrational preference for the old and 'traditional' in building, and a rational return to the advantages of certain vernacular building techniques blended with new building technology. (Such factors as using smaller windows, and the adaptation of heavy masonry construction to provide Trombe walls being particularly important). This trend is helped further by changes in building society policy which admit to differences in desirability between different building types. However, the slack is soon taken up in terms of building availability, and rehabilitation only becomes the most important housing sector in a few areas for a short time whilst properties are still available.

Although historical trends towards higher car ownership continue for a while, steeply rising oil prices after the year 2000 finally halt this growth and bring a slow but steady downwad trend. Private car ownership is thus slowly replaced after 2000 both by improved forms of information technology,including attendant trends such as working from home, and by a rural 'mass transit' system which is largely privately or community financed, rather than being paid for by public money. Such a system makes use of information technology to create highly efficient forms of car sharing and the flexible timetabling of small, probably electric, buses. Subsidised publicly financed transport is restricted to a minimum skeleton service in those few areas where it still remains uneconomic for transit systems to be privately run.

3.4 U.K. Agriculture-

With the relaxation of planning controls comes a change in the structure of land values, and whilst some agricultural land near major centres of population rises in value with the prospect of possible future development, most land prices remain fairly static or fall slightly with the abatement of speculative 'land fever' and the return to more economic agricultural land values.

Large private estates, though experiencing some continued pressure from death duties etc.,causing some of them to change hands, are rarely split up into smaller units, and there is no particular political pressure to do so. The growth in institutional farm ownership slows down, though such bodies as the pension funds continue to own and manage farms in large numbers, particularly in the more profitable farming areas.

The 'anti-bloodsports' lobby eventually has a considerable effect, if not in terms of legislation then on public opinion, which eventually filters down to the opinions of landowners. This trend is aided by a changing perception of rural communities from idealised static pastoral scenes to dynamic communities, caused by the increasing contact of more and more people with rural life. Thus large estate owners feel the need to diversify away from purely sporting use for land. The landowners can no longer impress their peers with square miles of wilderness, but must be seen to be building local communities through the provision of jobs, services and infrastructure. A great 'improvement' in the management of such estates is therefore seen, in terms of the number and quality of livelihoods they can provide.

Eventually rising costs of energy and fertilizers are reflected in their lower use, enabled by improved crop strains, more complete use of organic fertilizers, and refined management practices with regard to fertilizer application. Chemical fertilizer use is reduced to around 70% of the present level.

Improved strains, the use of more selective pesticides and herbicides, and the more careful monitoring and control of amounts and timing, are able to reduce these inputs down to 50% of the present level, possibly encouraged by some legislative restriction on chemical input.

Areas which have gone over almost wholly to monoculture tend to return somewhat towards mixed farming due to high transport costs and higher emphasis on organic fertilizer use.

Organic farming also grows in importance, all farms becoming more organic by 2034, whilst 10% of farms, whether for truly economic or other reasons, are fully organic by 2034.

Albeit in a small uneconomic way, perhaps in a misplaced idealisation of the 'good life', many people, particularly many rural inmigrants, turn to food production, usually for home consumption. The number of people working their own small plots in this way trebles over 50 years.

Including these owners of small food producing plots, farmers' spouses with an active involvement on the land, part time and seasonal workers, some 15% of all adults have some involvement on the land by 2034. Full time agricultural workers' numbers continue their decline for some time however, eventually climbing slightly and stabilising at more or less present levels.

Current attitudes to perceived food 'overproduction', such as the periodic 'food mountain' scares throughout the E.E.C., die out with both public concern over food shortages worldwide, and the increasing realisation of the power of food as a political weapon in foreign policy. Thus markets are found for surpluses in individual crops, and the need to subsidise these ex-E.E.C. sales is no longer seen as a scandalous waste of resources by the public or by governments, albeit for different reasons. Therefore, present philosophies of producing to meet demand in certain crops dissapear in favour of food value maximisation. Aside from subsidies for export, C.A.P., whilst remaining complex, is seen as being less so by the average farmer, as policies switch to more market orientated ones after 2000.

In spite of these food maximisation philosophies however, only about the same area as today is ploughed in 50 years time, as subsidies for producing crops from marginal land are changed, so that it becomes no more lucrative. Emphasis is more on the better use of the most marginal land for livestock production.

Unlike the situation in many other countries, National Parks are never vested with highly restrictive conservational measures, and they remain conservation areas more in name than in practice. Instead, rigid conservation is restricted to smaller areas such as nature reserves, of which there are considerably more than at present, and S.S.S.I.'s, which become more rigidly conserved than at present. The effect of conservation on farming on a national scale is thus negligible.

Fuel price rises force a considerable move towards energy conservation on the farm. This is brought about both through improved machinery design, in common with sectors outside farming, including the use of more correctly sized machines for the job at hand, and savings through better management, such as the use of multiple implements on single passes over a field, which altogether save not only time, but some 30% of the energy presently used.

<u>Question</u>- Do you feel that the recent economics of farming are likely to continue to lead to greater aggregation of farms, and thus larger units, or that there is likely to be some factor leading to change, i.e. stabilised or lower farm sizes? Please explain your reasons briefly.

COMMENTS-

POTENTIAL SAVINGS IN RURAL ENERGY USE - QUESTIONNAIRE

There follow various lists of potential means of saving and producing energy in rural areas. You are requested to rank the elements of these lists to reflect their potential importance in saving or producing energy used in their particular sector, without necessarily assuming the conditions suggested in the foregoing scenario. (Please rank items 1 to n separately for each table, where item 1 has the greatest potential importance, and item n the least). You are also asked for your comments, including possible means of encouraging the implementation and growth of these measures, (whether it be through legislation, research, education or other means), and the likelihood of their occurrence.

(* Items marked with an asterisk should be considered not only in terms of the savings they might generate in direct rural fuel use, savings of energy used in processing and manufacture, or gains in food energy, should also be considered). Please add to the lists any additional items which you feel are of importance.

TABLE 1

	Ranking (1 - 7)	Comments
ENERGY PRODUCTION IN RURAL AREAS-		
Heat pumps and exchangers.		
Photovoltaic cells.		
Wind farms and other large wind projects.		
Wind and integrated projects (such as wind/diesel), at individual household or farm level.		
Solar water heating.		
Waste digesters producing methane.		
Other biomass.		

Comments - Table 1 ____________________

TABLE 2

	Ranking (1 - 8)	Comments
Sub-list, biofuels-		
Forest thinnings and timber presently left in after felling.		
Planting forestry for fuel.		
Managing farm woodland, hedgerows etc.		
Wet crop residues.		
Planting catch crops.		
Use of straw burning stoves.		
Commercial cutting of peat.		
Working of peat by individual families for their own use.		

Comments - Table 2 ______________________

TABLE 3

	Ranking (1 - 9)	Comments
RURAL DOMESTIC ENERGY USE-		
Insulating to reduce space heat waste.		
Smaller and adjoining new houses.		
More efficient control devices for energy using appliances.		
Voluntary rejection of some imported consumer goods. *		
Energy saving in the home merely by using less.		
Passive solar techniques in new housing.		
Passive solar techniques in rehabilitation		
Rehabilitation of farm buildings and the like. *		
Reducing food packaging and processing, using locally produced food products. *		

Comments - Table 3 ______________________________

TABLE 4

	Ranking (1 - 7)	Comments
AGRICULTURAL ENERGY USE-		
Reduced chemical fertilizer and pesticide use. *		
Less intensive livestock production. *		
Increased farm machinery efficiency.		
Use of multiple implements in one operation on crops.		
Replacing some machinery use with human labour.		
Use of waste machine heat.		
Passive solar techniques in farm buildings, e.g. for crop drying.		

Comments - Table 4 ______________________________

TABLE 5

	Ranking (1 - 4)	Comments
ENERGY IN RURAL TRANSPORT-		
Replacing transport with 'non-physical' forms of communication.		
Use of mobile services.		
Improved private car design.		
Greater use of privately financed mass transit systems.		
Widespread efficient car sharing.		

Comments - Table 5 ______________________________

Could you please also comment on the relative importance of those sectors detailed above in terms of their overall potential for energy saving compared to one another.

TABLE 6

RELATIVE IMPORTANCE OF THE TABLES	Ranking (1 - 5)	Comments
Energy production in rural areas (excluding biofuels).		
Biofuels.		
Rural domestic energy use		
Agricultural energy use.		
Energy in rural transport.		

Comments - Table 6. ______________________________

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Finally, thank you again for your help with our survey, we look forward to receiving your comments on this round.

From-

C. The Third Round.

A66

SCHOOL OF SURVEYING
GARTHDEE
ABERDEEN AB9 2QB
Tel. 0224 33247

ROBERT GORDON'S INSTITUTE OF TECHNOLOGY

HEAD OF SCHOOL:
S. H. BAXTER, FRICS, FIAS, MRSH, CIAgrE.

16/5/1986.

Dear

Rural Energy Delphi Survey.
Robert Gordon's Intitute of Technology
and the Royal Institution of Chartered Surveyors.

Thank you for returning round two of our 'Delphi' survey. We are now able to enclose the third and final round, and would again be grateful for any comments you might have on it. Once again we must apologise for the long delay between rounds, we hope you still feel able to help us.

The round three scenario has been amended to incorporate all second round responses wherever possible. Where it has proved impossible to fit opposing responses into a coherent statement, three different approaches have been taken: in one case several alternative scenarios have been added, elsewhere new questions have been asked, and from time to time individual comments are included anonymously, indented from the main text and in parentheses.

The final section is a summary of responses to the tabulated part of round two, which asked for rankings of various proposals for energy saving and production in rural areas. We would be grateful for any comments you might have on the conclusions drawn here.

Any comments you might have on any part of the scenario,or on the whole content or nature of the survey would be gratefully received,we look forward to hearing from you,

Yours sincerely,

H. Martin Edge.

DELPHI ROUND THREE, AMENDED SCENARIO.

1.0 INTERNATIONAL-

The assumption is made that no world war, (or other major war involving the developed nations), occurs.

World economic growth averages around 2%/annum, (being generally higher in developing than developed countries, though with considerable national differences) , and drops slightly after 2010. Around the same time population growth slows down in most developing countries as the long delayed result of cultural adaptation to rising life expectancy and lower infant mortality. The effects of low growth are offset from time to time in some countries, (depending on the internal politics and external influences by the major powers current at the time), by wealth redistribution, but starvation and malnutrition grow as problems throughout the period. Lack of fuelwood continues to add to problems of desertification in many of these areas. The diffusion of new technologies remains selective by area and class, and they solve few of the problems of the poorest countries. Growth begins to be replaced in public attitudes, and ultimately in some governments' policies, in terms of desirable activities in the solving of problems, whilst maximising gross products beging to lower in relative importance.

South East Asia, some countries of Latin America, and to a lesser extent China, can be defined as parts of the 'First World' within 50 years, and these countries and the present developed countries still dominate world trade and the economies of the poorer countries. Africa in particular shows little general improvement in living conditions for its populace. Although much of the more traditional, lower technology manufacturing, requiring lower levels of quality control, resides in Third World countries due to the cheapness of labour, more sophisticated new manufacturing, as well as new service industries such as software production, remain within the first world.

Following an initial slump, real energy

Prices rise 2%/annum on average, with oil prices rising at 5%/annum after 2010. There is little or no subsidising of oil prices by individual countries, and most countries respond by some legislative encouragement of energy conservation.

Coal liquefaction becomes an important source of high grade energy by the end of the period, whilst other oil substitutes such as Third World produced alcohol, though locally important in countries such as Brazil, with large land areas and low populations, are not significant energy sources internationally.

("Not just Third World alcohol, but also First World, to use up excess grain, sugar beet etc.")

New oil finds are still used for non-substitutable purposes by the end of the period, whilst electric vehicles have only limited impact since there are only a series of small improvements, rather than breakthroughs, in battery storage technology.

2.0 EUROPE-

The effects of the E.E.C. grow more far reaching and important to individuals within member countries, yet the additional powers accorded to the E.E.C. are not so far reaching as to give it greater authority than individual member states over the lives of their citizens.

However, recent growing nationalistic trends, as exhibitted both by accepted political parties such as Plaid Cymru and the S.N.P. and by more controversial bodies such as the I.R.A. and Basque Seperatists, do not abate, Europe is not a harmonious, benign entity, but one forced to become more important as a prerequisite of self preservation against other power blocks, in spite of opposition from many small, largely peripheral areas. Third world attitudes to Europe are mixed, with increasing hostility against those countries which are seen as being closely allied to the U.S.A., but less hostility against Europe as a group of nations, due to the influence of Greece, Spain and Portugal as relatively poor countries within the community.

3.0 NATIONALLY-

3.1 General-

After the year 2000, present arguments about the problems of unemployment begin to lose weight as government and the people begin to accept different employment structures. Such solutions as job sharing, (a scheme to promote which is already being operated by the Department of Employment, but with negligable success), , short hours working in the home and multiple occupations, begin to bridge the gulf between the 'employed' and the 'unemployed, and to relieve the tedium of long hours in repetitive occupations. Moves in this direction are encouraged by a shift in major union policy away from the protection of existing membership and on to job creation. 'Work hours' per capita are reduced by some 20%, (taking account of the increased numbers of retired people), though such statistics become increasingly more difficult to measure, with people not merely being employed for a wage, but doing work for payment in kind, or work the value of which can only be measured in terms of the savings it generates to the individual.

Thus does 'self-reliance' become increasingly more important, not so much in terms of total personal or family autonomy in such matters as food supply, but by the replacement of some specialist wage labour by 'DIY' work at home. Such fields as cheap,recycled components in vehicle maintenance, and the growth of occupant labour in house construction and repair, are able to replace an additional 10% of wage labour. This trend in popular attitudes is countered somewhat by the increasing complexity of much technology, but fueled by a reaction against the increasing specialisation needed to master it.

("Mixing up trends here. Strong current trend to <u>use</u> technologies which are imperfectly <u>understood</u> (by the user). People will swap (barter) specialist skills rather than becoming generalists")

These changes in the structure of the labour market affect the validity of conventional left-wing politics, and the Labour Party is forced to become more centrist to retain their support. The Conservative Party, in spite of periodic internal criticism, remains as far to the right as at present, and the Liberal/S.D.P. parties, though gaining support and becoming a more significant force in Parliament, never gain the status of being the main opposition party. Green party politics grow as a minority force through out the period. The general trend in British party politics is therefore slightly to the right.

The State continually withdraws from many areas of its present concern, particularly service provision which requires State finance, though without relinquishing control over these areas. Privatisation of Publicly owned industry continues, though support for the Welfare State halts the privatisation of these social welfare activities. The effects of an ageing population and changing employment structures mean that pensions are one area of growth in public finance.

'Leisure' grows in importance, though its definition becomes much changed to include the self-financing activities of many people, and the boundaries between work and leisure become increasingly blurred. Leisure facilities are provided more by private than by public funds. Service industries, including non-manufacturing industries such as computer software development, continue to grow in importance compared to manufacturing in the U.K.

Pressured by low economic growth and low employment levels, the concept of 'family' becomes increasingly important, and independence from the extended family becomes increasingly difficult, though a smaller 'counter-culture' of non blood-related groups grows up to counteract this trend slightly. More and more of economic life becomes based on these individual family units.

Comment- On the question of the necessity for economic groth, most respondents see no absolute need. Of those who perceive growth as a necessity, most assert that human beings need to better themselves continually, and that this includes economic advances, and thus infer that society as a unit also needs this. My personal view is that it is wrong to see society as if it were an individual, for it is obviously a group of individuals, each of whom can, due to the mortality of other individuals, become progressively better off economically throughout his life, even in a no growth situation. Indeed

If one's income from school leaving age to retirement increased only at the same rate as the G.N.P., one would certainly be considered to be an economic failure. Though the cultural attachment to individual betterment is a strong one, I imagine that attachment to collective betterment is rather less deeply rooted. Please comment.

3.2 U.K. Energy-

The use of coal increases throughout the period, whilst the use of oil drops. North Sea oil production peaks before 2010, reducing to almost nil by 2044, leaving some very small operations to the west of Shetland as the only U.K. production. The rise in coal use is most dramatic after 2020, encouraged by the perfection and common use of coal liquefaction techniques, as other sources of oil dry up, and oil is only consumed for highly specialised uses by 2044.

Please state which of the following three scenarios for nuclear power seems the most likely, giving your reasons briefly-

1. Continued conservative politics means a relatively large share of the market for nuclear power, particularly fast breeder reactors, in the short term.

2. The aftermath of the Chernobyl disaster creates such public ill feeling about nuclear power that all expansion programmes are halted by 1988, the halt is permanent and there is no replacement of older plants, which are run down more quickly than previously planned.

3. Rising cancer statistics in parts of Europe around 2000 are attributed to nuclear accidents such as Chernobyl, and the European nuclear industry runs down from this point.

Fusion does not become commercial by 2034, though there is still much expenditure on its development, whilst with uranium reserves finite and becoming very expensive, fission is not seen as a permanent solution by anyone. Nuclear fission peaks as a power source around 2015, at a peak capacity of 20 GW, and thereafter begins to run down, with the only new development being the replacement of some older plants.

Conventional thermal electricity generation becomes slightly more efficient throughout the 50 year period, reaching 40% efficiency for the actual generation, (not counting transmission losses). Combined Heat and Power scheme development in limited urban areas, takes the overall average efficiency of primary fuel use in thermal power stations up to 45%.

Electricity use rises slowly, though more quickly towards the end of the period, with the more general introduction of electric vehicles, though these are largely restricted to public transport. The grid system is also adapted towards the end of the period to accomodate a fairly large tidal scheme away from large centres of population.

("Development...(of large renewables schemes)...stimulated by more flexible use of E.E.C. resources through the European grid.")

In terms of renewables, breakthroughs in photovoltaic cell manufacture make it a very important alternative source worldwide after 2020, though it is of practically no importance in the U.K. A few large schemes are generating electricity from renewables, (excluding large hydro plants), such as the Severn barrage and one large wind farm. Most other renewables schemes are small scale however, and largely restricted to the more remote rural areas of Wales, Scotland and parts of Northern England, where small-scale hydro, wind etc. make up some 20% of the total electricity consumed. The use of wood as a fuel also grows considerably in these areas.

Most people's awareness and practice of energy conservation grows considerably as energy prices continue to rise, (a trend which continues, in a perhaps more educated form, the present predilection for hard sell tactics by double glazing companies etc. As this trend continues and demand for energy saving products increases, growth in research and development is largely taken up by the private sector, with the role of Government funding little different from the present. By the end of the period, micro-electronic control systems are able to save 25% of the energy used for most purposes.

3.3 U.K. Rural-

'Rural districts', as presently defined by the local authority areas, increase their share of total population from 23% to around 33% over 50 years. Only the most isolated of areas see any continued depopulation, whilst rural immigration, though affecting areas in the South East of England the most, eventually affects areas further and further away from present centres of population, largely as a result of changes in employment structure and advances in information technology. This new rural population concentrates largely around existing village communities and small market towns, and housing remains at fairly high densities rather than being scattered. The new housing development needed for such an influx takes some of the impetus away from urban renewal. (Obviously by the end of the period, this migration has changed the nature of many areas so that they can no longer reasonably be defined as truly rural).

Though there is attendant friction between incomers and the indigenous population, these definitions become slowly blurred, and friction arises even between the early and late 'newcomers, although no particularly serious problems are caused thereby.

Planning regulations in rural areas become progressively more 'conservative' and conservationalist. I.e. many general restrictions are totally removed, and the emphasis is more on extreme control within well defined areas of varying size, such as the conservation of historic buildings, villages and nature reserves, rather than on more general environmental control. Thus the strong pressure groups and lobbyists win the day, and the market economy is given a more free rein over most of the rest of land.

("There are present trends in this direction, but this would represent a failure of social organisation. There is a need to establish mechanisms capable of resolving conflicts of non-market values.......Attempts to tackle this issue to date have simply led to bureaucratic inertia.")

("I would have thought that the pressure in favour of this change would be exceeded by the pressure to oppose such relatively uncontrolled development.")

("Don't agree. Increased concern over the effects of human pressures on ecological processes rather than 'landscapes' will force improved control of land use.")

As such planning controls are lifted in rural areas, and the need for face-to-face communication in business is reduced due to advances in information technology, some small, high value new industries tend to locate in the rural districts, largely on the grounds of providing a 'better environment' for employees and management. Initially this occurs around major centres of population, particularly in the South East of England, but eventually most areas see some influence from this movement, albeit a small one in the more remote areas.

There is a decline in the level of public service provision in relation to the amount of private services, whilst in spite of the large influx of population into many areas, there are generally few more services provided than at present, reflecting new, more individualistic attitudes.

Rehabilitation remains a 'fashionable' and important sector in rural building for some time, particularly in areas where 'recolonisation' occurs later. This predilection for rehab is encouraged both by a subjective preference for the old and 'traditional' in building, and a rational return to the advantages of certain vernacular building techniques blended with new building technology. (Such factors as using smaller windows on all but the south face of a building, and the adaptation of heavy masonry construction to provide Trombe walls being particularly important). This trend is helped further by changes in building society policy which admit to differences in desirability between different building types. However, the slack is soon taken up in terms of building availability, and rehabilitation only becomes the most important housing sector in a few areas for a short time whilst properties are still available.

Historical trends towards higher car

ownership continue for a while, with cars becoming increasingly smaller and more energy efficient, eventually at the expense of performance, steeply rising oil prices after the year 2010, together with gradual attitudinal changes which no longer stress private transport as an essential status symbol, finally halt this growth and bring a slow but steady downward trend after 2020. Private car ownership is thus slowly replaced both by improved forms of information technology, including attendant trends such as working from home, and by a rural 'mass transit' system which is increasingly privately or community financed for short distance travel, rather than being paid for by public money. Such a system makes use of information technology to create highly efficient forms of car sharing and the flexible timetabling of small, probably electric, buses. Subsidised publicly financed transport is restricted to a minimum skeleton service in those few areas where it still remains uneconomic for transit systems to be privately run.

3.4 U.K. Agriculture-

Question- There remains much disagreement as regards agriculture, based on total amounts of U.K. food production. Many respondents argue, on the basis of surpluses of certain foods, that Britain produces a food surplus, and that we should be cutting back on agricultural production, even in the long term, at the same time saying that Third World countries should not rely on food imports, (even, in some cases, if they have the industrial wherewithal to pay for them). Others argue from the basis that agricultural production must be maximised to meet future world shortfalls, presumably aiming at a position where the U.K. produces enough 'gross food value' to feed itself. This issue colours people's reactions to all other agricultural parts of the scenario, please comment.

With the relaxation of planning controls comes a change in the structure of land values, and whilst some agricultural land near major centres of population rises in value with the prospect of possible future development, 'building land' as such can no longer command such high prices. Most land prices remain fairly static or fall slightly before 2000, with the abatement of speculative 'land fever' and the return to agricultural land values based more accurately on potential agricultural production. Ultimately however, land remains an inflation proof investment.

Large private estates, though experiencing some continued pressure from death duties etc., causing some of them to change hands, are rarely split up into smaller units, and there is no particular political pressure to do so, though there is some slight economic pressure from the influx of new rural residents. The growth in institutional farm ownership slows down, though such bodies as the pension funds continue to own and manage farms in large numbers, particularly in the more profitable farming areas.

With more people moving into rural areas, 'environmental' opinion sees the countryside less as a static landscape and more as a community with similar needs to other communities. Thus those estate owners who presently under utilise their resources are encouraged to fall into line with the better estates and concentrate on building employment etcetera in the community. A thriving local economy is seen as being more important than a thriving grouse shoot. Of course improvements which can be made in this direction are dependant both on land quality and the efforts which have already been made to create a diverse employment structure.

Eventually rising costs of energy and fertilizers, as well as increasingly hostile public opinion against farm chemical use, are reflected in their lower use, enabled by improved crop strains, more complete use of organic fertilizers, and particularly refined management practices with regard to fertilizer application. Chemical fertilizer use is reduced to around 80% of the present level.

("It is difficult to see this, better strains can be more productive largely because they can use more fertilisers. Fertiliser has dramatic effects on output.")

Improved strains, the use of more selective pesticides and herbicides, and the more careful monitoring and control of amounts and timing, are able to reduce these inputs down to 60% of the present level, possibly encouraged by some legislative restriction on chemical input induced by 'pesticide incidents'.

Areas which have gone over almost wholly to monoculture tend to return somewhat towards mixed farming due to high transport costs, higher emphasis on organic fertilizer use, pressure from public ecological opinion and changes in the structure of C.A.P. subsidies. This trend is somewhat restricted however by some changes in dietary habit away from meat consumption.

Organic farming also grows in importance, all farms becoming more organic by 2034, whilst 10% of farms, whether for truly economic or other reasons, are fully organic by 2034.

("Organic farming cannot really become significant.")

Albeit in a small uneconomic way, in a perhaps misplaced idealisation of the 'good life', some people, particularly many rural immigrants, turn to food production, usually for home consumption. The number of people working their own small plots in this way doubles over 50 years.

Including these owners of small food producing plots, farmers' spouses with an active involvement on the land, part time and seasonal workers, some 10% of all adults have some involvement on the land by 2034 This trend is added to by a movement towards increasing farmers' margins by increasing on-farm processing of products, thus more people are involved in farming without necessarily working 'on the land'. In this way the decline in the number of full time agricultural workers is halted by 1995, thereafter the numbers increase slightly.

Only about the same area as today is ploughed in 50 years time, as subsidies for producing crops from marginal land are changed, so that it becomes no more lucrative. Emphasis is more on the better use of the most marginal land for livestock production.

Unlike the situation in many other countries, National Parks are never vested with highly restrictive conservational measures, and they remain conservation areas more in name than in practice. Instead, rigid conservation is restricted to smaller areas such as nature reserves and S.S.S.I.s, which become more rigidly conserved than at present. Other areas become subject to new classifications such as 'Environmentally Sensitive Areas', administered by M.A.F.F. and D.A.F.S. under E.E.C. agricultural structures regulations. However the effect of conservation on farming on a national scale is little more than negligible except through the voluntary action of some farmers. Forestry becomes seen as more compatible with the aspirations of environmentalists, and some growth is seen in the uplands.

Fuel price rises force a considerable move towards energy conservation on the farm. This is brought about both through improved machinery design, in common with sectors outside farming, including the use of more correctly sized machines for the job at hand, and savings through better management, such as the use of multiple implements on single passes over a field, which altogether save not only time, but some 25% of the energy presently used. There is also a greater awareness of intensive building energy costs, and whilst many farmers concentrate on energy saving and the use of renewables, others abandon intensive animal rearing techniques altogether.

There remains considerable divergence in farm sizes, with no increase in size of the largest units, but some amalgamation of smaller and medium sized units and a larger number of very small units. Larger farms tend to become more internally diverse. Economically the larger units do grow however, as other food processing functions are adopted by farmers and the boundary between farming and the rest of the food industry becomes increasingly blurred.

("Not enough account has been taken of the potential of factory food production. The technology of bioengineering and controlled environment is taking us there, so that it will become economic to produce raw material in 'growth units' for the food manufacturing industry.")

There follows a general description of some of the results of the tabulated part of round two, which asked for your response to various proposals for future savings and production of energy in rural areas. In this section the majority view is recorded, if you disagree with any points could you please give brief reasons.

On energy production in rural areas, though agreement is by no means unanimous, there is generally higher confidence in small scale projects (particularly integrated wind projects and heat pumps and exchangers) and to a lesser extent biomass. There is little confidence in the future of methane production from waste, or photovoltaics.

The types of biofuels which are seen as having the most potential are new forestry plantations, straw burning, peat cutting and forest thinnings.

In domestic energy use insulation standards, passive solar design (in new housing rather than retrofit), and micro-electronic control devices are seen as having the greatest potential, whilst the building of smaller homes, direct energy saving without any technological change, and particularly the voluntary rejection of consumer goods are seen as non-starters.

Reductions in intensivity are seen as the best energy savers in agriculture, both by moving away from intensive animal rearing and the reduction of field chemical inputs. The replacement of some machinery by human labour, on the other hand, is rejected by nearly everyone.

In rural transport, avoiding the need to travel is seen as a better solution than making travel more efficient. Most respondents giving the replacement of travel by non-physical forms of communication, and the use of mobile services, higher priority than more efficient mass transit or car sharing.

In general, energy saving in the home and in agriculture, are seen as having greater potential than energy production in rural areas, with savings in domestic energy use at the top of the list and renewables given far less confidence, even by those whose specialist field is in renewables. Energy in transport is seen as the least important sector.

APPENDIX 4, TELEPHONE QUESTIONNAIRES OF FUEL SUPPLIERS.

Ref.

A81

RURAL ENERGY PROJECT-PILOT QUESTIONNAIRE, DOMESTIC AND AGRICULTURAL FUEL OILS

COMPANY NAME
AND ADDRESS ....
(Please alter.... ....
if incorrect)

1. Does your company supply domestic heating and/or agricultural fuel oils for use in rural areas [ ] YES [ ] NO

2. Could your company make available any information on amounts of oil handled. [ ] YES [ ] NO

3. If YES, would such information be in the form of-

   Accounts of amounts delivered to individual customers [ ]

   Aggregated deliveries by area/delivery route [ ]

   Other (please specify)...
   ....

4. Would a full year's information be available. [ ] YES [ ] NO

5. Approximately what area do your deliveries mainly cover.
(Please state main area/villages)
(and mark on accompanying map) ....
....

6. Do you consider that you are the only major supplier in this area. [ ] YES [ ] NO

   If NO, please list briefly other suppliers

   ....

7. Do you also deal with the delivery of fuel to filling stations [ ] YES [ ] NO

8. If YES, would any information be available on amounts of petrol and diesel delivered to these filling stations [ ] YES [ ] NO

9. Which oil company do your supplies come from.

   ....

10. If you are prepared to let me have any information, please state when and where I might have access to it.

   ....

   ....

Ref.

RURAL ENERGY PROJECT- PILOT QUESTIONNAIRE, COAL MERCHANTS A82

COMPANY NAME
AND ADDRESS ....
(Please alter ....
if incorrect)

1. Could your company make available any information on fuel deliveries and/or sales — YES [ ] NO [ ]

2. If YES, would such information be in the form of-

Accounts of deliveries to individual customers [ ]

Aggregated deliveries by area/delivery route [ ]

Other (Please specify) ....

....

3. Would a full year's information be available — YES [ ] NO [ ]

4. What area do you mainly cover in your deliveries
(Please specify area/villages)
(and mark on accompanying map) ....

....

5. Are you the only major supplier of coal to that area — YES [ ] NO [ ]

If NO, please list other suppliers ....

....

6. Approximately what proportion of your sales are made up of direct sales without delivery ....

7. Do you supply fuels other than coal-

Peat [ ] Domestic heating oil [ ] Bottled gas [ ]

Firewood [ ] Other (Please specify) ....

8. Would information be available on the delivery and sales of these fuels — YES [ ] NO [ ]

9. If you can make any information available, please state when and where I might have access to it ....

....

Ref.

RURAL ENERGY PROJECT-PILOT QUESTIONNAIRE, PEAT SUPPLIERS A83

COMPANY NAME ....
AND ADDRESS
(Please alter ....
if incorrect)

1. Does your company supply any peat for fuel

- [x] YES
- [ ] NO

2. If YES, is this carried out by- Direct sale from your premises only [x]

Direct sale and delivery [ ]

3. Could your company make available any information on the amounts of peat sold

- [ ] YES
- [x] NO

4. If YES, would such information be in the form of-

Accounts of total amounts sold on the premises ____

Accounts of deliveries to individual customers ____

Other (Please specify) ....
....

5. Would a full year's information be available

- [ ] YES
- [ ] NO

6. If you do make deliveries, what area do you mainly cover
(Please specify area/villages)
(and mark on accompanying map) ....
....

7. Are you the only major supplier of peat to that area

- [ ] YES
- [ ] NO

If NO, please list other suppliers ....
....

8. If you can make any information available, please state when and where I might have access to it ....
....

Ref.

RURAL ENERGY PROJECT-PILOT QUESTIONNAIRE, FUELWOOD SUPPLIERS A84

COMPANY NAME ....
AND ADDRESS
(Please alter ....
if incorrect)

1. Does your company supply any wood for fuel ☐ YES ☐ NO

2. If YES, is this carried out by- Direct sale from your premises only ☐
Direct sale and delivery ☐

3. Could your company make available any information on the amounts of firewood sold ☐ YES ☐ NO

4. If YES, would such information be in the form of-
Accounts of total amounts sold on the premises ☐
Accounts of deliveries to individual customers ☐
Other (Please specify) ....
....

5. Would a full year's information be available ☐ YES ☐ NO

6. If you do make deliveries, what area do you mainly cover
(Please specify area/villages) ....
(and mark on accompanying map) ....

7. Are you the only major supplier of fuelwood to that area ☐ YES ☐ NO

If NO, please list other suppliers ....
....

8. If you can make any information available, please state when and where I might have access to it ....
....

Ref. A85

RURAL ENERGY PROJECT-PILOT QUESTIONNAIRE. BOTTLED GAS SUPPLY

COMPANY NAME .. ..
AND ADDRESS ....
(Please alter
if incorrect)

1. Does your company supply bottled gas for domestic, industrial or agricultural use in the rural areas. ☐ YES ☐ NO

2. If YES, is this carried out by- Direct sale from your premises only. ☐
   Direct sale and some delivery. ☐

3. Could your company make available any information on the amounts of gas sold. ☐ YES ☐ NO

4. If YES, would such information be in the form of-
   Accounts of total amounts sold on the premises ☐
   Accounts of deliveries to individual customers ☐
   Other (Please specify) ....
   ....

5. Would a full year's information be available ☐ YES ☐ NO

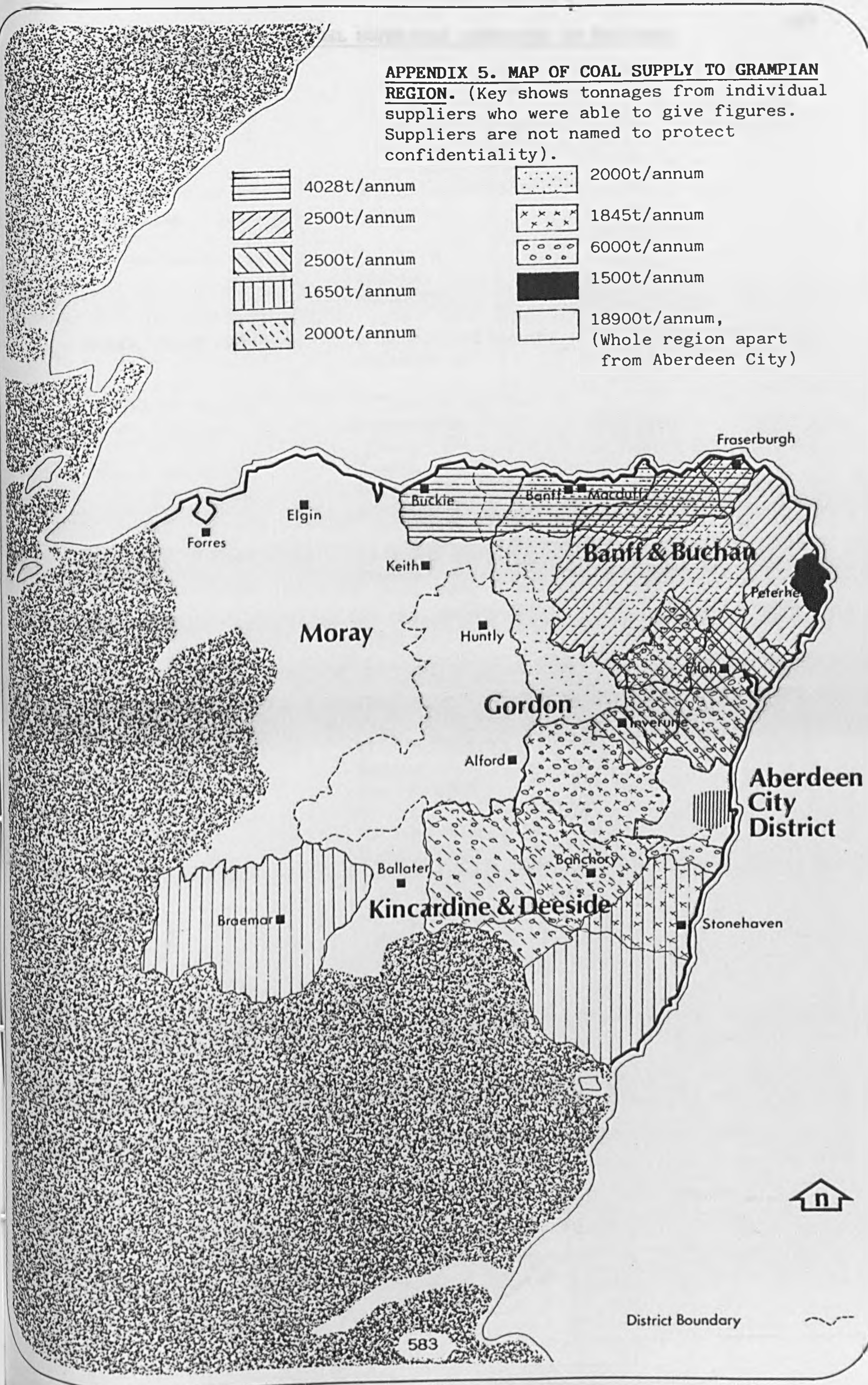
6. If you do make deliveries, what area do you mainly cover.
   (Please specify area/villages) ....
   (and mark on accompanying map) ....

7. Are you the only major supplier of gas within this area. ☐ YES ☐ NO

   If NO, please list other suppliers ....
   ....

8. If you can make any information available, please state when and where I might have access to it ....
   ....

APPENDIX 5. MAP OF COAL SUPPLY TO GRAMPIAN REGION. (Key shows tonnages from individual suppliers who were able to give figures. Suppliers are not named to protect confidentiality).



APPENDIX 6, LIST OF FUEL SUPPLIERS CONTACTED IN REGIONAL SUPPLY SURVEY.

1. COAL-

NAME	ADDRESS	HARD DATA AVAILABLE
National Coal Board Marketing Department	349 Union Street Aberdeen	yes
George Duncan	Coalyard Deebank Banchory	yes
Smith, Hood and Co.	6 Market Buildings Stonehaven	yes
D. and W. Taylor	17 Market Square Stonehaven	yes
Connon Brothers	Newark Pipeworks Tipperty Ellon	yes
G. and C. McConnachie	19 Torry Road Huntly	no
J. McIntosh	15 Main Street Rhynie	no
Duguid and Masson	32 Skene Street Macduff	no
W. Ironside and Sons	Findon Smithie Gamrie Gardenstown	yes
J.V. Milne	Mill of Millfield Monquhitter Cuminestown	yes
T. and K. Neilson	10 Loch Street Rosehearty	no
J. Sheran and Co.	Station Yard Maud	yes
Ellis and McHardy	Leith House 3 Bedford Road Aberdeen	yes
Aberdeen Coal and Shipping Co. Ltd.	Albert Quay Aberdeen	yes
Adam Bros. Coal	Albert Quay Aberdeen	no

W.H. Cook	Mugiemoss Road Bucksburn	yes
Alex Noble and Sons	Girdleness Road Aberdeen	no

2. WOOD-

Forestry Commission East (Scotland) Conservancy	6 Queens Gate Aberdeen	yes
George Burr	North Cookney Newtonhill	yes
J. Cordiner and Son	Silverbank Sawmills Banchory	no
William Gray and Co.	Carve Cottage Dinnet	no
Jones, Jones and Sons	Burnroot Sawmill Aboyne	no
J. Melvin	8 Woodlands Durris	yes
H. Ewen	Marionburgh Sauchen	no
J.B. Middleton	Lodge of Auchindoir Lumsden	yes
G.M. and D.A. Moir	Sonach Croft Tarves	no
Moirs Timber Products	Cloisterseat Croft Udny	no
Colin C. Scott	Monteach Mills Methlick	no
C. Smith	Ordbrae Huntly	no
Waterside Sawmill	Bridge of Alford	no
Buchan Timber Co.	Coldwells Longhaven Peterhead	no
William Gray and Co.	Victoria Sawmills Albert Street Frazerburgh	no

K.A. Walker	9 Gellymill Street Macduff	no
Brownlees	Bridge of Don Aberdeen	no
G. Carle and Son	Heatherdale Mosside Parkhill Dyce	no
J. Fleming and Co.	2 Baltic Place Aberdeen	no
E.J. Foote	Persley Castle Sawmill Woodside Aberdeen	no
H. Petrie	Glassieburn Cottage Scotstown Aberdeen	no
D. Rattray	Parkhill Station Dyce	no
John Woyka and Co.	Balgownie Road Bridge of Don Aberdeen	no
Redwing Firewood	Eastland Lodge Maryculter	yes
G. Melvin	Drumoak	no

3. BOTTLED GAS-

Calor Gas Ltd. Scottish Region	Friarton Perth	no
Dee Valley Caravans	Drumoak	yes
Stonehaven Motors	110 Barclay Street Stonehaven	yes
J. Cruickshank and Son	30 The Square Huntly	yes
Methlick Motors Ltd.	Methlick Ellon	yes
T. Murison	59 Cross Street Frazerburgh	no

W.T.B. Thomson	9 Skene Street Macduff	no
Ellis and McHardy	Leith House Bedford Road Aberdeen	no
Gas and Equipment Ltd.	Greenbank Road Aberdeen	no
Willowbank Gas Supplies	56 Park Road Aberdeen	no
Aberdeen Calor Centre	Wellheads Industrial Estate Dyce Aberdeen	no
C. Frazer, Nigg Caravans	Altens Road Aberdeen	no
A.C. Cruickshank	Red House Service Station Ellon	no
J.R. Duguid Equipment	83 Station Road Ellon	no
County Garage	99 Station Road Ellon	no
Pitmedden Garden Centre	Oldmeldrum Road Pitmedden	no

4. PEAT-

Dr. R.A. Robertson	Department of Peat and Forest Soils Macaulay Institute for Soil Research Craigiebuckler Aberdeen	no
The Northern Peat and Moss Co. Ltd.	Cairngall Longside Peterhead	no
Herbst Peat and Energy Partnership (Scotland)	Blackhills Rora Longside Peterhead	no

5. OIL-

United Kingdom Petroleum Industry Association Ltd. Economics and Statistics Group	Room 0320 BP House Victoria Street London SW1E 5NJ	yes
The Institute of Petroleum	61 New Cavendish Street London W1M 8AR	yes
Mr. Alex Scott, Department of Energy Economics and Statistics Division	Thames House South Millbank London SW1P 4QJ	yes
Mr Keith Clifton Southwark Computer Services Ltd.	1 Farnham Place London SE1 ONA	yes
Conoco (UK) Ltd.	Rubislaw House Anderson Drive Aberdeen	no
Chevron Petroleum UK Ltd	Ninian House Crawpeel Road Altens Aberdeen	no
Shell UK Ltd.	123/157 Bothwell Street Glasgow	no
BP Oil Ltd.	33 Bothwell Street Glasgow	no
Texaco Ltd.	Product Distribution Department South Esplanade East Aberdeen	no
ICI Area Sales Office	4 Blythwood Square Glasgow	no
Esso Petroleum Co.	Abbey Road Aberdeen	no
North Eastern Fuels	Head Office Bannermill Aberdeen	yes
James Milne and Sons	17 Seagate Inverurie	no
Gordon and Innes Ltd.	46 Gordon Street Huntly	no

Caley Oils (Peterhead)	12 Harbour Street Frazerburgh	no
Northern Engineering and Oil Co.	4 Balaclava Frazerburgh	no
John A. Smith and Sons	11 Seagate Peterhead	no
Mitchells Oils	The Harbour Crook O'Ness Street Macduff	no
Mackie Oild Ltd	Mintlaw Station Mintlaw	no
Ellis and McHardy	3 Bedford Road Aberdeen	yes
Woodacon Oild (Aberdeen Ltd)	167 Sinclair Road Torry Aberdeen	no
Regency Oils	Marine Place Buckie	no
Gleaner Oils	Elgin	no
Highland Fuels	Inverness	no

6. NATURAL GAS-

Scottish Gas	Regional Headquarters Office Granton House 4 Marine Drive Edinburgh	no

7. ELECTRICITY-

North of Scotland Hydro-Electric Board Area Commercial Manager	Aberdeen Area Office Millburn Street Aberdeen	yes

APPENDIX 7. PILOT DOMESTIC AND AGRICULTURAL QUESTIONNAIRES.

THE ROYAL INSTITUTION OF CHARTERED SURVEYORS
and
ROBERT GORDON'S INSTITUTE OF TECHNOLOGY

RURAL ENERGY USE SURVEY

Household Survey

GRID REFERENCE [, ,]

DWELLING REFERENCE [ ]

FARM REFERENCE [ ]

ADDRESS ....

....

NAME OF HEAD OF HOUSEHOLD ....

1. How many people normally live in this house? (Flat?) [ ]

2. Please list each person giving their age, sex, relationship to the head of the household, occupation, and how far they each have to travel to work, school or college (one way), each day-

PERSON No.	AGE GROUPING 0-4	5-11	12-16	17-24	25-64	65+	SEX M	F	RELATIONSHIP TO HEAD OF HOUSEHOLD		OCCUPATION		TRAVEL TO WORK (MILES)
	1	2	3	4	5	6	1	2		Code		Code	
01									Head of household	1			
02													
03													
04													
05													
06													
07													
08													

A96

3. How long have you lived here?

3.1. In the Region?

Moved to North East in last 5 years	☐	1
Moved to North East at some time	☐	2
Born in North East, moved back after at least 2 years absence (excluding as a student)	☐	3
Always lived in the North East	☐	4

3.2. In the Locality? (within 10 miles)

Moved here in the last 5 years	☐	1
Moved here at some time	☐	2
Born here, moved back after at least 2 years absence (excluding as a student)	☐	3
Always lived here	☐	4

4. How long ago did you move to this house?

0-1 years	1-2 years	2-5 years	over 5 years
☐	☐	☐	☐
1	2	3	4

5. Is your house-

Detached?	☐	1
Semi-detached or end terrace?	☐	2
Terraced?	☐	3
A flat?	☐	4

6. How many floors does the house have?

7. Are You-

The owner occupier?	☐	1
Renting from the Council?	☐	2
Renting from a private landlord?	☐	3

8. Which of the following facilities does your house have?

- Mains electricity
- Mains water
- Mains drainage
- Bathroom
- W.C.
- Telephone

(0 or 1)

9. Apart from Kitchen, Bathroom and Storage rooms, how many rooms does your house have?

10. Some details about the basic construction of your house-

10.1. Wall construction- 1. Inner skin-

Stone	1
Brick or Blockwork	2
Wood frame	3

2. Outer skin-

Stone	1
Brick or Blockwork	2
Wood Frame	3

3. Wall thickness in millimetres-

10.2. Roof construction-

Flat	1
Pitched	2

Slate	1
Tile	2
Asbestos	3
Felt	4
Corrug. Iron	5

10.3. Floor Construction-

Suspended timber	1
Concrete	2
Both	3

11. Please give details of any insulation you have in your-

Roof YES 1

NO 0

Thickness in Millimetres

TYPE

....

Walls YES 1

NO 0

Thickness in Millimetres

TYPE

....

12. Are there any features of your house which you would like to improve? YES 1

NO 0

If YES, Please give some details-

....

....

13. Have you ever received grant aiding for any improvements to your house?

A98

YES [ ] 1
NO [ ] 0

If YES, Please give some details

....

....

14. (Ask all EXCEPT full-time farmers) About how much land, in acres, do you own or have the long term lease of?

Total Acres

No. of plots

Grid references of plots not around the dwelling ....

To what uses is this land put? ....

....

15. Please give details of any outhouses you have on your land, their location, use and approximate size-

	1	2	3	4	5	6	
Location							Grid Ref
Use							Use Code
Dimensions							Size M^2

16. Could you tell me about how much of these different types of fuel you have used in the past year for these different purposes, and about what price you have to pay for them at the moment?

	FUEL TYPE	UNIT	PRICE/ UNIT	HEAT	COOK	POWER + LIGHT	TOTAL	OCCASIONAL USE ONLY	TOTAL FREE RESOURCE
01	Mains Electricity								
02	Generator Electricity								
03	Mains Gas								
04	Bottled Gas								
05	Coal								
06	Smokeless Fuel								
07	Peat (Bought)								
08	Peat (Home Cut)								
09	Wood (Bought)								
10	Wood (Home Cut)								
11	Heating Oils								
12	Parafin								
13	Other								
				0 or 1	0 or 1	0 or 1		0 or 1	

17. Do you burn any of your household waste as fuel?

None [ ] 0
Under 10% [ ] 1
11 to 50% [ ] 2
50 to 100% [ ] 3

18. How many open fires do you have in your house? A99 ☐

and how many would you say you used for a large part of the year? ☐

19. Do you have a solid fuel burning stove for cooking purposes?

YES ☐ 1
NO ☐ 0

If YES, Do you use it-

Always ☐ 1
Occasionally ☐ 2
Winter Only ☐ 3
Never ☐ 0

20. What kind of central heating, if any, does your household have?

None ☐ 0
Oil fired ☐ 1
Solid fuel ☐ 2
Gas ☐ 3
Electric storage ☐ 4

21. If you have ever considered changing the type of heating you use in your house, please state what you considered changing to- ....

....

22. If you know, could you please tell me about how old the main part of your house is?

0-5 years ☐ 1
5-20 years ☐ 2
20-40 years ☐ 3
40-70 years ☐ 4
over 70 years ☐ 5
Dont Know ☐ 0

23. How many, if any, of the following does your household have at the moment?

Private cars ☐
Cars or vans also used for business ☐
Motorcycles ☐

24. Do you think that there is any more scope for you to save money on fuel by using fuels which you could provide yourself without having to pay for them?

YES ☐ 1
NO ☐ 0

Please explain the opportunities and constraints- ....

....

....

25. Do you consider there to be any problems in the supply of fuels to your area?

YES ☐ 1
NO ☐ 0

If YES, Please explain what these are- ....598..........................

....

26. Have you ever considered using any alternative types of energy such as- A100

Wind

Hydro

Solar

Methane

None

(0 or 1)

If YES, Please give more details- ....

....

27. Could you please state whether you think that the following suggested trends for the next 10 years are likely or unlikely-

		Likely	Unlikely	Dont Know
01	Rising oil prices	1	2	0
02	Falling oil prices	1	2	0
03	Return to using more coal	1	2	0
04	Mains gas to most villages	1	2	0
05	More use of electricity	1	2	0
06	More use of wood for burning	1	2	0
07	More use of peat	1	2	0
08	Greater use of wind power	1	2	0
09	Greater use of solar power	1	2	0
10	greater use of small 'hydro' plants	1	2	0
11	Greater use of methane	1	2	0
12	Generally rising cost of living	1	2	0
13	Falling cost of living	1	2	0
14	Stable cost of living	1	2	0
15	Spread of computers to most homes	1	2	0
16	A change of Government at the next election	1	2	0

28. Generally, how much do you feel that your area relies on support from, and trade with other areas?

Very Much 1

A Little 2

Not at all 3

Dont Know 0

29. In terms of fuel supply, if all trading between your locality and elsewhere were to stop, do you think that the village could adjust to providing from local resources-

Easily 1

With a few difficulties 2

With considerable hardship 3

Not at all 4

Dont Know

30. The North of Scotland Hydro-electric Board have agreed to let me see their records for the amount of electricity consumed by the people I am interviewing, provided that they all agree. So I would be grateful if you could sign the attached form allowing me to do this. Your records will be treated in the strictest confidence, and no amounts will appear in my report other than those which have been added up for the whole area. Thank you for your help.

A101

THE ROYAL INSTITUTION OF CHARTERED SURVEYORS
and
ROBERT GORDON'S INSTITUTE OF TECHNOLOGY

RURAL ENERGY USE SURVEY

Agricultural Holdings Survey

GRID REFERENCE [, ,]

FARM REFERENCE [ ]

DWELLING REFERENCE [ ]

ADDRESS ....

....

NAME OF FARMER ....

---

1. Is your farm-

Owner occupied?	[ ]	1
Rented from an estate?	[ ]	2
Rented from a company?	[ ]	3
Managed for the owner?	[ ]	4

---

2. If not owner occupied, what is the owner's-

NAME ....

and ADDRESS ....

....

---

3. How many acres do you farm here?

And could you please mark your boundaries on the accompanying map.

satisfactory	rough	not completed
[ ]	[ ]	[ ]
1	2	0

4. Do you have any other holdings?

YES [ ] 1

NO [ ] 0

If yes, please give some details-

	1	2	3	4	
ACREAGE					Acres
LOCATION					Grid
OWNERSHIP					Ref

5. Total acreage of all holdings-

6. How many people (other than yourself), do you employ on your farm?

Full time

Part time

Hours/week part time

7. Could you please give me some details about the amounts of land you use for different purposes on the farm, and land improvements?

		ACRES	YIELD RANGE	code	ACRES IMPROVED LAST 10 YEARS	ACRES IMPROVABLE WITH NO CONSTRAINTS
1	Rotational arable land					
2	Inbye fenced grassland not ploughed in the rotation					
3	Hill land/rough grazing forming part of the farm					
4	Hill land/rough grazing forming part of a commonty or common grazing					
5	Productive forestry					
6	Woodlands not managed for timber					
7	Roads and buildings					
8	Other					

8. How many of the following do you normally run on the farm?

1 Ewes

2 Beef cattle

3 Dairy cows

4 Poultry

5 Pigs

If POSITIVE answers to 3, 4, or 5, please indicate the systems followed for-

Dairy cows ....

Poultry ....

Pigs ....

A103

9. Do you run any other enterprises of any kind (whether agricultural, sporting, tourist or other)?

YES [ ] 1

NO [ ] 0

If YES, please give some details- ....

....

10. Where do you market, and how many have you sent to market in the past year, of the following?

		MARKET	code	NUMBER	code
CATTLE	Stores				01
	Cast cows				02
	Fat stock				03
SHEEP	Store lambs				04
	Fat lambs				05
	Cast ewes				06
POULTRY					07
PIGS					08
GRAIN	Oats				09
	Barley				10
VEGETABLES (Specify)					1_
....					1_
OTHER (Specify)					2_
....					2_

11. Where do you normally purchase, and how much have you purchased in the past year, of the following?

	SOURCE	code	AMOUNT	code
CONCENTRATE FEEDSTUFFS				01
HAY				02
STRAW				03
FERTILIZERS (BY TYPE)				1_
....				1_
....				1_
....				1_

12. Could you please give me some details of the farm buildings that you have? A104

	01	code	02	code	03	code	04	code	05	code	
USE											code
DIMENSIONS	x		x		x		x		x		m^2
CONSTRUCTION Walls											code
Roof											code
INSULATION Walls											0 or 1
Roof											0 or 1
AGE											years
HEATING APPLIANCE											code
TYPE OF HEATING FUEL											code
AMOUNT USED/ ANNUM											unit code/amount
LIGHTING HOURS/DAY											hours
LOCATION											grid ref.

13. Could you please list the different types of plant that you have on the farm and give me some details about it?

			MAKE	code	MODEL	code	HORSEPOWER	FEATURES	code	AGE	FUEL USE	unit code
01	TRACTORS	01 02 03 04 05										
02	COMBINES	01 02										
03	BALERS	01 02										
04	ROAD VEHICLES (Trucks, vans etc except listed family cars)	01 02 03 04 05										
05	GENERATORS	01 02 03										
06	PUMPS	01 02										
07	MILKING MACHINES	01										
08	DRYING PLANT	01 02										
09	OTHER FUEL USING	01 02 03 04										
11	PLOUGHS	01 02 03										
12	SEED DRILLS	01 02										
13	DIGGERS	01 02										
14	SPRAYS AND OTHER SPREADERS	01 02 03										
15	OTHER NON-FUEL USING	01 02 03 04 05										

14. Do you have mains electricity on the farm? YES [ ] 1 NO [ ] 0

If YES, for about how many years have you been connected?

(Code '0' for dont know, 1 for positive answer)

15. About how many gallons of the following fuels would you say you have used in the past year on machinery

	KNOW 2	DONT KNOW 0	ROUGH 1	GALLONS	
AGRICULTURAL DIESEL					01
TAXED DIESEL					02
PARAFIN					03
KEROSINE					04

16. About how much straw do you produce in a year (bales)? .... total

And what size of bales do you use? .... code

About how much of this straw is used for the following?

BEDDING	bales	total
SOLD	bales	total
BURNT AS FUEL	bales	total

17. If you do burn any straw for fuel, please state the appliance used-

....

18. Do you burn off any straw in the field? YES [ ] 1 NO [ ] 0

If YES, about how many acres in a year?

How do you think that you might change practice in this respect in the next few years?

INCREASE BURNING [ ] 1

DECREASE BURNING [ ] 2

REMAIN STATIC [ ] 3

19. Do you use any animal wastes for fuel? YES [ ] 1 NO [ ] 0

If YES, please specify-

TYPE OF WASTE .... code

AMOUNT OF WASTE .... tonnes

TYPE OF FUEL .... code

APPLIANCE .... code

USE .... code

AGE .... yrs

A106

20. If NO to 19, have you ever considered using animal wastes for fuel via such appliances as methane producing digesters?

YES [ ] 1

NO [ ] 0

What do you consider to be the advantages and disadvantages of such systems?

....

....

21. Have you ever considered growing any crops for fuel on any of your land such as-

MANAGING EXISTING WOODLAND YES [ ] 1 NO [ ] 0

PLANTING ROUGH GRAZING LAND YES [ ] 1 NO [ ] 0

OTHER LAND YES [ ] 1 NO [ ] 0

If YES to any of the above, please state-

CROP CONSIDERED .... code

ACREAGE CONSIDERED

USE CONSIDERED .... code

TECHNIQUE CONSIDERED .... code

What do you consider to be the advantages and disadvantages of these types of fuels?

....

....

22. Do you use, or have you ever considered using, wind, solar or home-produced hydro power on the farm? Please state what you consider to be their advantages and disadvantages, and in what form you have considered using them.

WIND YES [ ] 1 NO [ ] 0

....

SOLAR YES [ ] 1 NO [ ] 0

....

HYDRO YES [ ] 1 NO [ ] 0

....

23. Please state whether you think that each of the following will grow, decrease or remain static in importance on farms in this area within the next 10 years-

		GROWTH 1	STATIC 2	DECREASE 3	DONT KNOW 0
01	WIND GENERATED ELECTRIC				
02	WIND PUMPING				
03	SOLAR ELECTRIC				
04	SOLAR HEATING				
05	SMALL HYDRO PLANTS				
06	GROWING CROPS FOR FUEL				
07	SHELTER BELTS MANAGED FOR FUEL				
08	ANIMAL WASTES USED FOR FUEL				
09	STUBBLE BURNING				
10	USE MORE CHEMICAL FERTILIZERS				
11	GENERALLY MORE INTENSIVE FARMING				
12	IMPROVEMENT OF HILL LAND				

24. Please state any other problems which you think exist with regard to energy supply to farming in this area-

....

....

APPENDIX 8. DOMESTIC AND AGRICULTURAL QUESTIONNAIRES FOR THE MAIN SURVEY AREAS.

A108

THE ROYAL INSTITUTION OF CHARTERED SURVEYORS
and
ROBERT GORDON'S INSTITUTE OF TECHNOLOGY

RURAL ENERGY USE SURVEY

Household Survey

AREA 2 - CUMINESTOWN

LINE 1

CASE NUMBER

ADDRESS ....
....

NAME OF HEAD OF HOUSEHOLD ....

1. How many people normally live in this house flat?

2. Please list each person giving their age, sex, relationship to the head of household, occupation, education level, mode of travel and how far they each have to travel to work, school or college, (one way) each day.

AGE GROUPING							SEX		RELATIONSHIP TO HOUSEHOLD HEAD		OCCUPATION		TRAVEL		EDUCATION LEVEL		COMPLETED BY
0-4	5-11	12-16	17-24	25-44	45-64	65+	M	F					MILES	MODE			
1	2	3	4	5	6	7	1	2		code		code		code		code	
									Head of household	1							

3. How long have you lived here?

3.1. In the Region?

Moved to North East in last 5 years	[ ]	1
Moved to North East at some time	[ ]	2
Born in North East, moved back after at least 2 years absence, (excluding as student)	[ ]	3
Always lived in the North East.	[ ]	4
Missing answer	[ ]	9

3.2. In the locality? (Within 10 miles)

Moved here in the last 5 years	[ ]	1
Moved here at some time	[ ]	2
Born here, moved back after at least 2 years absence, (excluding as a student)	[ ]	3
Always lived here	[ ]	4
Missing answer	[ ]	9

4. How long ago did you move to this house?

0–2 years	2–5 years	5–10 years	over 10 yr	missing V
1	2	3	4	9

5. Is your house-

Detached	[ ]	1
Semi-detached or end terrace	[ ]	2
Terraced	[ ]	3
A flat	[ ]	4

6. How many floors does your house have? (1.0, 1.5, 2.0, 2.5.)

7. Are you-

The owner occupier?	[ ]	1
Renting from the council?	[ ]	2
Renting from a housing association?	[ ]	3
Renting from a private landlord?	[ ]	4
Missing answer.	[ ]	9

If 4, please give your landlord's name ....

8. Which of the following facilities does your household have?

- Mains electricity
- Mains water
- Estate water
- Private water supply (or shared)
- Mains drainage
- Septic tank
- Bathroom

9. Apart from Kitchen, Bathroom and Storage rooms, how many rooms does your house have?

10. What is the construction of your....

10.1. Walls-
1. Block outer, timber lining, insulated
2. Cavity brick or block with insulated cavity
3. Cavity brick or block without insulation
4. Stone with uninsulated timber lining
5. Stone with plasterboard lining, insulated

10.2. Roof-
1. Pitched, slate, uninsulated
2. Pitched, slate, 50mm insulation
3. Pitched, slate, 100mm insulation
4. Pitched, tiles, uninsulated
5. Pitched, tiles, 50mm insulatbn
6. Pitched, tiles, 100mm insulation
7. Flat (describe) ....
....

10.3. Floor- (Enter % of each type-
1. Concrete, lino or tile finish
2. Timber, lino or tile finish
3. Concrete, carpeted
4. Timber, carpeted

11.
Approximate glazed area (m²)
Percentage double glazed

12. Are there any features of your house which you are thinking of improving?
yes 1
no 0

Or which you would like to improve if there were no constraints?
(e.g. financial or landlord constraints)
yes 1
no 0

If yes to either question, please explain, including what are constraints.
....

13. Have you ever received grant aiding for any improvements to your house?
yes 1
no 0
d.k. 9

Level of awareness of grants available
low 1
medium 2
high 3
Missing value 9

14. (Ask all except full-time farmers) About how much land, in acres do you own or have the long term lease of?

To what uses is this land put?
No land 0
General Garden 1
Garden and Smallholding 2
Garden with Heated Greenhouse 3
Garden with Business 4
Farmer 9

LINE 3 ______________________________

15. What is the main aspect of the house?

N	S	E	W
1	2	3	4

(maximum 2 aspects, representing separate alignments)

16. How many, if any, of the following does your household have at the moment?

Private cars

Cars or vans also used for business

17. Could you tell me about how much of these different types of fuel you have used in the past year for these different purposes, and about what price you have to pay for them at the moment?

FUEL TYPE	UNIT	PRICE /UNIT	(0, 1, or 2 occasional)) HEAT	COOK	POWER+ LIGHT	TOTAL
Mains electric						
Coal						
Smokeless fuel						
Wood (bought)						
Wood (home cut)						
Peat (bought)						
Peat (home cut)						
Bottled gas						
Heating oils						
Parafin						
Generator						
Other						
			0 or 1	0 or 1	0 or 1	

LINE 4

18. How many fireplaces do you have in your house (Including fires now boarded up)?

And how many would you say you used for a large part of the year?

19. Do you have a solid fuel burning stove for cooking purposes?

- yes 1
- no 0

If yes, do you use it-

- Always 1
- Occasionally 2
- Winter only 3
- Never 4
- Missing value 9

20. What kind of central heating, if any, does your household have?

- None 0
- Oil fired 1
- Solid fuel stove 2
- Solid fuel back boiler (background) 3
- Bulk gas 4
- Electric Storage 5

608

And how many radiators (or similar) are served (excluding ordinary electric radiators.)

21. If you have ever considered changing the type of heating you use in your house, please state what you considered changing to- ....

....

Given no constraints on fuel type (e.g. you could use mains gas), or on finance, what fuel type would you choose? ....

....

22. If you know, could you please tell me about how old the main part of your house is?

0-5 years		1
5-20 years		2
20-40 years		3
40-70 years		4
70-100 years		5
over 100 years		6
Dont know		0

23. Do you-

Cut free firewood for your home?	yes	1	no	0	missing	9
Buy large logs and cut them up?	yes	1	no	0	missing	9

Please explain why you do not get more of your own free fuels than you do?

....

....

25. Have you ever considered using any alternative types of energy such as-

wind		1
hydro		2
solar		3
methane		4
wind and solar		5
wind,solar and hydro		6
wind,solar hydro and methane		7
none		0

26. Could you please state whether you think that the following suggested trends for the next ten years (not just for your village, but for the U.K. as a whole,) are likely or unlikely-

	LIKELY	UNLIKELY	DONT KNOW	DESIRABILITY 1-5 (1=low)
Rising oil prices				
Return to using more coal				
Mains gas to most villages				
More use of electricity				
More use of wood for burning				
More use of peat				
Greater use of wind power				
Greater use of solar power				
Greater use of small hydro plants				
Greater use of methane	609			
The spread of computers to most homes				
General political move to right				

A113

27. In terms of fuel supply, if all trading between your locality and elsewhere were to stop, do you think that the village could adjust to providing from local resources-

Easily	☐	1
With a few difficulties	☐	2
With considerable hardship	☐	3
Not at all	☐	4
Dont know	☐	0

28. Strength of opinions, knowledge and understanding of energy matters.

Not recorded	☐	9
No opinions	☐	0
Little thought given	☐	1
Average	☐	2
Well thought out, interested	☐	3

NOTES/COMMENTS

....
....
....
....
....
....
....
....

THE ROYAL INSTITUTION OF CHARTERED SURVEYORS
and
ROBERT GORDON'S INSTITUTE OF TECHNOLOGY

RURAL ENERGY USE SURVEY

Agricultural Holdings Survey

CASE NUMBER

GRID REFERENCE

FARM REFERENCE

DWELLING REFERENCE

ADDRESS ....

....

NAME OF FARMER ....

1. Is your farm-

Owner occupied?	☐	1
Rented from an estate?	☐	2
Rented from a company?	☐	3
Managed for the owner?	☐	4
Missing value	☐	0

2. If not owner occupied, what is the owners-

NAME ....

and ADDRESS ....

....

3. How many hectares do you farm here?

Grouping code-

And could you please mark your boundaries on the accompanying map.

Satisfactory	Rough	Not completed
☐	☐	☐
1	2	0

A115

4. Do you have any other holdings?

yes	no	missing
1	0	9

If **yes**, please give some details- ....

....

.... hectares-

5. Total area of all holdings- (Hectares)

6. Could you please give me some details about the amounts of land used for different purposes on the farm, and any land improvements you have made or for the future?

	Hectares
Rotational arable land	
Inbye fenced grassland not ploughed in the rotation	
Hill land/rough grazing forming part of the farm	
Productive forestry/woodland	
Woodland/shelter belts not managed for timber	
Roads and buildings	

7. If any productive woodland, please state how used? (Management practice, casual/organised felling etc, and yield)

....

....

Other comments, including annual variation etc., land use. ....

....

....

8. How many people, other than yourself, do you employ on your farm?

Family

Full time

Seasonal

Family and Seasonal employment details- ....

....

9. How many of the follcwing do you normally run on the farm?

	number
Ewes	
Beef cattle (incl. young stock + calves)	
Dairy cows	
Poultry	
Pigs	

10. About how many/much of the following have you sent to market in the past year?

		Amount
CATTLE		
SHEEP	(no)	
POULTRY	(no)	
PIGS	(no)	
GRAIN Oats	(t)	
Barley	(t)	
OTHER (Specify)	(t)	

And how much of the following have you purchased in the past year?

	Amount
CONCENTRATE FEEDSTUFFS (Type) (t)	
STRAW (t)	
FERTILIZERS (Type) (t)	

LINE2

11. Where do you normally market beasts and produce? (Up to 3 locations) ....

....

Other comments, including annual variations, stock and marketing- ....

....

....

12. Do you run any other enterprises of any kind, (Whether agricultural, sporting, tourist, craft or other)?

yes	no	missing
1	0	9

If yes, please give some details- ....

....

13. Do you have mains electricity on the farm?

yes	no	missing
1	0	9

If yes, for about how many years have you been connected? ....

14. About how much straw do you produce in a year (bales)? ....

x

And what size of bales do you use (tonne)? ....

Total (t)

15. About how much of this straw is used for the following-

BEDDING .... T

FEED .... T

....

SOLD .... T

16. If you do burn any straw for fuel, please state the appliance used and for how long you have been using it? ....

17. Do you burn off any straw in the field?

yes	no	missing
1	0	9

If yes, about how many hectares in a year?

18. Do you think that you might change practice in this respect in the next few years?

INCREASE BURNING	☐	1
DECREASE BURNING	☐	2
REMAIN STATIC	☐	3
MISSING VALUE	☐	9

19. have you ever considered using animal wastes for fuel via such appliances as anaerobic digestors?

yes	no	missing
☐	☐	☐
1	0	9

What do you consider to be the advantages and disadvantages of such systems?

....

....

Have you ever considered growing any crops for fuel on any of your land such as-

	yes	no	missing
Managing existing woodland	☐	☐	☐
Planting rough grazing land	☐	☐	☐
Other land	☐	☐	☐
	1	0	9

If yes to any of the above, please state- Crop considered ....

Hectares considered ....

Use considered ....

Techniques considered ....

What do you consider to be the advantages and disadvantages of such fuels? ....

....

Enter if YES to any of above

yes	no	missing
☐	☐	☐
1	0	9

20. Do you use, or have you ever considered using, wind, solar, small scale hydro or waste machine heat on the farm? Please state what you consider to be their advantages and disadvantages.

	No	Using	Considered using	Missing
WIND	☐	☐	☐	☐
SOLAR	☐	☐	☐	☐
HYDRO	☐	☐	☐	☐
	0	1	2	9

Further comments, particularly advantages and disadvantages- ....

....

....

A118

21. Could you please give me some details about the mechanical plant you have on the farm?

	Number	Details/comments
Road vehicles (except listed family cars)		
Servicable tractors		
Combines		
Other powered plant		
Grain drying equipment		

Additional information- ....

TOTAL ANNUAL PLANT FUEL USE (Litres)-

22. Could you please give me some details about the buildings you have on the farm?

	m²
Machine store	
Hay/straw store	
Stock wintering	
Poultry	
Dairy	
Pigs	
Silo	
Other	
TOTAL m²	

Total annual fuel used in farm buildings excluding dwellings (KW)

Type of fuel ....

main uses ....

23. Please state whether you think that each of the following will grow, decrease or remain static in importance on farms in this country over the next ten years, and whether the function described is a generally good or bad thing.

	CHANGE up 1. down 2. unch. 0.	COMMENTS
Wind generated electricity		
Wind pumping		
Solar electricity		
Solar heating		
Small hydro plants		
Growing crops for fuel		
Shelter belts managed for fuel		
Animal wastes used as fuel		
Stubble burning		
Use of chemical fertilisers		
Intensivity of farming		
Improvement of hill land		
Friction between farmers + conservation		
Change in large estate ownership		
Organic farming		
Mixed farming		
Number of field operations		
Number of small food plots		

A119

Additional information- ....

....

....

27. Please state any other problems which you think exist with regard to energy supply to farming in this area, nationally or internationally.
....

....

....

OTHER INFORMATION/COMMENTS- ....

....

....

....

....

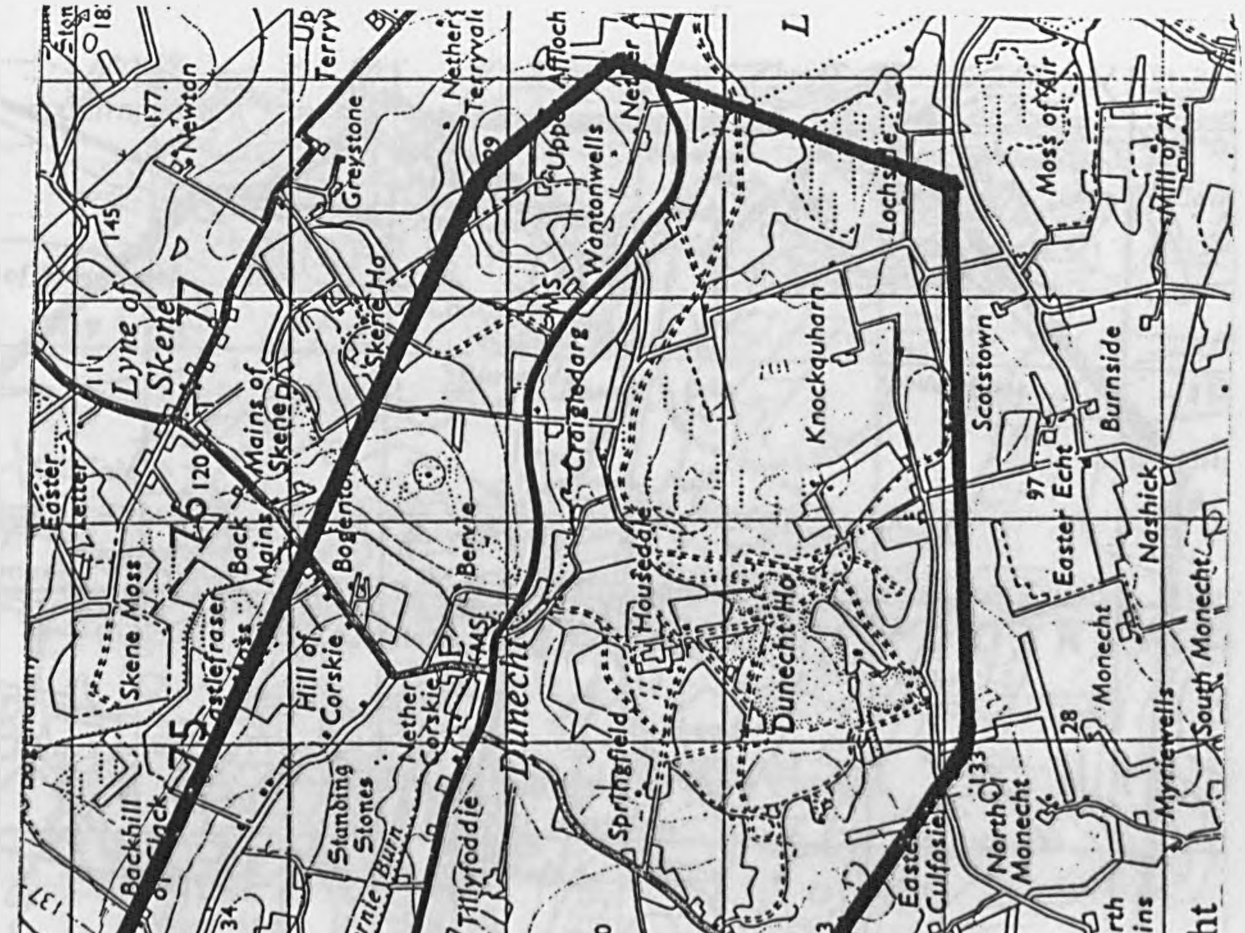
....

....

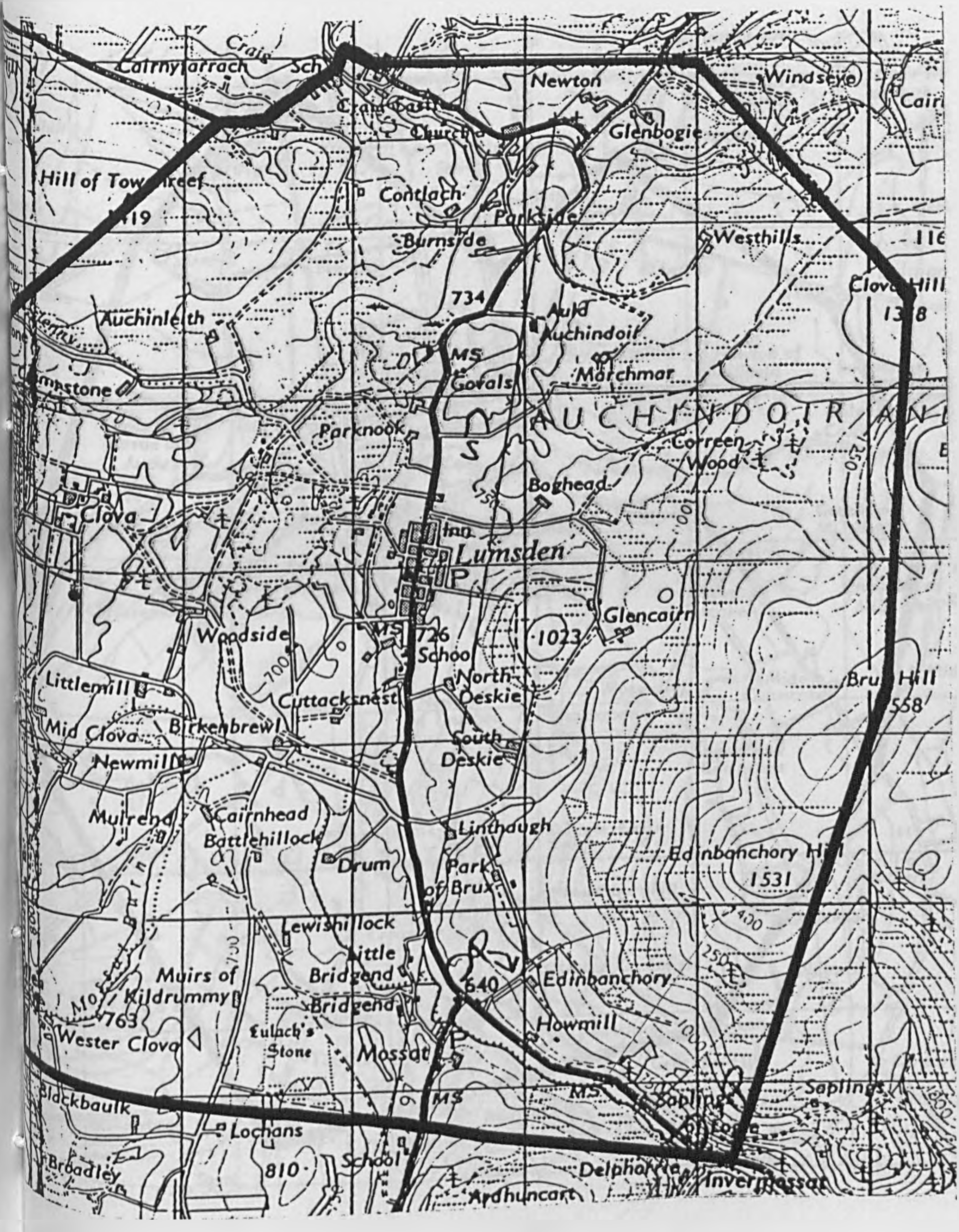
....

APPENDIX 9. MAPS OF THE LOCAL SURVEY AREAS.

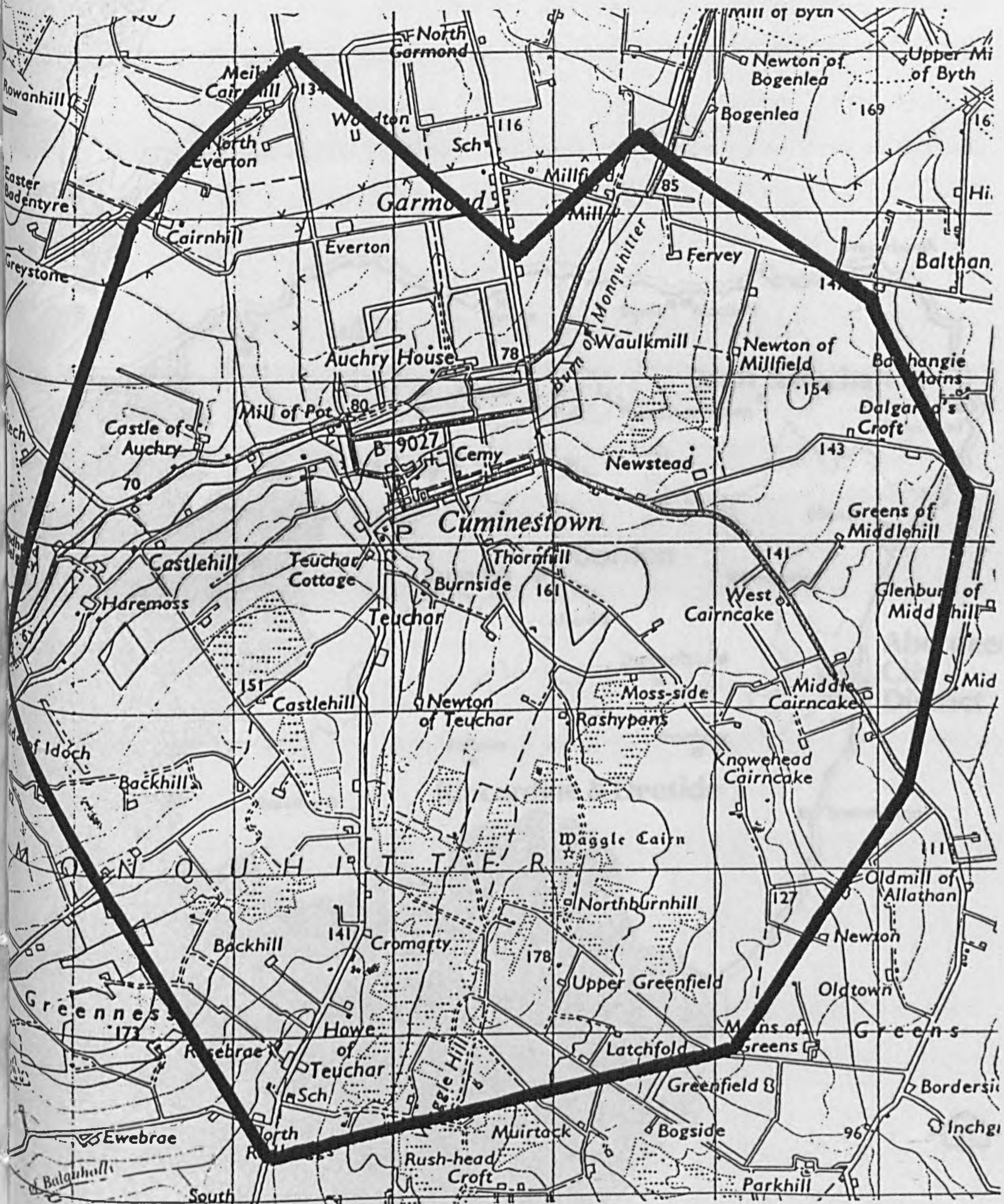
A. Dunecht.



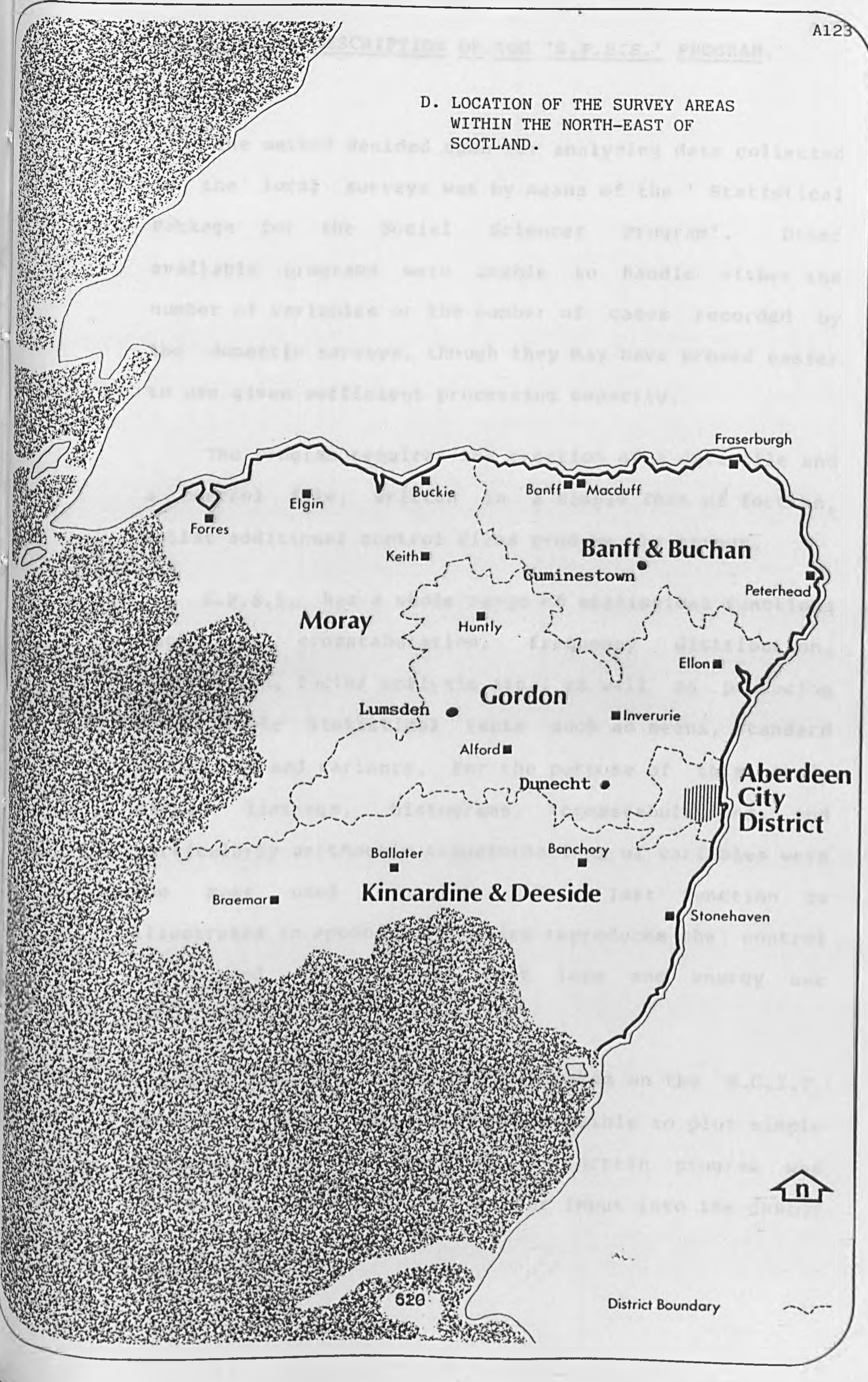
B. LUMSDEN.


Cairnyfarrach
Craig
Craig Castle
Church
Newton
Windseye
Glenbogie
Hill of Towanreef
1419
Contlach
Parkside
Burnside
Westhills
Clova Hill
1338
734
Auchinleith
Auld Auchindoir
Marchmar
MS
Govals
AUCHINDOIR AN
Parknook
Correen Wood
Boghead
Clova
Inn
Lumsden
P
Glencairn
Woodside
MS 726
School
1023
Littlemill
Cuttacksnest
North Deskie
Bruz Hill
558
Mid Clova
Birkenbrewl
South Deskie
Newmill
Muirend
Cairnhead
Battlehillock
Linthaugh
Drum
Park of Brux
Edinbanchory Hill
1531
Lewishillock
Little Bridgend
Muirs of Kildrummy
640
Edinbanchory
763
Bridgend
Howmill
Wester Clova
Eulach's Stone
Mossat
Blackbaulk
MS
Saplings
Lochans
Broadley
810
School
Delphorrie
Invermossat
Ardhuncart

C. CUMINESTOWN.



D. LOCATION OF THE SURVEY AREAS WITHIN THE NORTH-EAST OF SCOTLAND.



APPENDIX 10, DESCRIPTION OF THE 'S.P.S.S.' PROGRAM.

The method decided upon for analysing data collected in the local surveys was by means of the ' Statistical Package for the Social Sciences Program'. Other available programs were unable to handle either the number of variables or the number of cases recorded by the domestic surveys, though they may have proved easier to use given sufficient processing capacity.

The program requires the creation of a data file and a control file, written in a simple form of fortran, whilst additional control files produce the output.

S.P.S.S. has a whole range of statistical functions such as crosstabulation, frequency distribution, correlation, factor analysis etc., as well as producing more simple statistical tests such as means, standard deviations and variance. For the purpose of this study simple listings, histograms, crosstabulations, and particularly arithmetic transformations of variables were the most used functions. This last function is illustrated in Appendix 11, which reproduces the control file used to generate heat loss and energy use calculations.

Unfortunately, a bug in the program on the R.G.I.T. mainframe meant that it proved impossible to plot simple graphs of data, and therefore a fortran program was written to transform the data for input into the GRPLOT program for this purpose. This program is also listed in Appendix 11.

APPENDIX 11. PROGRAM LISTINGS FOR ENERGY USE AND LOSS CALCULATIONS.

A. Input File for S.P.S.S. Processing.

```
RUN NAME          cumine
INPUT MEDIUM      cumine.dat
VARIABLE LIST     LINE1,CASE,PERSONS,AGE1,SEX1,REL1,OCCUPAT1,MILES1,
                  MODE1,EDUCATN1,COMPLET1,AGE2,SEX2,REL2,OCCUPAT2,
                  MILES2,MODE2,EDUCATN2,COMPLET2,AGE3,SEX3,REL3,
                  OCCUPAT3,MILES3,MODE3,EDUCATN3,COMPLET3,AGE4,
                  SEX4,REL4,OCCUPAT4,MILES4,MODE4,EDUCATN4,
                  COMPLET4,AGE5,SEX5,REL5,OCCUPAT5,MILES5,MODE5,
                  EDUCATN5,COMPLET5,LINE2,AGE6,SEX6,REL6,OCCUPAT6,
                  MILES6,MODE6,EDUCATN6,COMPLET6,AGE7,SEX7,REL7,
                  OCCUPAT7,MILES7,MODE7,EDUCATN7,COMPLET7,ORIGINR,
                  ORIGINL,STAY,HTYPE,FLOORS,TENURE,LANDLORD,
                  MELECTR,MAINSW,ESTATEW,PRIVATEW,MAINSD,SEPTIC,
                  BATHROOM,ROOMS,WALL,ROOF,FLOOR,
                  M2GLASS,%DOUBLE,IMPROVE1,
                  IMPROVE2,GRANT,GAWARE,ACRES,LANDUSE,LINE3,
                  ASPECT,CARS,BCARS,EHEAT,ECOOK,ETOTAL,
                  CHEAT,CCOOK,CTOTAL,SHEAT,SCOOK,STOTAL,
                  BWHEAT,BWCOOK,BWTOTAL,HWHEAT,HWCOOK,HWTOTAL,
                  BPHEAT,BPCOOK,BPTOTAL,HPHEAT,HPCOOK,HPTOTAL,
                  GASHEAT,GASCOOK,GASTOTAL,OILHEAT,OILCOOK,
                  OILTOTAL,LINE4,PARHEAT,PARCOOK,PARTOTAL,
                  TOTFIRES,
                  USEFIRES,RAYBURN,RAYUSE,CENTHEAT,RADS,HEATCH,
                  PREFHEAT,HOAGE,FREEWOOD,LOGS,REASON,RENEWABL,
                  OIL,COAL,GAS,ELECTRIC,WOOD,PEAT,WIND,SOLAR,HYDRO,
                  METHANE,COMPUTER,POLCHANG,SELFSUFF,
                  OPINIONS,GFA
INPUT FORMAT      FIXED(F4.0,F3.0,4F1.0,2F2.0,6F1.0,2F2.0,6F1.0,
                  2F2.0,6F1.0,2F2.0,6F1.0,2F2.0,3F1.0/F4.0,3F1.0,
                  2F2.0,6F1.0,2F2.0,7F1.0,F3.1,10F1.0,3F1.0,
                  2F2.0,4F1.0,F2.0,F1.0/F4.0,A2,4F1.0,F4.0,2F1.0,
                  F3.1,2F1.0,F3.1,2F1.0,F3.1,2F1.0,F3.1,2F1.0,
                  F3.1,2F1.0,F3.1,2F1.0,F3.0,2F1.0,F4.0/F4.0,2F1.0,
                  F2.0,5F1.0,F2.0,21F1.0,F3.0)
MISSING VALUES    ETOTAL(9999)/CTOTAL,STOTAL,BWTOTAL,HWTOTAL,BPTOTAL,
                  HPTOTAL(9.9)/GASTOTAL(999)/OILTOTAL(9999)/PARTOTAL(99)
                  /REASON(9)/OIL TO OPINIONS(9)
N OF CASES        116
IF                ((CENTHEAT NE 5) AND (OCCUPAT1 NE 1))
                  MJELEC=(ETOTAL-31.92)*81.63
IF                ((CENTHEAT NE 5) AND (OCCUPAT1 EQ 1))
                  MJELEC=(ETOTAL-50.04)*81.63
IF                (CENTHEAT EQ 5) MJELEC=(ETOTAL-39.36)*111.05
COMPUTE           MJREALE=MJELEC*2.016
COMPUTE           MJCOAL=CTOTAL*32000
COMPUTE           MJSMOKE=STOTAL*36000
COMPUTE           MJHWOOD=HWTOTAL*18500
COMPUTE           MJBWOOD=BWTOTAL*18500
COMPUTE           MJBPEAT=BPTOTAL*21500
COMPUTE           MJHPEAT=HPTOTAL*21500
COMPUTE           MJGAS=GASTOTAL*56.05
COMPUTE           MJOIL=OILTOTAL*47.03
COMPUTE           MJPAR=PARTOTAL*46.98
COMPUTE           MJTOTAL=MJELEC+MJCOAL+MJSMOKE+MJHWOOD+MJBWOOD+
                  MJHPEAT+MJBPEAT+MJGAS+MJOIL+MJPAR
COMPUTE           MJREALT=MJTOTAL-MJELEC+MJREALE
```

```
ASSIGN MISSING  MJELEC,MJREALE,MJCOAL,MJSMOKE,MJHWOOD,MJBWOOD,
                MJHPEAT,MJBPEAT,MJGAS,MJOIL,MJPAR,MJTOTAL,
                MJREALT (9)
IF              (((FLOORS GT 1.4) AND (FLOORS LT 2.4)) AND
                (HTYPE EQ 1))
                GRWAREA=(SQRT(GFA/2))*8*2.3
IF              (((FLOORS GT 1.4) AND (FLOORS LT 2.4))
                AND (HTYPE EQ 2))
                GRWAREA=(SQRT(GFA/2))*8*2.3*0.75
IF              (((FLOORS GT 1.4) AND (FLOORS LT 2.4)) AND
                (HTYPE EQ 3))
                GRWAREA=(SQRT(GFA/2))*8*2.3*0.5
IF              ((FLOORS LT 1.4) AND (HTYPE EQ 1))
                GRWAREA=(SQRT(GFA/2))*8*2.3*0.75
IF              ((FLOORS LT 1.4) AND (HTYPE EQ 2))
                GRWAREA=(SQRT(GFA/2))*8*2.3*0.75*0.75
IF              ((FLOORS LT 1.4) AND (HTYPE EQ 3))
                GRWAREA=(SQRT(GFA/2))*8*2.3*0.75*0.5
IF              (FLOORS EQ 1.5) WALLAREA=GRWAREA/2
IF              (FLOORS EQ 2.5) WALLAREA=SQRT(GFA/3)*8*2.3
IF              ((FLOORS EQ 1.0) OR (FLOORS EQ 2.0)) WALLAREA=GRWAREA
COMPUTE         GRATIO=GRWAREA/M2GLASS
COMPUTE         NETWALL=WALLAREA-M2GLASS-(2*0.75*2)
IF              (WALL EQ 1) WALLU=0.49*NETWALL
IF              (WALL EQ 2) WALLU=0.40*NETWALL
IF              (WALL EQ 3) WALLU=0.99*NETWALL
IF              (WALL EQ 4) WALLU=1.20*NETWALL
IF              (WALL EQ 5) WALLU=0.49*NETWALL
IF              (WALL EQ 6) WALLU=0.29*NETWALL
COMPUTE         GLAZINGU=(M2GLASS*%DOUBLE/100)*2.8+
                (M2GLASS*(100-%DOUBLE)/100)*5.7+
                2*2*0.75*2.7
IF              (FLOORS EQ 1.5) FLOORS2=2.0
IF              (FLOORS EQ 2.5) FLOORS2=3.0
IF              ((FLOORS EQ 1.0) OR (FLOORS EQ 2.0)) FLOORS2=FLOORS
COMPUTE         GRFA=GFA/FLOORS2
IF              (((FLOORS EQ 1.0) OR (FLOORS EQ 2.0)) AND
                ((ROOF EQ 1) OR (ROOF EQ 4)))
                ROOFU=GRFA*2.6
IF              (((FLOORS EQ 1.0) OR (FLOORS EQ 2.0)) AND
                ((ROOF EQ 2) OR (ROOF EQ 5)))
                ROOFU=GRFA*0.61
IF              (((FLOORS EQ 1.0) OR (FLOORS EQ 2.0)) AND
                ((ROOF EQ 3) OR (ROOF EQ 6)))
                ROOFU=GRFA*0.35
IF              (((FLOORS EQ 1.5) OR (FLOORS EQ 2.5)) AND
                ((ROOF EQ 1) OR (ROOF EQ 4)))
                ROOFU=(1.305*GRFA)*2.6
IF              (((FLOORS EQ 1.5) OR (FLOORS EQ 2.5)) AND
                ((ROOF EQ 2) OR (ROOF EQ 5)))
                ROOFU=(1.305*GRFA)*0.61
IF              (((FLOORS EQ 1.5) OR (FLOORS EQ 2.5)) AND
                ((ROOF EQ 3) OR (ROOF EQ 6)))
                ROOFU=(1.305*GRFA)*0.35
IF              ((HTYPE EQ 1) AND ((FLOOR EQ 1) OR (FLOOR EQ 3))
                AND (FLOORS LT 1.4))
                FLOORU=0.62*GRFA
```

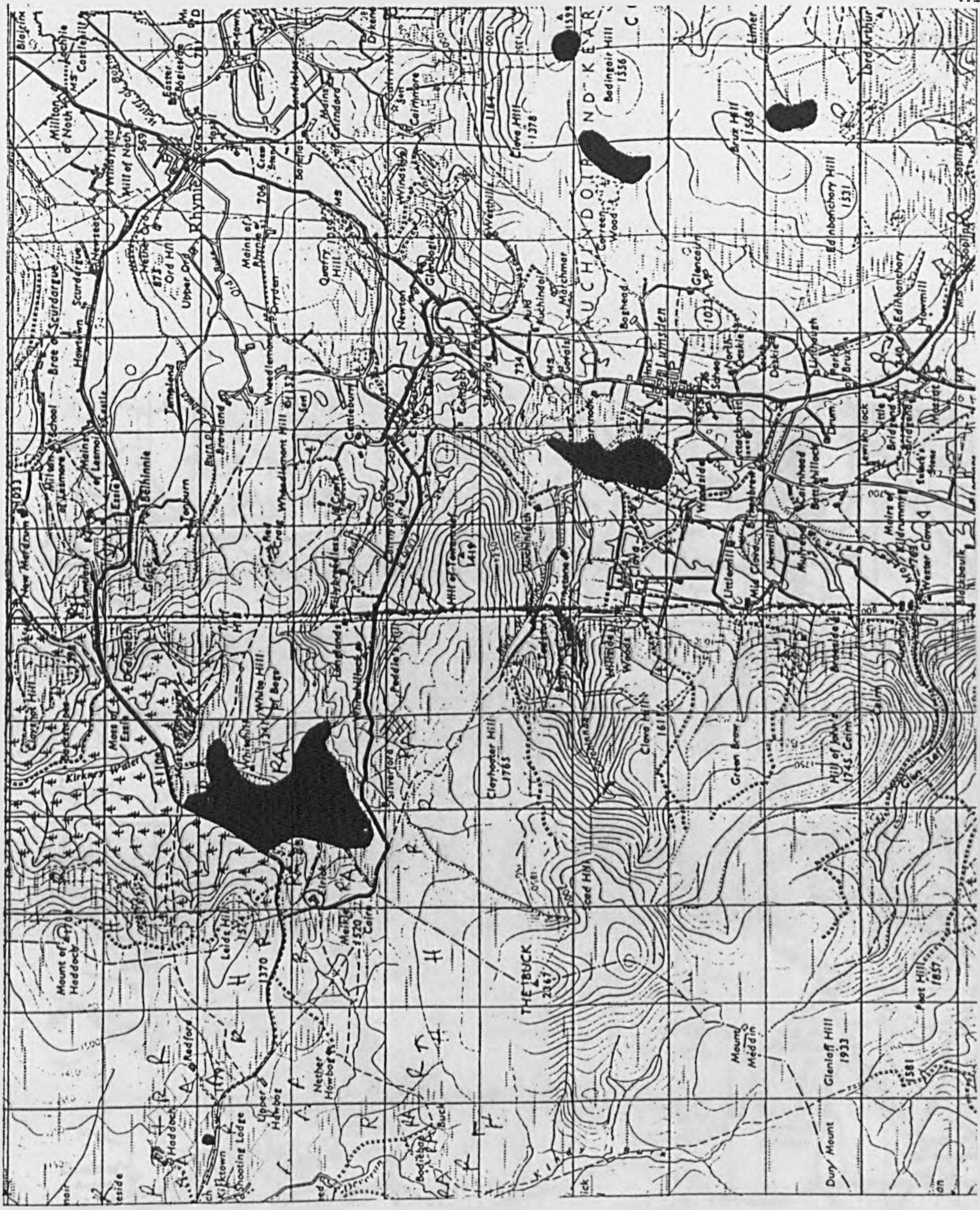
```
IF              (((FLOOR EQ 2) OR (FLOOR EQ 4)) AND (FLOORS LT 1.4))
                FLOORU=0.59*GRFA
IF              ((HTYPE EQ 1) AND ((FLOOR EQ 1) OR (FLOOR EQ 3))
                AND (FLOORS GT 1.4))
                FLOORU=0.74*GRFA
IF              (((FLOOR EQ 2) OR (FLOOR EQ 4)) AND (FLOORS GT 1.4))
                FLOORU=0.71*GRFA
IF              (FLOOR EQ 5) FLOORU=0.3*GRFA
IF              ((HTYPE EQ 2) AND ((FLOOR EQ 1) OR (FLOOR EQ 3))
                AND (FLOORS LT 1.4))
                FLOORU=0.49*GRFA
IF              ((HTYPE EQ 2) AND ((FLOOR EQ 1) OR (FLOOR EQ 3))
                AND (FLOORS GT 1.44))
                FLOORU=0.59*GRFA
IF              ((HTYPE EQ 3) AND ((FLOOR EQ 1) OR (FLOOR EQ 3))
                AND (FLOORS LT 1.4))
                FLOORU=0.36*GRFA
IF              ((HTYPE EQ 3) AND ((FLOOR EQ 1) OR (FLOOR EQ 3))
                AND (FLOORS GT 1.4))
                FLOORU=0.44*GRFA
COMPUTE         TOTALU=WALLU+ROOFU+FLOORU+GLAZINGU
COMPUTE         FABLOSS=TOTALU*264.6812
IF              ((FLOORS EQ 1.0) OR (FLOORS EQ 2.0)) VOLUME=2.3*GFA
IF              (FLOORS EQ 1.5) VOLUME=1.75*GRFA*2.3
IF              (FLOORS EQ 2.5) VOLUME=2.75*GRFA*2.3
IF              (((IMPROVE1 GT 3.5) AND (IMPROVE1 LT 5.5)) OR
                ((IMPROVE2 GT 3.5) AND (IMPROVE2 LT 5.5)))
                AC1=10.0
IF              ((IMPROVE1 EQ 8) OR (IMPROVE2 EQ 8))
                AC1=-5.0
IF              (HOAGE EQ 1) AC2=-10.0
IF              (HOAGE EQ 2) AC2=-5.0
IF              (LINE1 GT 1000) AC3=5.0
COMPUTE         AIRCHAN=AC1+AC2+AC3+30.0
COMPUTE         VENTLOSS=VOLUME*AIRCHAN/3.0*264.6812/10
COMPUTE         HEATLOSS=FABLOSS+VENTLOSS
COMPUTE         LOSSPERM=HEATLOSS/GFA
READ INPUT DATA
SAVE FILE       CUMINE.SPS
FINISH
```

B. Fortran Program for Calculation of the Same Variables.

```
      DOUBLE PRECISION ASPECT
      REAL JELEC,JREALE,JCOAL,JSMOKE,JHWOOD,JBWOOD,JHPEAT
      REAL JBPEAT,JG,JO,JP,JTOT,JREALT,NETWAL,LPERM
      REAL LINE1,MILES1,MODE1,MILES2,MILES3,MILES4,MILES5,MILES6
      REAL MILES7,MODE2,MODE3,MODE4,MODE5,MODE6,MODE7
      REAL LINE2,LINE3,LINE4,LINE5,LINE6,LINE7
      REAL LANDL,MELEC,MAINSW,MAINSD,M2GLA,IMP1,IMP2
      REAL LANDU,LOGS,METH
      OPEN (UNIT=21,FILE='LUMSD')
      OPEN (UNIT=23,FILE='LUMFOR')
      DO 100,IC=1,5000
      READ (21,10,END=1000) LINE1,CASE,PERSON,AGE1,SEX1,REL1,
     &OCC1,MILES1,MODE1,EDUCA1,COM1,AGE2,SEX2,REL2,OCC2,
     &MILES2,MODE2,EDUCA2,COM2,AGE3,SEX3,REL3,OCC3,MILES3,
     &MODE3,EDUCA3,COM3,AGE4,SEX4,REL4,OCC4,MILES4,MODE4,
     &EDUCA4,COM4,AGE5,SEX5,REL5,OCC5,MILES5,MODE5,EDUCA5,COM5
10    FORMAT (F4.0,F3.0,4F1.0,2F2.0,6F1.0,2F2.0,6F1.0,2F2.0,
     &6F1.0,2F2.0,6F1.0,2F2.0,3F1.0)
      READ (21,15) LINE2,AGE6,SEX6,REL6,OCC6,MILES6,MODE6,EDUCA6,COM6,
     &AGE7,SEX7,REL7,OCC7,MILES7,MODE7,EDUCA7,COM7,ORIGR,ORIGL,
     &STAY,HTYPE,FLOORS,TENURE,LANDL,MELEC,MAINSW,ESTW,PRW,
     &MAINSD,SEPTIC,
     &BATH,ROOMS,WALL,ROOF,FLOOR,CARPET,TILES,M2GLA,DOUBLE,EXPOSE,
     &VENTIL,IMP1,IMP2,GRANT,GAWARE,ACRES,LANDU
15    FORMAT (F4.0,3F1.0,2F2.0,6F1.0,2F2.0,7F1.0,F3.1,9F1.0,
     &  F2.0,3F1.0,4F2.0,6F1.0,F2.0,F1.0)
      READ (21,20) LINE3,ASPECT,CARS,BCARS,EHEAT,ECOOK,EPOW,ETOT,
     &CHEAT,CCOOK,CTOT,SHEAT,SCOOK,STOT,BWHEAT,BWCOOK,BWTOT,
     &HWHEAT,HWCOOK,HWTOT,HPHEAT,HPCOOK,HPTOT,BPHEAT,BPCOOK,
     &BPTOT,GHEAT,GCOOK,GTOT,OHEAT,OCOOK,OTOT
20    FORMAT (F4.0,A2,4F1.0,F1.0,F4.0,2F1.0,F3.1,2F1.0,F3.1,2F1.0,
     &F3.1,2F1.0,
     &   F3.1,2F1.0,F3.1,2F1.0,F3.1,2F1.0,F3.0,2F1.0,F4.0)
      READ (21,25) LINE4,PHEAT,PCOOK,PTOT,GENH,GENC,GENP,GENT,TOTF,
     &USEF,RBURN,RUSE,CENTH,RADS,HEATCH,PREFH,HOAGE,FREEW,LOGS,
     &REASON,RENEW,O,COAL,G,ELECTR,WOOD,PEAT,WIND,SOLAR,HYDRO,
     &METH,COMP,POLCH,VOTING,SELFS,PROB,OPIN
25    FORMAT (F4.0,2F1.0,F2.0,3F1.0,F4.0,5F1.0,F2.0,21F1.0,2F1.0)
      IF((CENTH.NE.5.0).AND.(OCC1.NE.1.0))THEN
      JELEC=(ETOT-31.92)*81.63
      ENDIF
      GFA=ROOMS*16+20
      IF((CENTH.NE.5.0).AND.(OCC1.EQ.1.0))THEN
      JELEC=(ETOT-50.04)*81.63
      ENDIF
      IF(CENTH.EQ.5.0) JELEC=(ETOT-39.36)*111.05
              JREALE=JELEC*2.016
              JCOAL=CTOT*32000
              JSMOKE=STOT*36000
              JHWOOD=HWTOT*18500
              JBWOOD=BWTOT*18500
              JBPEAT=BPTOT*21500
              JHPEAT=HPTOT*21500
              JG=GTOT*56.05
              JO=OTOT*47.03
              JP=PTOT*46.98
              JTOT=JELEC+JCOAL+JSMOKE+JHWOOD+JBWOOD+
     &        JHPEAT+JBPEAT+JG+JO+JP
              JREALT=JTOT-JELEC+JREALE
```

```
      IF(((FLOORS.GT.1.4).AND.(FLOORS.LT.2.4)).AND.(HTYPE.EQ.1.0))
     & GRWAR=(SQRT(GFA/2))*8*2.3
      IF(((FLOORS.GT.1.4).AND.(FLOORS.LT.2.4)).AND.(HTYPE.EQ.2.0))
     & GRWAR=(SQRT(GFA/2))*8*2.3*0.75
      IF(((FLOORS.GT.1.4).AND.(FLOORS.LT.2.4)).AND.(HTYPE.EQ.3.0))
     & GRWAR=(SQRT(GFA/2))*8*2.3*0.5
      IF((FLOORS.LT.1.4).AND.(HTYPE.EQ.1.0))
     & GRWAR=(SQRT(GFA/2))*8*2.3*0.75
      IF((FLOORS.LT.1.4).AND.(HTYPE.EQ.2.0))
     & GRWAR=(SQRT(GFA/2))*8*2.3*0.75*0.75
      IF((FLOORS.LT.1.4).AND.(HTYPE.EQ.3.0))
     & GRWAR=(SQRT(GFA/2))*8*2.3*0.75*0.5
      IF(FLOORS.EQ.1.5) WALLA=GRWAR/2
      IF(FLOORS.EQ.2.5) WALLA=SQRT(GFA/3)*8*2.3
      IF((FLOORS.EQ.1.0).OR.(FLOORS.EQ.2.0)) WALLA=GRWAR
              GRATIO=GRWAR/M2GLA
              NETWAL=WALLA-M2GLA-(2*0.75*2)
      IF(WALL.EQ.1.0) WALLU=0.49*NETWAL
      IF(WALL.EQ.2.0) WALLU=0.40*NETWAL
      IF(WALL.EQ.3.0) WALLU=0.99*NETWAL
      IF(WALL.EQ.4.0) WALLU=1.20*NETWAL
      IF(WALL.EQ.5.0) WALLU=0.49*NETWAL
      IF(WALL.EQ.6.0) WALLU=0.29*NETWAL
              GLAZU=(M2GLA*DOUBLE/100)*2.8+
     & (M2GLA*(100-DOUBLE)/100)*5.7+
     & 2*2*0.75*2.7
      IF(FLOORS.EQ.1.5) FLOR2=2.0
      IF(FLOORS.EQ.2.5) FLOR2=3.0
      IF((FLOORS.EQ.1.0).OR.(FLOORS.EQ.2.0)) FLOR2=FLOORS
              GRFA=GFA/FLOR2
      IF(((FLOORS.EQ.1.0).OR.(FLOORS.EQ.2.0)).AND.((ROOF.EQ.1.0)
     &.OR.(ROOF.EQ.4.0)))
     & ROOFU=GRFA*2.6
      IF(((FLOORS.EQ.1.0).OR.(FLOORS.EQ.2.0)).AND.((ROOF.EQ.2.0)
     &.OR.(ROOF.EQ.5.0)))
     & ROOFU=GRFA*0.61
      IF(((FLOORS.EQ.1.0).OR.(FLOORS.EQ.2.0)).AND.((ROOF.EQ.3.0)
     &.OR.(ROOF.EQ.6.0)))
     &        ROOFU=GRFA*0.35
      IF(((FLOORS.EQ.1.5).OR.(FLOORS.EQ.2.5)).AND.((ROOF.EQ.1.0)
     &.OR.(ROOF.EQ.4.0)))
     & ROOFU=(1.305*GRFA)*2.6
      IF(((FLOORS.EQ.1.5).OR.(FLOORS.EQ.2.5)).AND.((ROOF.EQ.2.0)
     &.OR.(ROOF.EQ.5.0)))
     & ROOFU=(1.305*GRFA)*0.61
      IF(((FLOORS.EQ.1.5).OR.(FLOORS.EQ.2.5)).AND.((ROOF.EQ.3.0)
     &.OR.(ROOF.EQ.6.0)))
     & ROOFU=(1.305*GRFA)*0.35
      IF((HTYPE.EQ.1.0).AND.((FLOOR.EQ.1.0).OR.(FLOOR.EQ.3.0)).AND.
     &(FLOORS.LT.1.4))
     & FLOORU=0.62*GRFA
      IF(((FLOOR.EQ.2.0).OR.(FLOOR.EQ.4.0)).AND.(FLOORS.LT.1.4))
     & FLOORU=0.59*GRFA
      IF(((HTYPE.EQ.1.0).AND.((FLOOR.EQ.1.0).OR.(FLOOR.EQ.3.0)).AND.
     &(FLOORS.GT.1.4)))
     & FLOORU=0.74*GRFA
      IF(((FLOOR.EQ.2.0).OR.(FLOOR.EQ.4.0)).AND.(FLOORS.GT.1.4))
     & FLOORU=0.71*GRFA
```

```
      IF(FLOOR.EQ.5.0) FLOORU=0.3*GRFA
      IF((HTYPE.EQ.2.0).AND.((FLOOR.EQ.1.0).OR.(FLOOR.EQ.3.0)).AND.
     &(FLOORS.LT.1.4))
     &   FLOORU=0.49*GRFA
      IF((HTYPE.EQ.2.0).AND.((FLOOR.EQ.1.0).OR.(FLOOR.EQ.3.0)).AND.
     &(FLOORS.GT.1.4))
     &   FLOORU=0.59*GRFA
      IF((HTYPE.EQ.3.0).AND.((FLOOR.EQ.1.0).OR.(FLOOR.EQ.3.0))
     &.AND.(FLOORS.LT.1.4))
     &   FLOORU=0.36*GRFA
      IF(((HTYPE.EQ.3.0).AND.((FLOOR.EQ.1.0).OR.(FLOOR.EQ.3.0))
     &.AND.(FLOORS.GT.1.4)))
     &   FLOORU=0.44*GRFA
              TOTU=WALLU+ROOFU+FLOORU+GLAZU
              FLOSS=TOTU*264.6812
      IF((FLOORS.EQ.1.0).OR.(FLOORS.EQ.2.0)) VOLUME=2.3*GFA
      IF(FLOORS.EQ.1.5) VOLUME=1.75*GRFA*2.3
      IF(FLOORS.EQ.2.5) VOLUME=2.75*GRFA*2.3
      IF(((IMP1.GT.3.5).AND.(IMP1.LT.5.5)).OR.((IMP2.GT.3.5)
     &.AND.(IMP2.LT.5.5)))
     &   AC1=1.0
      IF((IMP1.EQ.8.0).OR.(IMP2.EQ.8.0))
     &   AC1=-0.5
      IF(((IMP1.NE.4.0).AND.(IMP1.NE.5.0).AND.(IMP1.NE.8.0))
     &   .AND.((IMP2.NE.4.0).AND.(IMP2.NE.5.0).AND.(IMP2.NE.8.0)))
     &   AC1=0.0
      IF(HOAGE.EQ.1.0) AC2=-1.0
      IF(HOAGE.EQ.2.0) AC2=-0.5
      IF((HOAGE.NE.1.0).AND.(HOAGE.NE.2.0)) AC2=0.0
      IF(LINE1.GT.1000) AC3=0.5
              AIRCH=AC1+AC2+AC3+3.0
              VLOSS=VOLUME*AIRCH/3.0*264.6812
              HLOSS=FLOSS+VLOSS
              LPERM=HLOSS/GFA
      USEMJ=HLOSS/JREALT*100
      WRITE (23,30)AIRCH,VENTIL
30    FORMAT (2F)
100   CONTINUE
1000  CLOSE (UNIT=21)
      CLOSE (UNIT=23)
      STOP
      END
```



APPENDIX 12. MAPS OF THE PEAT RESOURCE IN SURVEY AREAS.

A. LUMSDEN.

B. CUMINESTOWN.