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The Socio Economic Impact of Renewable Energy Technologies

Hayley Myles

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Enquiries:
***Director of SEEC and Editor of SEEDS*:**
David Hawdon *email: d.hawdon@surrey.ac.uk*
Secretary:
Isobel Hildyard *email: i.hildyard@surrey.ac.uk*

SEEC, Economics Dept, School of Human Sciences, University of Surrey, Guildford GU2 5XH, UK.
Telephone: +44 (0)1483 259379 Fax: +44 (0)1483 259548

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ABSTRACT

Early rural electrification programmes, relying upon grid connected power, were once hailed as the catalytic drivers of rural development. However experience has shown that their impact upon indigenous rural growth has been minimal and the associated benefits have not been forthcoming.

Alternatively, the advent of commercially available renewable energy technologies has injected renewed optimism into the RE camp. Because they are able to devolve many of the income and employment opportunities associated with energy generation to the local community, it means that pre-electrification programmes using decentralised renewable energy systems, have the potential to succeed where conventional energies have failed.

The aim of this study is therefore to assess their propensity to effect socio-economic reform via the positive benefits they procure on local employment and income distributions.

To this end, the effect of a capital investment in renewable energy generation is evaluated under a *Keynesian Income Multiplier* methodology. The model formulation attempts to capture the full income and employment effects derived from the installation, whilst also accounting for capital import leakages, induced investment opportunities, labour markets extensions and in-migration.

The model is applied to the installation of a 3MW windfarm on the Isle of Islay. To establish the economic base, Islay's existing socio-economic structure is detailed in terms of economic activity and industrial distribution, as is the windfarm's expenditure. Although the windfarm does not generate substantial long term employment effects or any significant induced investment, its local expenditure in respect of land rental is found to be highly significant. Moreover, the case study highlights the need to maximise local involvement in both the long and short term, if the capital investment is to fulfill its role as a driver of indigenous growth.

Supplementary comment is thereafter given in respect of the model's application in less developed countries, where it is noted that many of the limitations found in the Islay case study, do not present the same negative ramifications in less developed countries.

The study concludes that if renewable energy technologies are to stimulate rural indigenous growth, then it is not simply enough to reconcile a region's natural resource base with the local energy requirements, but rather, they should attempt to maximise local participation in terms of labour and/or products in both the long and short term.

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NOTE ON REFERENCING

All references are given by the author's surname and date of publication. Full details of the article or text are then given in the bibliography, as author, date, title, publication and publishers

CHAPTER 1

BACKGROUND TO THE STUDY

1.0 Introduction

Since the 1950's, *'Rural Electrification'*, (RE)[1] has been promoted by enthusiasts as being the driving force behind the development of rural areas. But whilst the majority of RE programs have focused upon the expansion of national grid networks, alternative renewable energy supply options have received little coverage, with even less merit being attributed to pre-electrification programs using decentralised renewable energy networks.

Although many qualitative studies have been realised pertaining to the social benefits of RE programs, [World bank (1975), Munasinghe (1988), Foley (1992a)] few have attempted to provide a quantitative assessment of the investment's effect on income and employment distributions within the immediate locality, [Stevenson and Jones, (1995)]. Thus, the aim of this study is to quantitatively and qualitatively analyse the socio-economic impact of a decentralised/integrated renewable energy supply network on a local economic system. To this end a multiplier model has been used to determine the net economic gains creditable to a localised energy program, with supplementary comment being made in reference to the program's effect on induced investment, education and the empowerment of women.

1.1 Rural Electrification

Rural electrification (RE), once considered to be the driving force behind indigenous rural development is now viewed in a rather different and dimming light. Early proponents justified RE investment upon a multitude of benefits, both direct and indirect; the social aspect being credited with, "*increasing agricultural production; promoting rural industry; effecting improvements in the fields of health, education, training and the standard of living in general, and generating employment opportunities which will reduce migration from the countryside to the towns.*" (Ref 1)

Unfortunately however, since that first wave of RE euphoria, many *ex-post* studies, [Foley (1992a), Raganathan (1993) and Shobowale and Kozloff (1994)] have concluded that the traditional RE programs, relying upon either isolated diesel generators or highly capital intensive grid expansions, have not assumed the catalytic role that had first been projected in *ex-ante* appraisals.

In the majority of cases load growth fell significantly short of demand forecasts; primarily because the parachute funding of the 70's and 80's, aimed at initiating RE programs, failed to focus upon the factors needed to sustain them; namely the interaction of regional employment, income generation and load growth.

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[1] The supply of electricity to small, isolated and dispersed load pockets in rural areas

Furthermore the lack of load growth substantially weakened RE's role as a catalytic driver of rural development. In all but a few cases the assumed benefits; i.e. the financial benefits in the form of revenue to the utilities, efficiency benefits such as agricultural surplus and rural industrialisation, and finally, the redistribution of benefits to the poor, have all failed to materialise. (Raganathan, 1993)

Thus, with the advent of commercially viable renewable energy technologies, utilities and energy planners can now adopt a different tack, and should question whether decentralised grids using renewable energy technologies can succeed where conventional energies have failed. If they have a greater propensity to effect socio-economic reform in remote areas, then their implementation will not only contribute to indigenous rural development, but it will also inject renewed optimism into the RE camp.

1.2 The Pitfalls of Previous RE Programs

To date the achievements of grid based RE programs has been disappointingly poor, both in terms of load growth and rural development. Even now, 20 or so years after the first RE schemes were implemented, the French research agency CIRED has estimated that the proportions of the rural population with direct access to an electricity supply are 27% for Latin America, 19% for Asia and only 4% for Sub Saharan Africa, [Menanteau (1987)]. Indeed an ILO study has confirmed the disappointing performance, stating that, "*A major impression one retains from a review of the pertinent literature and statistics is that the benefits of RE, including the social benefits tend to be overestimated and the costs understated.*" [Ref 2].

The fact is that RE by itself does not cause development, [Foley (1992a)]. Undoubtedly there is a connection, but the key to the correlation lies in the fact that no one wants electricity for its own sake. It is a *'derived demand'* which develops once people have reached a certain level of disposable income at which they want, and can afford, the services it provides. We therefore have a reversal of causalities, or rather what Webb and Pearce (1985) note as being the "*development process leading RE, rather than the other way round*" (Ref 3).

This lack of understanding has been one of many stumbling blocks facing RE programs for the past twenty years. Private or public utilities may invest in electrifying isolated communities, under some precommitment to social directives, but there is no guarantee that individuals will avail themselves to the service. Indeed in many developing countries only communal facilities have been electrified, whilst for the community at large there still exists a considerable disparity between the derived demand for energy services and actual electricity need.

In such instances, it is important to realise that it is often the low level of indigenous economic activity, coupled with the inelasticity of household demand for electricity which ultimately hamper electricity load growth. The result of this being that the ineffective demand precludes rapid change and regional development[2].

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[2] Rural electrification programmes are expensive. There are heavy initial investments and the demand for electricity tends to be low within the first few years, as a result some form of subsidy is required in the short term since few programmes are financially self-sustaining within the first 5-10 years. Consequently ineffective demand could be

1.3 The Misconception and Multiplicity of RE

The misguided notion of RE initiating rural growth stems from the definitions that have been attributed to it, Foley (1992a) characterises it in four ways:-

- *as a commodity for consumption.*
- *as a production input.*
- *as a social provision.*
- *as development infrastructure.*

Unfortunately it has primarily been the preoccupation with the former two which has partly led to the failure of many RE schemes in a number of developing countries.[Raganathan (1993)]

If RE is taken to be a productive input rather than as a derived demand, the result leads policy makers to ignore the chronology of the development process. In the medium to long term there is little doubt that electricity will enhance regional productivity, but this will only be the case if prior localised economic development has already established a substantial base of end-use diversity, within which electricity offers the least cost solution, [Munasinghe (1988)].

Furthermore, if RE is seen as a commodity, the pervasive role of income immediately prejudices lower income regions. This then tends to cause a bias towards the areas within which, the utility has a feasible chance of recouping its investment, from either the consumer or more often from government subsides[3]. As a result, previous programs have not tended to involve themselves with the development process per se, but have been "supply led"; a trend which results from the heavy bias towards the supply of productive end uses which have already established themselves following the implementation of some other catalytic rural development program[4].

Ex-post appraisals have since highlighted the sequencing of energy policy and regional development as being paramount in determining the effectiveness of RE in achieving social objectives, [Raganathan (1993), Munasinghe(1988)]. However conventional systems and traditional thinking have detracted from the possibility of simultaneously combining the two.

If a rural electrification program can simultaneously introduce additional employment, income generation and induced investment opportunities into an area, whilst delivering the electricity needed to enhance existing productive end-uses, then there is every possibility that the additional income could fuel load growth and supplementary indigenous development by overcoming the adjustment inertia which characterises poor areas.

By maximising local participation, decentralised renewable energy systems could serve as a means of devolving many of the employment and income opportunities arising from energy

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partially attributable to RE subsides being set too low. Any attempt to burden a small number of initial customers with charges which provide an adequate return on the capital investment is likely to kill-off any hope of future load growth.

[3] Whilst subsides are essential in the short term, such pricing policies have had a variety of pernicious effects. Artificially low prices do not provide the appropriate signals to consumers and thus lead to wasteful levels and patterns of electricity consumption. They deprive the utility of the funds required for effective operation and maintenance whilst starving it of the finances needed for further expansion into other rural areas.

[4] The emphasis on productive end uses stems from the expected rapid load growth in these sectors. In turn this would indicate a better cost recovery of capital investment leading to increased funds for further RE expansion.

generation, to the local community. Following which the additional local income, or rather the '*Local Value Added*' component of the program's expenditure could initiate indigenous rural growth.

This aspect of RE has so far been neglected in much of the literature; primarily because the reliance upon rural grid connected power offers little scope for local participation in terms of income generation or employment opportunities. And secondly because policy makers presumed that the imminent bulk demand (as projected by erroneous demand forecasting) would be best met by bulk supply, thus tending to bias RE programs towards grid connected power.

The advent of commercially viable renewable energy technologies therefore provides the opportunity to redress existing fuel imbalances by extending the choice of rural supply systems. In addition *ex-ante* appraisals could, in the future, provide a quantitative assessment of the program's potential impact upon regional socio-economic structures, with a view to it being numerated and included within the evaluative process. Thereafter the resulting choice of energy supply could be partially dependent upon least cost considerations but with a greater emphasis being placed upon the installation's propensity to effect positive net economic gains to the local economy. This being especially important in areas exhibiting low levels of commercial and industrial infrastructure, a shortfall of employment opportunities and/or extreme poverty, since regional incomes will be the principal determinants of future load growth.

1.4 The Economics of RE Evaluation

Traditionally, RE appraisals have relied upon a simple cost-benefit approach as described by Munasinghe (1988), according to which, programs are generally accepted on the proviso that their *Net Present Value* (NPV) of net benefits is positive:-

$$NPV = \Sigma (B_t - C_t)/(1+r)^t$$

where C = The long run marginal costs
B = The social and commercial benefits
r = The interest rate

Or that the *Internal Rate of Return*[5] (IRR) is greater than the discount rate so that :-

$$NPV = \Sigma (B_t - C_t)/(1+r)^t = 0$$

Typically this process is rooted in the utility's ability to reduce the direct costs and benefits of competing programs to a common numeraire. However, cost-benefit evaluations are notoriously problematic; whilst least cost solutions are relatively easy to calculate, the derivation of benefits necessitates the numeration of often intangible factors. The result of this being that many of the social benefits arising from the installation itself and the introduction of electricity, are excluded from the evaluation process.

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[5] The Internal Rate of Return is the discount rate which reduces the NPV to zero

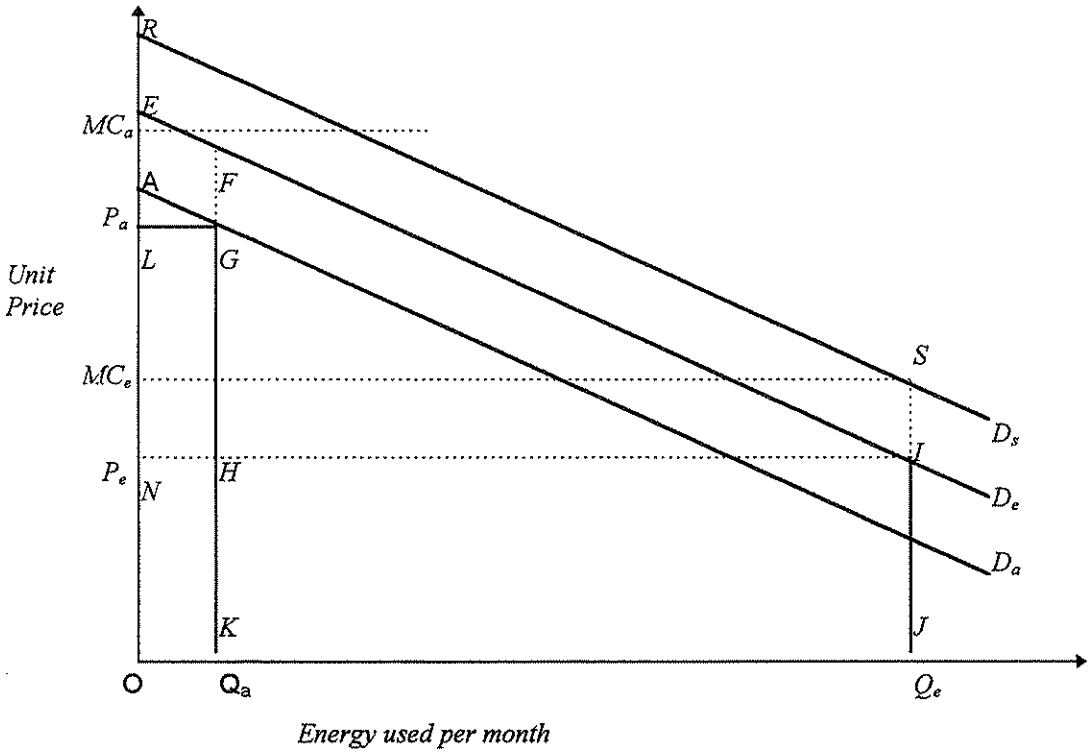
If we consider a purely static model, then the direct costs and benefits have traditionally been defined as:-

D_a = Demand curve for *alternative* energy form.
Q_a = Quantity of *alternative* energy consumed in KWh per month of electricity required to produce the equivalent output.
MC_a = Marginal cost of *alternative* energy supply.
P_a = Price of *alternative* energy supply (subsidized below MC)

D_e = Demand curve for *electricity*, shifted out due to the high quality output.
Q_e = Quantity of *electricity* consumed KWh per month.
MC_e = Marginal cost of *electricity* supply
P_e = Price of *electricity* (subsidized below MC)
D_s = Social demand curve which also includes the program's propensity to stimulate indigenous rural growth.

In accordance with conventional microeconomic theory, the benefit derived from consuming Q amount of energy is measured by the area under the respective demand curve, where the demand curve is defined by consumer's willingness to pay for the services electricity provides.

Thus the framework for measuring the net economic gain is given by :-



<u>Without an RE program</u>
$OAGK$ was the benefit derived from consuming Q_a.
$MC_a \, . \, Q_a$ was thus the corresponding cost of the energy supply

<u>With an RE program</u>
$OEIJ$ was the user benefit of consuming Q_e
whilst $MC_e \, . \, Q_e$ was the associated cost of electricity supply.

Thus the incremental benefit is given by :-

$$\begin{aligned} IB \quad &= \quad OEIJ - OAGK \\ & \qquad AEFG + FHI + Pe(Q_e - Q_a) \end{aligned}$$

and similarly the incremental costs are denoted as :-

$$IC \quad = \quad MC_e \, . \, Q_e \, - \, MC_a \, . \, Q_a$$

Finally the net benefit of RE is given by :-

$$\begin{aligned} NB \quad &= \quad IB - IC \\ &= \quad (AEFG + FHI + Pe(Q_e - Q_a)) - \; (MC_e \, . \, Q_e \, - \, MC_a \, . \, Q_a) \\ &= \quad Pe(Q_e - Q_a) \quad + \quad MC_a \, . \, Q_a \quad + \quad AEFG \quad + \quad FHI \quad - \quad MC_e \, . \, Q_e \end{aligned}$$

$Pe(Q_e - Q_a)$	$MC_a \, . \, Q_a$	$AEFG$	FHI	$MC_e \, . \, Q_e$
Sales revenue corresponding to the additional energy used	*Cost saving due to the alternative energy not used*	*Consumer Surplus*	*Consumer Surplus*	*Long Run Marginal*

By neglecting the social demand curve previous static interpretations have overlooked the socio-economic impact of rural electrification programs. Net benefits were determined on purely commercial terms, on the assumption that electricity prices would be lower than those of conventional fuels, so that net gains were based on the projected revenues derived from the incremental growth of electricity consumption. In the presence of subsidized supply this may well have been the case, but end-users must also be able to afford the equipment necessary to translate electricity provision into productive and beneficial end-uses. Thus with the benefit of hindsight, two criticisms can be directed at this approach :-

- If RE is viewed in the context of catalysing indigenous growth, then demand forecasting tends to optimistically overestimate rural load growth, and subsequently overstates the associated net benefits, [Foley (1992a)]. Indigenous load growth has been notoriously disappointing for many RE projects, therefore any future assessments should attempt to evaluate the program's effect on regional employment and income distributions, with future demand forecasting being based upon the consumer's marginal propensity to consume electricity from the additional income the installation could procure.

- Secondly no provision has been made for either:-

  ⇨The adjustment inertia which characterises many lower income regions.

  ⇨The evaluation of socio-economic benefits arising from the construction and operation of the network or the introduction of electricity. Although well documented in the literature, the qualitative social benefits have yet to be internalised within the demand curve[6], [Munasinghe (1988), Schramm (1990), Foley(1992a)].

With this said, the derivation of benefits based upon demand forecasting should be viewed with some scepticism, since they do not adequately assess load forecast uncertainties or socio-economic gains. Such disregard of demand uncertainties greatly enhances the prospects of future imbalances between the demand for power and the system supply capability, as well as erroneously biasing the selection of plant types to meet demand at least cost, [Sanghvi et al (1989)]. The advent of renewable energy technologies thus calls for a rethink of traditional methodologies, in terms of both the costs and the net benefits of rural energy.

1.4.1 Least Cost Planning

Traditionally RE programs have favoured conventional forms of electricity supply, i.e. extending national supply networks or relying upon isolated diesel generator sets. But this bias towards more monolithic electricity supply systems stems from two erroneous factors:-

- Firstly, the use of *'costs per kW of installed capacity'*, rather than the technology's long run *'life cycle costs'* within the evaluation process.
- Secondly, the presumption that bulk demand (based upon optimistic demand forecasting) should be matched by bulk supply, which is best met by grid based electricity.

The economies of scale associated with networked electricity supply mean that the costs per kW of installed power are much lower than those of renewable electricity, but taken on a life cycle basis, grid expansion is by far the most costly form of energy supply for low density, dispersed loads compared with other supply options. (Schramm 1993).

As a result much of the rural populus in developing countries are still denied access to electricity; firstly because the necessary investment costs are beyond the financial resources of the respective utilities, and secondly because energy consumption (or rather the density of energy throughput) is too low to warrant the relatively high expenditure on long run electricity supply.[Shobowale and Kozloff (1994)]

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[6] The social demand curve does attempt to include the social benefits derived from RE, but it tends not to be used. Not only is the numeration of intangible assets problematic, but it is more difficult to chart a demand curve based upon people's willingness to pay, when in most cases, local people may not have seen the benefits that electricity can induce and cannot therefore comment upon their willingness to pay for these services even if their budgets would allow them to.

Thus to confer development benefits any power generation technology must provide comparable energy services at lower life cycle costs than those of traditional energy sources. To this end, a breakdown of typical rural energy requirements highlights the suitability and cost effectiveness of a number of decentralised sources. Despite being more expensive per kW of installed capacity, the minimal operating and maintenance costs associated with renewable technologies mean that on a lifecycle basis several renewable options are now cost competitive for both non grid and grid connected power (Kozloff and Shobowale, 1994).

Indeed in many isolated rural locations renewable energy technologies will represent the optimum technical and economic solution for small, dispersed loads, since they have the potential to be tailored to future electricity demand, (especially if the program's effect upon income and employment generation is successful in driving rural growth).

1.4.2 The Derivation of Benefits

All environmental benefits aside, renewable energy technologies are able to confer a number of socio-economic benefits over their more traditional counterparts. These include:-

1.4.2.1 The Macroeconomic Benefits of Decentralised Renewable Supply Options

1. The pervasive distribution of conventional energy sources constitutes a significant handicap for many lower income countries; 8 countries hold 81% of all the worlds crude oil reserves; 6 countries hold 70% of all natural gas reserves and 8 countries have 89% of world coal reserves (IEA, 1994). Thus the use of local renewable sources, which exhibit a broad geographical distribution, will secure long run access to energy supplies at constant costs for the foreseeable future.

2. More than half of Latin America, Asia and Africa had to import over half of the commercial energy they used (Kozloff and Shobowale, 1994). Consequently a shift from imported fuels to renewable energy would stem existing hard currency outlays whilst insulating countries from any future price shocks.

3. Aside from other macro risks, the drain on foreign exchange earnings from imported energy is particularly painful for most lower income countries because their traditional exports (i.e. crops) fetch low prices in international markets. If conventional power generation expansion increases the countries dependence upon imported fuels, then this problem is likely to worsen.

4. Because indigenous renewable energies are not as exposed to international energy price volatility, as conventional fuels, then their integration into a utility's generating portfolio could promote financial stability. Indeed, in a number of cases the risk reduction may be grounds for sacrificing some economies of scale; although whether any particular diversification strategy is worthwhile will depend on the incremental costs involved. (Crousillat and Merrill, 1992).

1.4.2.2 Microeconomics Considerations

Constructing and operating small decentralised networks may offer a number of social and economic advantages over more monolithic and conventional generation facilities.

1. Renewables' modularity makes it possible to tailor them to the particular needs and circumstances of any setting. This means that they can be located closer to customer loads, thus reducing the need to invest in capital intensive transmission and distribution systems and thus minimising the transmission losses which pose a constant drain on limited financial resources.

2. Modular off grid renewable systems allow the utility to stagger capital investment to match with user load growth. In this way decentralised systems provide interim generating capacities until such time that rising demand levels justify connection to the national supply network. Thereafter, rather than sustaining localised load pockets renewable generated electricity can be used to supplement the existing fuel mix.

3. The implementation and costs of renewable technologies are extremely site specific and will depend upon a region's natural resource base. Consequently the area specificity coupled with the technology's modularity mean that the financial risks associated with mismatches between project consumption and power demand are lower with modular RE schemes than with fossil fuel installations due to the lower sunken costs.

4. Involving local people in commercialising decentralised grids will be critical to stimulating sustainable generating capacity and developing indigenous growth. Decentralised systems offer the opportunity for local entrepreneurs to be involved in adapting technologies to suit conditions, meet services needs and reduce system costs. Together such activities have the potential not only to increase local income and employment generation, but also to raise the odds of technical diffusion throughout the country and could lead to rural urbanisation.

No attempt will be made to quantify the entire social dimension as listed above, but RE's role as an engine for rural growth may be partly measured by its positive impact on local economic distributions. If an RE program is able to contribute to local income and employment generation, particularly in an area characterised by a shortfall in employment opportunities and/or extreme poverty, then the additional net gains could be identified, numerated and subsequently incorporated into the social demand curve, (D_s).

In this way a provisional choice of energy investment could be based upon the installations capacity to generate forward linkages, (in the sense that the generation of electricity could encourage investment in sectors that require it as an input) and backward linkages (the investment in sectors producing the inputs that electricity generation requires), since the interaction of indigenous growth, employment creation and income redistribution are equally important in determining future load growth and local development as the previously noted price considerations.

To this end, the following chapters will focus upon a strategy for quantitatively determining the socio-economic impact derived from a decentralised or even integrated renewable energy network. The outcome of which could contribute to pre-program evaluation processes, with a view to internalising the additional economic benefits under the social demand curve (D_s). Thereafter an attempt will be made to apply the model to an 'integrated' renewable supply option, although further consideration will be given to its application in developing countries (LDCs) with respect to decentralised electricity networks.

CHAPTER 2

LITERATURE REVIEW

2.0 Regional Impact Study

If the aim of this study is to quantitatively assess the socio-economic impact of a decentralised/integrated energy program on a local economic system, then any evaluative framework will need a regional impact model which can identify and enumerate the '*knock-on*' effects derived from the program's local expenditure. To this end the model will need to analyse the program's short and long term impact upon associated, forward and backward linkages, since the technologies and *mode d'emploi* in these sectors, will not only affect output supply and input demand, but also local employment levels and income generation. Moreover, subsequent changes in the demand and supply of other related activities could similarly result in adjustments being made in their own production techniques and employment and income distributions.

Furthermore, it should be understood from the outset that the model, rather than being a purely academic exercise, is expected to act as a integral and practical part of ex-ante energy project appraisals, therefore the context of its application present certain limitations against which models can be accepted or rejected. In the first instance regional impact studies will be both site and technology specific, therefore the pure scope of possible applications necessitates a flexible and progressive approach. Secondly the model's predictive success will hinge upon its comprehensives, yet its inclusion within a wider framework will call for a concise yet simple format yielding good results. Finally its application at local level is perhaps the most problematic factor for most models, since the required data sets may be difficult if not impossible to obtain at local or even regional level.

With this said, regional quantitative assessments of this kind are scarcely documented in current economic/energy literature[7]. Nevertheless this chapter is an assessment of the suitability of four commonly used economic models which could serve as the basis for an energy related regional impact study. They include:-

a) Input - Output Models

b) Multimarket Models

c) Time Trend Extrapolation

d) Base and Keynesian Income Multiplier Models

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[7] Research pertaining to the socio-economic impact of renewable technologies include Pearson (1984), Fluitman (1983), New York State Energy Plan (1994) and Ecotec (1995). However the aforementioned studies tend to have been realized at a national or state level whilst only the Cemmaes Impact Study (Stevenson and Jones, 1995) concentrates upon the economic impact of a renewable technology at local level.

and will be assessed according to their ability to involve both forward and backward linkages, (in terms of employment, income distributions and induced investment) and also by their flexibility, so that they may adapt to the specific milieu in which the evaluative process is to take place. (As a point of interest, an alternative model to those mentioned above is the CGE model. They have been developed for various regional economies but an assessment of their suitability is currently beyond the scope of this report. For future reference I would direct interested parties to the Fraser of Allander Institute at the University of Strathclyde for more information)

2.1 Input - Output Analysis

A programme's impact upon employment and income distributions may be extensively captured by a regional *Input-Output Model,* which empirically measures the structural inter-relationships existing between productive sectors within the local economy. Their appeal stems from their ability to identify a program's direct effects on energy source suppliers, the supplier chain displacement arising from the type (e.g. construction/machinery) and source (domestic/imported) of capital investment and finally the indirect multiplier effects resulting from changes in direct expenditure and employment. [Sadoulet and De Janvry (1995a)]

It does this by presenting a *Social Accounting Matrix,* of which the I-O model is a subset detailing all relevant inter-industry flows. They in turn attempt to relate the factor inputs required by different industries to achieve a given quantity of output. They are based on the assumption that the amount of i's output required for the production of j's output (X_{ij}) is proportional to sector j's output (X_j). Thus in order to develop a framework for modeling changes in product demand or supply, tables of coefficients are prepared, defining the inputs required for every end-product within each sector of the economy. e.g.

$$X_{ij} = \alpha_{ij} X_j$$

Thereafter, if the coefficients (α_{ij}) are represented in a matrix format (A), the multiplier can be derived by inverting the co-efficient matrix to become $(1-A)^{-1}$ (the Leontief inverse). This may then be used to establish the overall changes in sectoral outputs resulting from changes in final demand.

To date I-O methodologies have been the most favoured form of research model pertaining to the impacts of renewable energy technologies in general equilibrium analysis. Most recent studies include, ECOTEC(1995); SECDA(1994); Murray et al(1994) and Gipe et al (1993) and provide estimates of jobs generated, with respect to either monetry or energy units. One of the most attractive features of I-O analysis is that it is able to take account of jobs displaced as well as jobs created and include all direct, indirect and induced investment impacts[8]. Indeed Murray et al (1994) also considered consumption multiplier and

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[8] Indirect employment effects in the economy arise from the change in direct employment, by taking account of the 'knock-on' effect of increased employment in the firm's suppliers, and also any decreased employment which may be caused by the technology displacing employment in other technologies supplying the same final demand. The induced effect is due to the respending of wages in the general economy and results in employment changes throughout all sectors

supply side multiplier effects, whilst ECOTEC (1995) highlighted the usefulness of I-O methodologies in deriving lateral energy comparisons; for example, spending on wind energy alone would generate a net employment change of 42.21 jobs per £1M of expenditure on wind power in 2005[9]. This being some 1.7 times the employment generated by the expenditure of a similar quantity on a conventional gas turbine plant and 18% more than that for coal fired generation[10]

The analysis of net employment effects under I-O modeling has tended to be more robust and authoritative than those using empirical estimates (Richardson, 1995); but the deficiencies of the ECOTEC study highlight the need to consider all imported products within the supplier chain, if the final employment projections are to be a true reflection of linkage effects. However, once imported goods have been accounted for, I-O analysis provides a comprehensive methodology for the systematic ranking of energy programs in accordance with their propensity to effect positive changes in employment distributions. Moreover their data specifications can be manipulated and altered to accommodate sensitivity analysis and further research prescriptions.

However problems begin to arise when I-O modeling is transferred to regional analysis. Whilst the aforementioned studies existed at national level, research into the effects of renewable energy generation using I-O models have yet to permeate local impact studies. This is partly because the model specification must be adjusted to compensate for the imbalance which exists between regional and national coefficients ($x^r_{ij} \neq x^n_{ij}$), with the result that the *A-matrix* must be modified to mirror the use of imported as well as local inputs in the productive process. Although it should be noted that the difficulties associated with local I-O models will be compounded by a possible shortfall of local data, since regional economies do not compile the range of statistics found at national level.

Since the 1960's a number of studies have attempted to accommodate for regional differences by subjecting the A-matrix to a number of regional techniques; for instance Shen (1960) used *Regional Weights*, whilst McMenamin and Haring (1974) and Morrison and Smith (1974) advocated a form of *RAS Iteration* to customise the A-matrix, (although this method has since been described as having co-efficient errors that tend to be "*large and theoretically unsystematic*" (Malizia and Bond (1974), p72). Further attempts at a *Locations Quotient Model* were attempted by Round (1978) and Schaffer and Chu (1969), but both their results tended to underestimate exports and resulted in a new bias towards local supply, whilst inter regional crosshauls were buried in an intraregional interindustry matrix (Richardson, 1995).

Since then a number of attempts using an array of methodologies [*Commodity Balances* ~ Vanswynsberghe (1976), Alward and Palmer (1981); *Regional Purchase Coeffiecents* ~ Stevens and Trainer (1980) and various *Short Cut Methods* ~ Drake (1976) and Harrigon

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[9] One of the drawbacks of the ECOTEC study was that it only accounted for jobs created during the operational stage, whilst no allowance was made for the employment generated throughout the construction phase.

[10] However the main criticism of the ECOTEC study was that it assumed that all the equipment for a 590MW wind programme would be manufactured in the UK. This is unlikely to be the case, so any inclusion of national import factors would detract from the overall net gains of a windfarm program.

(1982)] have encountered similar problems and limitations, with the outcomes substituting, "computational tractability for economic logic". (Ref 4).

The difficulties of regional translations are further compounded by the shortfall of local data sets, this being even more problematic in developing countries . On the one hand, the intra-industry structure may be quite simple with many empty cells in the *A* matrix, but whilst this may facilitate the construction of input-output tables, the linear production functions may be more difficult to justify in countries/regions facing rapid change (Pearson, 1984). This being particularly the case when regional input-output models are used for policy analysis, because the major goal of regional development is to achieve structural transformation (i.e. to change production functions and hence input coefficients). Therefore it is "highly dubious whether regional multipliers in such circumstances would be stable". (Ref 5)

A further drawback of I-O modeling is that it tends to be a one shot phenomenon, in that the data upon which the co-efficient matrix is composed, is obtained at a specific point in time. Not only does this imply that its predictive capacity represents a very static picture of economic inter-relationships, but it will also mean that at any point in the model's application, the matrix of coefficients will only reflect a specific stage of technical development. Thus the process of technical change will plague all I-O research; the predicted impact of a given renewable energy technology cannot serve as an estimate for future impact studies because no provision has been made for the technological change that may take place in the interim.

In addition the ECOTEC study (1995) underlined the fact that input-output tables only relate the use of domestic intermediate inputs, thus the calculation of outputs for a given injection ignores the direct purchase of labour since it is classified as a primary rather than an intermediate input. The result of this is that the consumption multiplier generated by the expenditure of those directly employed by the project is unaccounted for.

A further point highlighted by Richardson (1995) is that I-O models tend to be demand deterministic, since they assume that supply is infinitely elastic at the cost price and that excess production exists within all sectors of the economy. This is quite unlikely to be the case for most renewable technologies because the variability of some renewable sources (e.g. wind, solar) and the rotational lifespan of others (coppice) will preclude constant supply.

Finally the fact that the introduction of electricity introduces new activities into the area only serves to complicate I-O modeling further. Miernyk (1970) highlighted the fact that the growth of a new industry producing import substitutes necessitates, firstly a major change to the existing coefficients in the *A-matrix,* and secondly the inclusion of an additional row or column. This would therefore mean that the multipliers have to be estimated from a preimpact and a postimpact Leontief inverse, with adjustments being made in each entry of the input-output table where import effects are felt. However, even after these adjustments have been made, Miernyk (1970) found that the respecified model still tended to underestimate the aggregate impact of the new industry on the regional economy because it did not measure the direct and indirect effects of induced capital investments.

Nevertheless I-O models do yield internally consistent and comprehensive estimates of future demand and supply relationships. Furthermore the greater the disaggregation, the greater the insight into the magnitude of the impact, and the sectors to which the benefits accrue. Although Munasinghe and Schramm (1983) argue that the construction of an I-O model not only requires a very substantial amount of intellectual and financial resources but also quite detailed and reliable sets of statistical data.

2.2 Multimarket and General Equilibrium Models

Multimarket models extend the analysis of price and non price policy instruments from the analysis of their impact in commodity - or factor- specific partial equilibrium models to the interactions among markets on both the product and factor sides, [Sadoulet and De Janvry (1995a)]. It does this by detailing the nature of one or more energy systems, each of which is represented by a profit function, from which are derived product supplies and factor demands. This producer core is then complemented with systems of final demand, factor supplies, income equations and market equilibrium conditions.

The model specification therefore allows one to follow the impact of costs on production, factor use, prices, household incomes and consumption, government revenue and regional balance of trade.

Although very comprehensive, no energy related impact studies have used this approach; but, as a point of reference it has been used in regional impact studies pertaining to the effects of changes in agricultural production. [Sadoulet and De Janvry (1995a)].

There are two traditions in the use of multimarket models for policy analysis. The first is of a more academic nature and is associated with Quizon and Binswinger(1986) (based upon rigorous estimation of the complete producer core and a complete system of final demand); whilst the latter is a more suitable and pragmatic approach and is associated with Bravermann and Hammer (1986), (specifies only the equations and exogenous variables of a subset of interest in the producer core and uses best guesses to quantify the necessary elasticities)

While the former has the merit of rigor and econometric validation, the latter has the advantage of serving as a quick consistency check on complex policy decisions involving trade-offs that are far from intuitively obvious. Consequently the latter approach would be more in keeping with the overall evaluation strategy of rural electrification programs.

A number of methodologies fall under the umbrella of multimarket modeling, but those involving *'Programming Techniques'* appear to be the most appropriate in meeting the needs of a regional impact study. Such models include the *Mathematical Programming Approach* derived by Brink and Mc Carl (1978) and Barnett et al (1982) and more recently the *Multilevel Programming Approach* realized by Hazell and Norton (1986)

Initially the model framework rests upon a simple utility function, where y is the vector of energy objectives. These can cover a wide range of social and commercial goals, such as profit sustainability and employment, therefore if we wanted to install an energy programme at least cost whilst wishing to maximise the system's impact upon the local economy, then these factors would be internalised within the objective function. Similarly, x is the production function associated with each of the supply options and ***K*** are the resource endowments which are a function of the exogenous natural energy resource ***R***.

Thus the optimisation of energy objectives is given as :-

$$\max u(y) \quad \text{s.t.} \quad \begin{aligned} & f(T, R, x) \leq k(R) \\ & y = f(T, R, x) \\ & x \geq 0 \end{aligned}$$

The advantage of this technique is that the varying supply options can be assessed following four distinct criteria, with the outcome being dependent upon principle government objectives.

Efficiency	Changes in real regional income
Welfare	Changes in real income levels of the poorest rural groups
Equity	The income distribution effects within the rural sectors
Political Feasibility	The real income effect on the rural rich

However whilst multimarket models have the advantage of being able to deduce the optimum energy program, satisfying a multiplicity of social objectives and of specifying in considerable detail the constraints under which energy generation will take place, the programming approach suffers from a number of difficulties.

The condition for the maximisation of the sum of the producer and consumer surplus to correspond to a perfectly competitive equilibrium is that each market is dealt with as a partial equilibrium solution. This implies that the model solution does not take account of the income generated by the sector as a shifter of the model's product demand functions. [McCarl and Spreen (1980)]

Furthermore oscillations between local and global optima do not necessarily converge and the algorith to solve a multilevel programming remains cumbersome and not necessarily consistent.[Sadoulet and De Janvry (1995a)]

A final drawback of this approach is that it tends to oversimplify the technologies involved, with no provision being made for any feedback into the system. Supply and demand linkages are simply restricted to what can be feasibly captured by a utility function with fixed factors.[Quizon and Binswanger (1986)]

In conclusion, the specification of the objective function used to derive optimum policy remains largely arbitrary and data requirements are extensive and suffer from the same difficulties as those encountered by I-O models, implying costly and time demanding research and cumbersome policy analysis

Consequently, although multimarket models provide an effective tool to evaluate policy packages according to multiple criteria and to search for alternative desirable scenario's, they are best implemented at national rather than local level, for use within an integrated national energy program. (Munasinghe 1980)

2.3 Time Trend Extrapolation

This is perhaps one of the more simplistic predictive models and consists of analysing historic growth and practices, and then predicting the development of potential projects based upon observed past trends. However, its use in renewable energy impact studies will depend upon the availability of relevant historical data, which by the very nature of renewable energies is confined to very narrow boundaries. This is because any reference to past programmes must accord with the technology and regional characteristics of the project being evaluated. To date no time trend extrapolative models have been used to formulate the impact of renewable energy investments; various field study exercises have been realied, the results of which could lend themselves to time extrapolative models. Such studies include Keuper (1995), Madsen (1995) and Jenkins (1996), but whilst being useful as rough guides thay do not attempt to assess the induced investment arising in related activities and therefore such field studies tend to underestimate the employment generated by the renewable energy industry.

The foundations of this approach are based upon the assumption that little change will occur in the growth pattern of income, employment and induced investment opportunities between programmes or experiences. Consequently any growth trends may be estimated via OLS regression or some other similar statistical method which plots variable changes against time.

The main advantage of this approach is its simplicity and modest data requirements, although it is doubtful that specific case histories will translate and adapt to new regions and improved technologies. Pachauri (1975) highlights this point, and argues that simple time trend extrapolation will only work if there are no major changes in local socio-economic activities, which could in the event, render any results invalid.

The outlook for time trend extrapolation would therefore seem bleak; despite being able to identify the correlation which exist between renewable energy investments and local economic variables, no attempt is made to establish why the trends exist in the first place. Nevertheless, a more suitable application for this approach may exist within an 'Integrated National Energy Programme', in that it may identify the strongest links between energy options and employment and income variables. Thereafter energy policies could vigorously pursue those programmes which effect the most rapid and significant changes in regional development, whilst those offering few net gains could be phased out over time.

2.4 Base and Keynesian Income Multipliers

Economic base models have had a long and checkered history, but despite this, they have never quite achieved academic respectability. The basic theory underpinning multiplier methodologies is simple. It is thought that an initial injection into a self contained economic system, whether at national or regional level will cause an increase in the level of income and/or employment by some multiple of the initial investment. Their appeal, and indeed their staying power stems from their ability to define separate employment and income effects creditable to capital investment injections. As a result they have been a favorite tool in many regional econometric models since the 1960's, with great advancements being made in their formulation through compound applications.

The table below displays a very basic specification of each multiplier model. They provide the basis upon which researchers can build and channel models to suit specific applications.

Economic base $K^B_r = 1/(1-e_r)$

Keynesian Income $K_r = \dfrac{1}{(1-c^* -\Sigma m_{sr})(1-t_r)}$

where n sectors (i,j,.....), z regions (r,s,.......)

e_r	Marginal (average) propensity to spend locally in region r
c^*	Marginal (average) propensity to consume in region r
m_{sr}	Marginal (average) propensity to import of region r from region s
t_r	Marginal tax rate
K^b_r	Economic Base Multiplier
K_r	Keynesian Income Multiplier

Economic base models are derived from the entity $Y \equiv EB + NB$ (basic plus non basic activity) and $z=f(NB + eY)$ which together imply that the multiplier can be estimated if Y and EB are known. The major issue involved with base multipliers has therefore been the measurement of EB with a view to calculating NB as the residual form $(Y-EB)$ and the calculation of the marginal propensity to spend (e) thereafter. Once these have been estimated the multiplier may be defined as $1/(1-e_r)$, although its validity depends upon a number of restrictive assumptions such as linearity, homogeneity and the existence of excess capacity.

Keynesian multipliers are formulated in much the same way although they tend to be alot more comprehensive since they are income determined. The appeal of both these forms lies in their simplicity and flexibility at regional level but the crux of their success lies in the derivation of the economic base.

This has been the subject of much debate since the 1960's, with the result that a number of techniques have been implemented to establish the *EB*. These include the ***Location Quotient*** ~ Gibson and Worden (1981), Isserman (1980), Leigh (1970); ***Consumption Location Quotient*** ~ Nordcliffe (1983); ***Minimum Requirements*** ~ Ulman and Dacey (1960), Pfister (1980) and finally ***OLS Regression*** ~ Mathur and Rosen (1975). However it is still thought that the best indications of regional economic activity are given by *Census Survey Details*, but the gathering of such data sets tends to be "awkward, time consuming and expensive". (Ref 6).

Consequently the predictive success of multiplier models rests on the validity of economic base interpretations, these can be quite difficult to establish therefore the outcome of most multiplier models should be viewed with some caution.

Nevertheless one of the most attractive features of the Keynesian income multiplier is its flexibility. Although primary model specifications attempt to mirror existing industrial and commercail structures, in subsequent rounds their formualtion may be easily adapted to reflect changes in local socio-economic structures. Such feedback effects include labour market extensions [Ledent (1978)]; induced investment [Grieg (1971)] and the introduction of new industries and firms [Wilson (1977)].

Ledent's model of 1978 was able to estimate multipliers that quantified the impact of changes in basic employment on total employment, net migration, regional population, unemployment and labour force participation. Further studies by Plaut (1982) and Polese (1978) also found that the size of the base multiplier depends upon the elasticities of labour demand and supply and the induced population growth (ie in-migration) resulting from an initial change in basic employment. Both models concluded that labour market considerations generate a much larger multiplier than the standard formats, whilst Polese also underlined the fact that inward migration generates labour demand in addition to labour supply. Thus the size of he net effect will depend upon local economic growth and labour market conditions.

Furthermore, several British studies [Ashcroft and Swales (1982); Blackwell (1978); Brownrigg (1971, 73); Gordon (1973); Grieg (1971a, 1976)] have explicitly taken account of, or suggested the importance of migration effects and other aspects relating to the source of supply of labour in Keynes employment and income multiplier models. Moreover they also argue that it is very important to differentiate between first round and subsequent multiplier effects, especially when different types and sources of labour have been identified. This point is especially important in models analysing highly technical industries, since it is doubtful that rural labour markets will have the required skills base to complete the job. The shortfall of skilled labour then raises the question of a labour influx, albeit a temporary one. The adopted model must be able to reflect such labour market movements since any in-migration to a small area will have a significant impact on induced investment and indigenous growth.

A final attraction of multiplier methodologies stems from their ability to involve both spatial analysis; by using gravity model effects, studies can measure how the multiplier impacts can decay over space. Erickson (1977) was one of the first to use a standard regional income multiplier in conjunction with procurement and commuting effects, the result of which concluded that the income multiplier declined with the distance from the plant. A later study by Richardson and Gordon (1978) compounded this result, but highlighted the fact that employment impacts could be felt for as far as 38 miles, which served as a warning against measuring multiplier impacts within too narrow a radius. This point is particularly noteworthy since the outcome of any spatial multiplier could define the geographical range of any induced investment opportunities. Indeed the regional impact study commissioned by the Cemmaes Windfarm project (Stevenson and Jones, 1995) found that whilst only £300,000 accrued to the 'Travel to Work Area', the regional economy profited to the tune of £2.5M.

A final point of interest is the contentious issue of whether multiplier models are long or short run; although this now seems to have settled down with most analysts favouring the former. In contrast, a number of studies have attempted to express long run multiplier interpretations by the imposition of a distributive lag structure, [Moody and Puffer 1970); Moriarty (1976); and Cook (1979)]. However the arbitrary imposition of a particular lag structure and the frequent use of annual data make the results highly dubious regardless of the position they favour.

Whilst we would welcome a long run forecast of projected impact effects, the effects of the later rounds would seem somewhat marginal if the research of Henry and Nyankori (1981) is proved to be correct. They found that 56% of the total impact had occurred by the end of the first quarter whilst Ashcroft and Swales (1982) have argued that the first round of the multiplier is crucially important. Firstly because the initial injection is very sector specific and secondly because an error in the first round estimate will lead to wrong estimates of the size of subsequent rounds.

In conclusion economic base and Keynesian Income models provide a very flexible and simple approach to regional impact studies, and although they are not always accredited academically, they nevertheless serve as practical and logical models for practical applications. However its adoption must be assessed according to whether its simplicity justifies sacrificing an element of precision in the determination of the economic base, (EB).

2.5 Conclusion

Having given a brief overview of the competing models and their suitability to local impact studies, it would appear that the regional and technological factors are the main stumbling blocks for the majority of the models reviewed.

The disaggregation of I-O models, coupled with their ability to identify both the forward and backward linkages would make them the most suitable choice for regional impact assessment. However their case is substantially weakened by the statistical limitations posed at local level, and the intellectual and financial demands that the model places on the evaluation process.

Multimarket models have their advantages but the specification of the objective function remains purely arbitary and open to mispecification;, whilst the site-specificity of supply options and their characteristic impact on local economies precludes the use of time trend extrapolation.

Therefore it would appear that the most suitable model for use in a local impact study is the Keynesian Income multiplier model. Although it tends to be less comprehensive than the aforementioned models, it is progressive in style and can adapt to maximise the use of limited data sets, and to accomodate economic feedbacks resulting from capital investment, (e.g. in-migration, induced investment and labour market extension may concur with the program's development).

The subsequent chapter will therefore concentrate upon the formulation of a regional income model which may be used to investigate the socio-economic impact derived from the capital investment in a renewable energy supply system.

CHAPTER 3

THE MODEL

3.0 The Derivation of Socio-Economic Impacts

Having chosen the *Keynesian Income Multiplier* model as the basis of an energy related regional impact study, its specifications must now be refined and partially modified to accord with our particular research goals. Consequently an attempt will be made to construct an economic model which can determine both the extent and magnitude of an energy programme's short and long run effects on the local economy, including any induced capital investment that may arise from in-migration and additional consumer spending.

A primary point of discussion should be the exact boundaries of the impact study, since regional definitions by themselves, are quite vague, and to some degree are slightly misleading. Thus the regional impact study will concentrate upon the immediate economic system, the boundaries of which are defined by what Stephenson and Jones (1995) refer to as '*The Travel To Work Area*'[13]. It is expected that this area will be defined by:-

- A self contained labour market, which extends to the point beyond which it becomes unfeasible to work at the plant due to geographical distances and excessive journey times..
- A local economic system, within which the majority of local disposable income is spent.

In establishing separate income and employment effects, the chapter is subdivided into an analysis of each, paying particular attention to both the short and long run effects and the direct and indirect impacts of the capital investment injection. Moreover supplementary comment is also given in respect of additional factors which may be particularly noteworthy at local level.

The model specification will concentrate upon an industrialised country application at first, although supplementary comment will be given in subsequent chapters regarding the necessary adaptations required for an application of the approach in Less Developed Countries (LDCs).

3.1 The Model

The basic theory underpinning multiplier methodology is simple. It is thought that an initial capital investment into a self-contained economic system, whether at national or regional level will cause an increase in the level of indigenous income and/or employment opportunities by some multiple of the initial investment.

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[13] Although it should be noted that confining the expansion to too narrow a radius may limit the economic gains derived from multiplier expansion. [Richardson and Gordon (1978)]

However the application of this approach within regional impact studies, coupled with its reference to renewable energy technologies, mean that the process of capital investment and subsequent multiplier expansion become a little more contrived.

Renewable energies have traditionally been sited in remote, rural areas,[14] whose economies are primarily characterised by low levels of indigenous economic activity. As a result the local economy and the multiplier expansion are expected to suffer from comparatively higher capital leakages than those incurred by urbanised/industrialised centres. Thus the exact magnitude of any capital outflow will depend upon :-

- The region's existing goods and services base.
- available excess capacity.
- the indigenous labour force.
- the subsequent skills base of the indigenous labour force.

3.2 The Income Multiplier

The translation of the Keynesian multiplier to a regional formulation will assume that the level of investment (I), and regional exports (X) will all remain autonomous and constant over time[15]. The proportion of government expenditure allocated as income to public sector employees (G') is considered to be endogenous to the model whilst the remaining element is taken to be autonomous (G).

Therefore at a regional level if :-

Y	Regional Income
C	Local Consumption
M	Regional Imports
Y_d	Regional Disposable Income
I	Investment
c^*	Marginal propensity to consume locally

And the leakages within the regional economy are defined as:-

t_d	Direct tax rate
t_i	Indirect tax rate
m	Marginal propensity to import goods and services manufactured outside the area

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[14] Cases in point include windfarms or photovoltaic installations.

[15] Treating (I) as autonomous is reasonable in this context, since it is unlikely that remote regional exports are sensitive to small changes in the level of income in the rest of the country

λ Income of public sector employees expressed as a proportion of total income
u Proportion of unemployment benefit to income

Then the traditional formulation assumes the following relationship:-

$$Y = G + G' + I + C + X - M$$

where

$$C = a + c^{*}Y_d$$
$$Y_d = (1 - t_d - u)Y$$
$$M = b + mC$$
$$G' = \lambda Y$$

Thus by substitution and rearrangement the regional income multiplier is defined as:-

$$k_i = \frac{1}{[1 - \lambda - c^{*}(1-t_d-u)(1-m-t_i)]}$$

In which case any change in the level of regional income (ΔY_r) may be denoted by :-

$$\Delta Y_r = k_i J$$

Where J is the capital investment injection arising from the installation of the energy program.

Despite the difference of techniques adopted, this is the simple multiplier framework used by the majority of regional impact studies, [Grieg (1971a), Brownrigg (1971), Gordon (1973)] . The model in itself is quite simple, but the crux of the regional interpretation lies in:

- The estimation of the economic base to establish the relevant coefficients.
- The re-specification of the model to accommodate the social and economic structure of both the local economy and the renewable energy programme.

Normally regional multipliers have tended to lie within the range 1.19 - 1.54 [Archibald (1967), Steele (1969), Grieg (1971), Hodge & Whitby (1977)] but ultimately the size of multiplier for any given area will depend upon a number of factors, including regional boundaries and how they are drawn; the industrial structure; the local labour market and the respective social and economic characteristics of the area. All of which impact upon the relative value of the various multiplier leakages, particularly the important import leakage.

3.3 Regional Characteristics

If the renewable energy installation is sited in a remote or rural area, (as has often been the case for windfarms and bioenergy plants) then the regional income multiplier will be subject to a higher percentage of capital outfow than that experienced in urbanised or industrialised centres.

Remote rural areas are often characterised by unskilled labour markets and low levels of industrial and commercial infrastructure, both of which, give rise to a greater proportion of regional consumer imports. This, when coupled with the highly specialised nature of the majority of renewable technologies will mean that:-

- The impact of the investment and the magnitude of the multiplier expansion may not be as large as was first anticipated .
- The plant's role as a catalyst for regional growth may be constrained by the very structure that it is attempting to enhance.

Thus to accommodate the often underdeveloped economic structure of many rural areas a number of modifications must be made to the original income formulation,

$$(\Delta Y_r = k_i J).$$

3.3.1 Injection Leakages

As it stands the original formula already incorporates regional imports via the import variable (m), thus accounting for the proportion of goods and services imported into the region from outside the immediate locality. However, it should be acknowledged that the initial capital investment in the energy programme may also be subject to leakages prior to multiplier expansion. These may take the form of insurance costs, project commissioning, feasibility studies etc., and can result in serious ramifications for the multiplier expansion; so much so that if *"the industrial structure of the region is such that its capital goods industries are little developed, then it is conceivable that the only part of the injection to pass through to the multiplier would be the wages and salaries of firstly the construction workers and later the maintenance and management crew"*. (Ref 7)

Inevitably the installation of a renewable energy technology will be particularly vulnerable to capital leakages of this kind, since not only are the labour requirements highly sector specific but it concerns the installation of highly specialised technologies. The result of this being that, both labour and fixed capital will have to be bought outside the area, so the expenditure on external factors of construction and production cannot be included within the multiplier expansion.

Thus if (m^*) is taken to represent that proportion of the initial investment which is spent on goods and services outside the area, then the model may be re-specified in the following way:-

$$\Delta Y_r = k_i J(1-m^*)$$

Implying that $(1\text{-m}^*)^{16}$ will represent that portion of the investment's expenditure which will impact upon the local community, or rather the Local Value Added (LVA) component of the programme's expenditure.

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[16] This is most commonly identified as Local Value Added, and represents that part of the programme's expenditure which can be subjected to multiplier expansion

In a critique of the multiplier process Wilson (1968) underlined the fact that if the value of m^* is taken to be equal to m in the income multiplier, (say 0.5 for instance), then it is quite plausible that :-

$$\Delta Y_r = k_i\, J(1-m^*) < J$$

Thus indicating that if there is a significant import leakage in the initial injection, then the final multiplied income expansion could be less than the original investment expenditure.

This problem is expected to typify the majority of capital investments in renewable energy technologies and will be particularly acute in the short run when fixed capital expenditure constitutes the greater part of the energy programme's spending.

3.3.2 Induced Investment

Archibald (1967) and later Wilson (1968) also identified the need to further incorporate the multiplier accelerator relationship of a feedback effect from induced investment. Initially I and G are taken to be autonomous but it is argued that as income and expenditure rise through multiplier expansion, then the additional income procured may induce further investment, especially if excess capacity is unable to sustain increased consumer spending. Moreover, this point is particularly relevant if the process of income generation is based upon the interaction of income, expenditure and additional employment in both the private and public sector. In which case it is reasonable to expect a degree of induced capital investment in increased capacity within both these sectors to support the employment generated by increased spending.

The first attempt to include this modification was made by Archibald (1967), who assumed that the initial injection took the form of wages paid to employees, all of whom were immigrants to the region. Thus the annual induced investment (ΔN) would be given by:-

$$\Delta N = n\Delta Z$$

Where ΔZ is the total annual earnings of immigrant employees and n is the induced investment co-efficient.

In his model the capital injection represented employee earnings, all of whom were immigrants, implying that Archibald's ΔZ is identical to the original investment J in the our modified model. Thus if $\Delta Z = J$, then by introducing the induced investment component into the model and subjecting it to multiplier expansion, the model is denoted by:-

$$\Delta Y_r = k_i J + k_i \Delta N$$

$$\Rightarrow \quad \Delta Y_r = k_i \Delta Z + k_i \Delta N$$

which when substituted will yield:-

$$\Delta Y_r = k_i(\Delta Z + \Delta N)$$

$$\Rightarrow \quad \Delta Y_r = k_i(\Delta Z + n\Delta Z)$$

$$\Rightarrow \quad \Delta Y_r = k_i(1+n)\, \Delta Z$$

Now if we are to incorporate this methodology into our model for use in a situation where there is likely to be a large proportion of non immigrants due to a partial reliance upon local labour, (i.e. $\Delta Z < J$) then the addition of the induced investment component will yield:-

$$\Delta Y_r = k_i J(1-m^*) + k_i \Delta N$$

and if $\Delta N = n\Delta Z$ then by substitution we have:-

$$\Delta Y_r = k_i \, [J\,(1-m^*) + n\Delta Z\,]$$

Where n is the induced investment co-efficient and $n\Delta Z$ represents the induced investment arising from the direct expenditure of immigrant employees.

3.3.3 Short and Long Run Effects

As yet the above equation fails to identify the two separate elements contained within J, notably the short and long run capital injections, which relate to the construction and the operational stages of the investment respectively[17]. If we sub-divide the capital investment, then the primary investment injection J_1, will constitute the construction phase, or rather the short run effect, and will include all the capital expenditure on all goods and services during that time. Alternatively the long run impact will be determined by the annual flow of income arising from the operational stages of the plant, namely J_2 and subsequent rounds of $J_3, J_4, J_5 \ldots\ldots J_n$[18].

In view of the relatively high sunken costs associated with energy related capital investment, it is expected that the initial first round multiplier process will be the dominating influence, in spite of the higher import leakages incurred during that stage. Indeed, the majority of studies pertaining to other developments have also found that the first round process is of greater magnitude than that of any other round and is particularly sector specific. Therefore it is particularly important that the first round multiplier expansion should be estimated correctly, (Sinclair and Sutcliff (1978)) although some other authors, (Brownrigg (1971), Grieg(1971)) have tended to ignore it.

The construction phase for renewable energy technologies is disappointingly short compared to conventional fuel generating systems, with the result that J_1 is not expected to extend beyond 1 or 2 years. Nevertheless its exclusion could severely understate the income and employment multiplier effects during the crucial first round[19].

In separating the project phases it would be pertinent at this point to underline the fact that when considering the problem of capital injection leakages, our previous allowance for

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[17] There has been a long standing debate regarding whether the entire multiplier effect is a long or a short run phenomena, with the majority of analysts favouring the latter. Nevertheless whilst we acknowledge the short run status of multiplier effects as a whole, for the purpose of this study , the construction stage is dented as the short run, whilst the operational stage is deemed to be long run.

[18] n being dependent upon the expected lifetime of the renewable energy installation

[19] This being especially the case if the construction stage continued for any significant length of time.

induced investment should only be applied to J_1 rather than to $J_2 \ldots J_n$. This is because if we assume that the construction stage will not exceed 1-2 years, then we would expect the majority of labour immigration to take place over the first year. Consequently, following the construction of the plant we would expect the induced investment on capital provision (initiated in response to increased consumer spending) to peter out after the first year or so because any further induced investment on capital provision would be surplus to requirements once the immigrants needs had been met.

A further point of discussion is that if the plant employs a continuous flow of immigrant labour, then suitable weights should be attached to the induced investment co-efficient to reflect the exact percentage of total immigrant labour needed for that stage.

Returning to the very first modification, the capital investment is divided to yield:-

$$\Delta Y_r = k_i J_1 (1 - m^*) + k_i J_2 (1-m^*)$$

Leading to:

$$\Delta Y_r = k_i (1 - m^*) [J_1 + J_2]$$

After which, an injection leakage should be equally applied to the induced investment component[20]. Thus, if we include the induced investment element into our model, then the change in regional income is given by:-

$$\Delta Y_r = k_i J_1 (1 - m^*) + k_i J_2 (1 - m^*) + k_i \Delta N (1-m^*)$$

which becomes

$$\Delta Y_r = k_i (1 - m^*)(J_2 + J_1 + n\Delta Z)$$

We are now left with a model that separates both the long term and short term effects. Furthermore it also takes account of both the in-migration of labour (if the existing skills base is unable to supply the necessary skills for the installation of the plant) and the induced investment arising from the original capital injection.

The re-specified model is without doubt problematic in its requirements, with the major difficulty being the estimation of the induced investment coefficient (n), whose magnitude will depend upon:-

- The degree of regional excess capacity.
- The variety of lags relating to consumers expenditure and suppliers' reactions
- The size and industrial structure of the region.

Thus any shortfall of regional data will render the estimation of the relevant co-efficients an almost impossible task.

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[20] Whether the induced investment component exhibits the same LVA content as the energy programme's capital expenditure is undetermined at this time and will depend upon the specific requirements of the induced capital investments and the area's ability to service those investments.

3.4 Further Comments and the Final Model

To conclude, it is expected that the import coefficient will have a rather more marked and serious effect upon the construction stage rather than the operational phases and will have serious and obvious effects on the income generation potential of induced investment. Indeed this interaction highlights three very important elements in the multiplicand.

Firstly, the total annual earnings of immigrant employees (ΔZ) will be a proportion of J_2, in line with the dependence on immigrant labour, such that

$$\Delta Z = zJ_2$$

substituting this back, the restated and final model becomes:-

$$\Delta Y_r = k_i\,(1 - m^*)\,(J_1 + J_2(1 + nz))$$

where	m^*	The capital outflow from the investment injection
	n	The induced investment co-efficient
	z	The dependence on immigrant labour

so that it has the benefit of specifying more clearly the immigration source which induces the investment in question. In addition it also facilitates sensitivity analysis by simply allowing one to change the value of variables in accordance with further research prescriptions.

Regarding the value of z, if we recall the estimation of n, we highlighted that the annual total of induced investment is not related to the final proportion of J_2 earned by immigrants at the end of the period of immigration but to the total earnings of any one year's group of immigrants. The same methodology therefore applies to the derivation of z, (eg. if immigrants make up 30% of labour over a 5 year period then $z \neq 0.5J_2$ but $z = 0.1J_2$ assuming a constant influx over time).

Secondly since immigration will typically be biased towards the more professional posts then, z cannot simply be taken as the proportion of immigrant persons in the labour force, but it must be weighted to take account of the skill differential and thus the higher income received where this is the case.

Finally to conclude the model specification, once the initial capital expenditure or construction has been realised, the influx of immigrants has ceased and their capital requirements have been met, ΔN will drop out of the multiplicand as has J_1 at an earlier stage, allowing the model to revert to a simple

$$\Delta Y_r = k_i\,J_n$$

3.5 The Employment Multiplier

To a great extent the estimation of the employment multiplier is a little more problematic. Essentially the impact of an energy program upon employment can be divided between direct and indirect effects; the former relating to the persons directly employed by the plant and resident in the area, and the latter relates to the employment resulting from direct expenditure by the plant and by its employees.

In order to define the employment relationship the following variables may be used in conjunction with those used in the derivation of the income effect. Therefore:-

E	*Total employment*
E_d	*Local Direct employment*
W_d	*Average earning of DIRECT employees*
W_p	*Average earnings of PUBLIC SECTOR employees*
l	*Increase in Local Value Added (LVA) necessary to create one extra job in the service trades*
θ	*Ratio of public service employees to direct employees*
s	*Marginal propensity to save*
t_d	*Average direct tax rate and NI contributions*
m	*Marginal propensity to import*
t_i	*Indirect taxation*
v	*Proportion of an increase in income which is local value added (LVA)* $v = (1-s-t_d)(1-m)$
ΔV	*Increase in LVA created by direct employees* $\Delta V = E_d . W_d . v$

Direct employment at the plant will very much depend upon the renewable energy adopted and its subsequent short and long run labour requirements. In the long term it is expected that the implementation of a renewable energy technology will create relatively few direct jobs within the immediate locality, this being primarily due to the minimal operating and maintenance requirements during the operational stage. Consequently we would expect the first round multiplier expansion to exceed that of any subsequent round.

Furthermore in both stages of the investment it is expected that not all direct employees will be employed at the plant itself. Indeed the distribution of employment types will cover a range of professions from manufacturing and project planning, to financial and engineering. Consequently in determining the extent of local direct employment opportunities (E_d) we should preclude all those direct jobs which do not take place locally, since they will have little or no direct impact upon the local economy. Whilst those employed and based locally, will require additional public services and whose expenditure on local goods and services will generate extra income and jobs in private service trades.

3.5.1 Direct and Indirect Employment (Phase 1)

It is thought that the initial stage of the investment injection, namely the construction phase will have a substantially larger impact upon the local job market than any subsequent round, although it is expected that the main construction contractors will rely upon a core body of workers who are not locally based. . To gauge the extent of this effect the number of direct employees may be obtained from the project outline itself or the accounts of other investments which have implemented similar technologies of similar size and in similar surroundings.

Conversely various studies using I-O table shave derived estimates of labour requirements per TWh, but whilst they are useful as tentative estimates of potential employment impacts, they remain a static interpretation and only reflect a specific stage of technological development and will not allow for any change in productive techniques which may take place over the lifetime of the plant. Moreover they are unable to distinguish between 'head office' and local employees therefore any estimate of local employment made on the basis of these figures will be subjective at best and woefully misleading at worst.

To derive the indirect effect resulting from the construction stage we must determine the change in indirect employment at the completion the first round. This will need to consider the number of direct employees, their impact upon local value added and any potential increase in the local workforce as well as their subsequent effect on the total local population. This may be expressed as follows:-

$${}^{1}E_i = {}^{1}E_d\,\theta + [(\Delta V)/l](1 + \theta)$$

Where ${}^{1}E_i$ is the indirect employment created in the 1st phase of the development (construction)

and ${}^{2}E_i$ is the indirect employment created in the 2nd phase of the development (operation)

3.5.2 The Regional Employment Multiplier

For subsequent rounds the overall increase in indirect employment ($\Delta^{1}E_i$) generated from the expenditure of direct employees during construction is given by the first round increase in employment ($\Delta^{1}E_i$), plus subsequent round income generation, divided by the weighted average of income increases (l & w_p) necessary to create one extra job in private and public services.

Assuming θ now becomes the ratio of public services to total employment, (θ_1) we have:-

$$\theta_1 = [\theta/(100+\theta)].100$$

then the total increase in employment, attributable to the project is given by:-

$$\Delta^{1}E_i = {}^{1}E_d\,\theta + \{(\Delta V)/l\}.(1 + \theta) + \{{}^{d}E_d\,w_d\,(k_l - 1)\} / \{l(100-\theta_1)+w_p\theta_1\}$$

The above represents the total increase in employment attributable to the first stage of the project. To derive the total employment multiplier the process must be repeated with respect to the direct labour employed throughout the operational stage of the project. Only when we have determined both Δ^1E_i *and* Δ^2E_i can we deduce the overall employment multiplier which is given by:-

$$k_e = 1 + \{(\Delta^1E_i + \Delta^2E_i) / ({}^1E_d + {}^2E_d)\}$$

Therefore the total increase in employment attributable to the project is given by the employment in the plant itself $({}^1E_d + {}^2E_d)$ and the indirect employment arising from each stage $(\Delta^1E_i + \Delta^2E_i)$.

Grieg (1971) argues that this approach is still likely to underestimate the true employment opportunities arising from the investment since it makes no provision for immigrant workers. Invariably some employment may not be related to increased income but rather increased population and hence to increases in employment. In particular the employment in the public services which is proportional to the regional workforce. This interaction is particularly important when considering the provision of education and the empowerment of women who are more likely to work in the service sector industries.

In conclusion it would appear that direct employment and expenditure from the first round will create additional employment and income in both public and private sector services; secondly the expenditure of indirect income resulting from the first round will generate additional jobs (mainly in the private sector), finally these employment additions will also require further public sector services thus creating the multiplier effect. However as with the income multiplier, the magnitude of the expansion will depend upon both the labour requirements of the technology and to some extent the import leakage of goods and services within the area.

CHAPTER 4

THE CASE STUDY

4.0 The Case Study

The model derived in the previous chapter will now attempt to assess the income and employment effects procured by the installation of a renewable energy program on the Isle of Islay, just off the west coast of Scotland.

Research commissioned by United Distillers (ETSU 1995) has already established the need for a supplementary electricity supply[21], and has further identified a number of indigenous renewable energy supply options which could serve to alleviate the expected network pressures posed by future load growth, and to supplement existing energy imports.

The conclusions drawn from this study form the basis of this chapter whilst the main body will devote itself to investigating how the chosen technology may impact upon the socio-economic structure of the region.

The impact of both the construction and operational stages of the development are examined in terms of primary and secondary income generation as well as the sales from regional and local businesses. This is then followed by a discussion of the long term impact on the local economy resulting from the plant's operational expenditure with supplementary comment concerning economies of speculation, *vis a vis* indigenous growth and derived demand.

4.1 The Local Economy

In order to provide a context within which the economic impact of the development can be evaluated, the existing structure, performance and sensitivity of the local economy is examined. From the outset it should be understood that the local economy is defined as being that of the Isle of Islay, although I acknowledge that the Isles of Jura and Colonssey lie in close proximity. Localised and self contained labour market data is used wherever possible but when this is unobtainable it is necessary to refer to district (Argyll and Bute) or regional (Strathclyde) level[22].

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[21] This research has already characterised the island's energy supply and demand patterns, coupled with an outline of possible electricity distribution problems which could result from future load growth.

[22] Consequently some of the estimated parameters should be taken as a tentative first estimate of the possible effects that the development may procure. Moreover particular care should be taken when any interpretations are drawn from Strathclyde statistics.

The island itself lies just off the west coast of Scotland and is connected to the mainland by a 2 hour ferry crossing, therefore it is expected that all those who work on the island are also resident there. (See fig. 4.a)

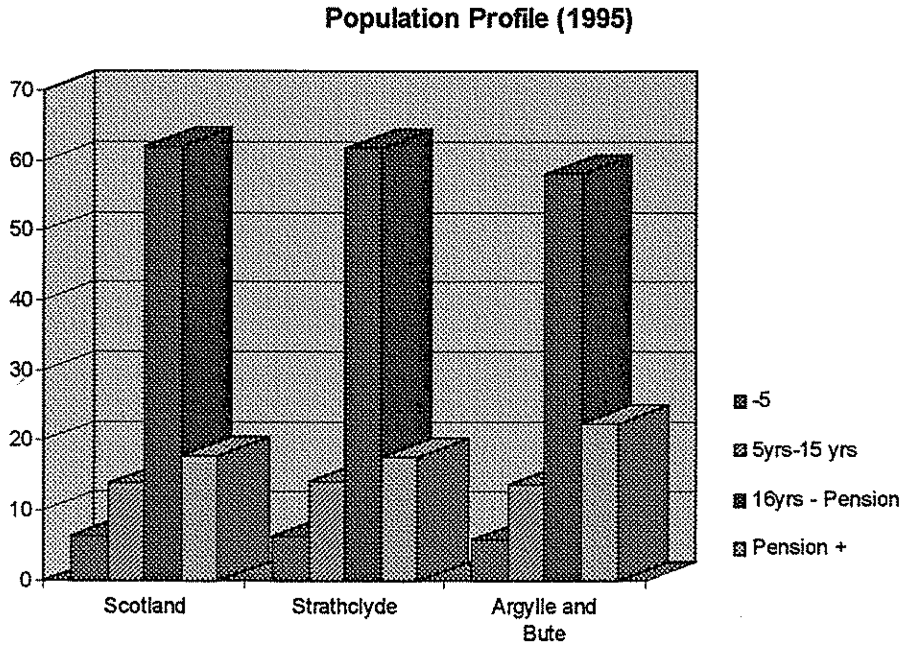
4.1.1 Population and Labour Force Participation

The Isle of Islay has a resident population of only 3500 people, having one of the lowest population densities within Scotland, at 10 persons per square km.

Figure 4a. ***The Isle of Islay***

The regional population profile is detailed below (Fig 4.b) and assuming Islay's age distribution is representative of district trends then it appears that almost a quarter (22.4%) of the population are 65 or over, this being significantly higher than the Scottish Average (17.8). Conversely at the other end of the spectrum the island has relatively fewer young people and working age adults.

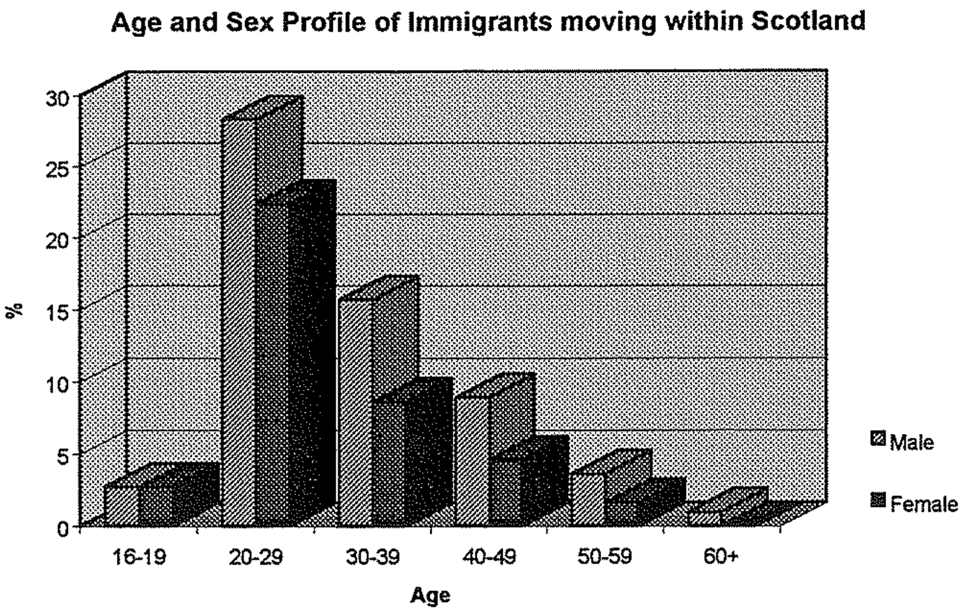
Fig 4.b



Source:* *Regional Trends (1995)

Furthermore, the Argyll and Bute area has experienced a steady exodus of almost 3% between 1981 and 1993, [Regional Trends (1995)]. This, together with statistics regarding migration flows within Scotland (which exhibit a marked bias towards the younger age categories; see fig 4.c) would seem to suggest that such structural population differences may have existed for some time. Indeed 11 of the 19 local districts within the Strathclyde region have experienced significant population losses between 1981 and 1993, ranging between 2 and 12%.

Fig 4.c



Source: Census of Population (Migration Studies, 1991)

Day (1995) suggested that the persistence of the age profile may be symptomatic of deeper economic pressures, which could mitigate against population stability. Indeed, regional trend figures indicate that similar experiences permeate other remote rural areas or where "the underlying economic base is unable to sustain the population or at least provide income and employment opportunities commensurate with those available elsewhere". (Stevenson and Jones 1995, p.8).

Inevitably, given the comparative ease of population and labour mobility within the UK, it is unsurprising that Islay, along with other similar 'economically disadvantaged' areas have fallen prey to migration and depopulation.

Indeed current self contained labour market statistics obtained from "*Argyll and the Islands Enterprise*" indicate that Islay is in the unfortunate position of having the highest unemployment rate within the Argyll and Bute area. At a level of 11.9% it appears to exceed both the regional and national averages which stand at 10.3 and 9% respectively.

Activity Tables for the district portray a similar story, in that the number of people registered as being economically active at national level exceed those for the Argyll and Bute district. In short, the statistics indicate that Islay and its surrounding environs suffer from a higher than average level of unemployment, which, taken *prima facia* has contributed to the depopulation of the area.

Undoubtedly the island has much to gain in employment terms from the advent of a renewable energy installation which could generate significant income and employment multipliers. Indeed the merits could be twofold, firstly by creating direct employment and indirect employment via primary and secondary income generation and secondly by partially stemming the migratory trend of the younger populus.

4.1.2 Industrial Distribution of Employees

As highlighted previously the income and employment opportunities indigenous to the island can and will exert huge pressure upon migratory trends, with any shortfall contributing to labour migration.

Looking at the distribution of employment across the main sectors of economic activity, it appears that the Strathclyde area exhibits a higher than average dependence upon the service trades (Table 4.d). This being a trend mirrored in the majority of rural areas. Using the location quotient, which is a crude indicator of the relative importance of an industry to the local economy we can see that the manufacturing and service industries are as equally important locally as they are nationally, whilst it would suggest that the primary industries are not a significant contributor to the local economy.

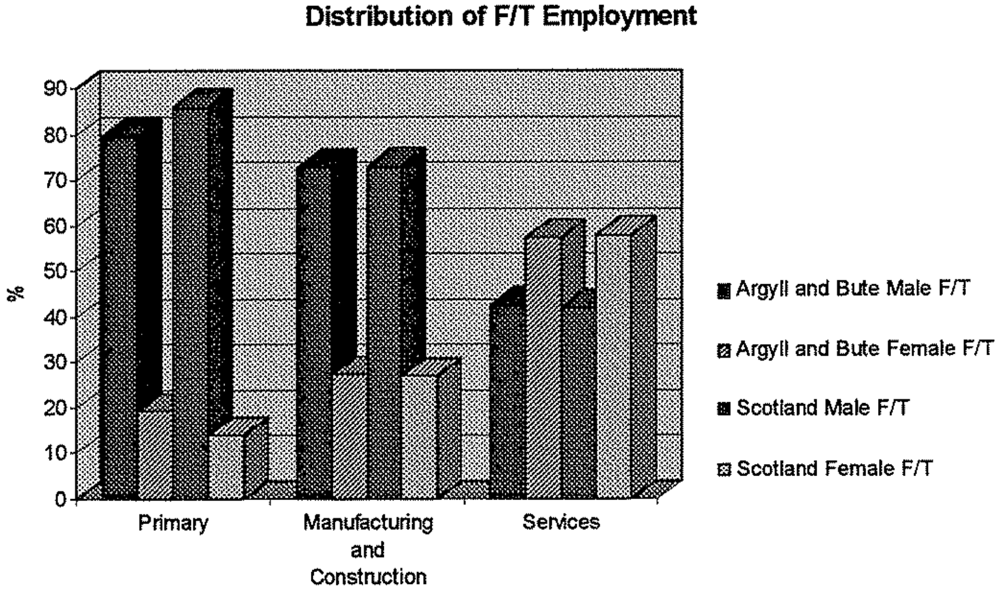
Table 4.d Employment Distribution according to Sector

	Area		
Industrial Sector	*Strathclyde*	*Scotland*	*Local Quotient*
Primary	*2*	*4.4*	*0.45*
Manufacturing and Construction	*28.7*	*27.3*	*1.051*
Services	*69.1*	*68.3*	*1.01*

Source: ***Regional Trends 1995***

A further deconstruction of the national and regional employment profile highlights the greater prevalence of female employment within the service trades, (see fig 4e). Both national and district figures suggest that almost 1/3 more women work in this sector than men, whilst in the remaining two employment categories women feature comparatively less than their male counterparts.

Fig 4.e



Source: Regional Trends (1995)

4.1.3 The Farming Community

In reference to the Isle of Islay, the location quotient may be particularly misleading and greatly detracts from the importance of the farming community to the island economy. Many of those engaged in agricultural work are self employed and are therefore precluded from the Census of Employment figures, thus the location quotient substantially understates their economic involvement.

To a great extent Islay's economy forms a dichotomy between the contribution made by the distilleries (7 in all) and that made by the farming community. Whilst the former is primarily felt in terms of income, it is the latter which generates the greater proportion of employment on the island.

'Argyll and the Islands Enterprise' estimate that there are between 200-250 small agricultural holdings on the island, but as with other rural farming communities they have become increasingly reliant upon government subsidies rather than from the income derived from their holdings[23].

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[23] Notable exceptions to this include dairy farms and the large estates who remain (by and large) quite profitable.

High interest rates, reduced levels of government support and falling prices have severely eroded farm incomes in all rural areas, yet Islay is further disadvantaged by its remote and insular location. Having no island market, farmers incur substantial costs in transporting livestock to and from markets on the mainland, which when coupled with recent wildlife projectionist measures[24] have only served to push farmers further to the margin of financial viability.

Although no specific details regarding farm incomes have been made available, we would expect Islay's upland crofts to exhibit the same financial characteristics as those detailed in Stevenson and Jones (1995)[25]. In that it is unlikely that many of the 200 or so small holdings could be financially viable without the support of EC or government subsidies, (both of which have fallen in recent years, Table 4.f).

Table 4.f Government and EC Subsidy Payments

Subsidy (£ million)	***1988***	***1989***	***1990***	***1991***	***1992***	***1993***	***1994***
AHDS[26]	*22639*	*17.67*	*10.09*	*4.91*	*3.79*	*2.118*	*1.999*
AHDS (Higher Grant)	*3.087*	*3.538*	*3.815*	*2.451*	*0.517*	*1.205*	*0.701*
AHGS[27]	*12.032*	*12.6*	*2.415*	*0.151*	*0.093*	*0.018*	
AHGS (Higher Grant)	*1.641*	*1.862*	*0.762*	*0.076*	*0.013*	*0.02*	
CAG[28]	*1.394*	*2.574*	*2.555*	*2.504*	*2.523*	*2.745*	*2.8*
ADP[29]					*2.895*	*6.127*	*6.127*
HCLA[30]	*39.607*	*37.22*	*47.82*	*44.126*	*43.62*	*47.321*	*48*

Source: Scottish Abstract of Statistics (1995)

It is thus in relation to the poor prospects of making a sustainable living from farming alone, that one may begin to evaluate the contribution that could be made by a renewable energy project. If a development were to be located on land belonging to marginal crofts, there is every indication that the rent obtained from the plant could significantly contribute to the long term viability of the respective crofts involved and the employment that they thus

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[24] Islay is an important habitat for a protected species of wild geese, as such any farm holding having this particular species on his land is forbidden to farm the area and is compensated for the loss of revenue as a result.

[25] Both being primarily involved in upland hill farming

[26] Agriculture and Horticulture Development Scheme

[27] Agriculture and Horticulture Grant Scheme

[28] Crofter Agricultural Grants

[29] Agricultural Development Programme for Scottish Islands

[30] Hill Livestock Compensatory Allowance

generate. Thus the employment benefits of a renewable energy installation could be twofold, firstly by creating much needed direct employment opportunities and secondly by supporting the long term financial viability of upland farms, thus maintaining the jobs therein.

4.2 The Energy Baseline

Having given an overview of the local economy, the focal point now switches to the island's energy baseline and the problems that are posed by increasing load growth.

The overall energy supply and demand on Islay is best described by a Sankey diagram (fig 4.g). Despite its complexity a number of points come to light.

- Petroleum products are by far the largest source of energy on the island.
- The largest consumer of electricity is the domestic sector, (13.9%), accounting for double that of the commercial and industrial users.
- Unusually peat provides 33% of the islands total energy needs. Its consumption exceeds that of electricity in the domestic sector, even though it tends to be less efficient when used for heating purposes.
- All energy sources are imported except peat which is cut locally. Therefore the introduction of a reliable and indigenous electricity network using renewable technologies could significantly reduce the reliance upon energy import

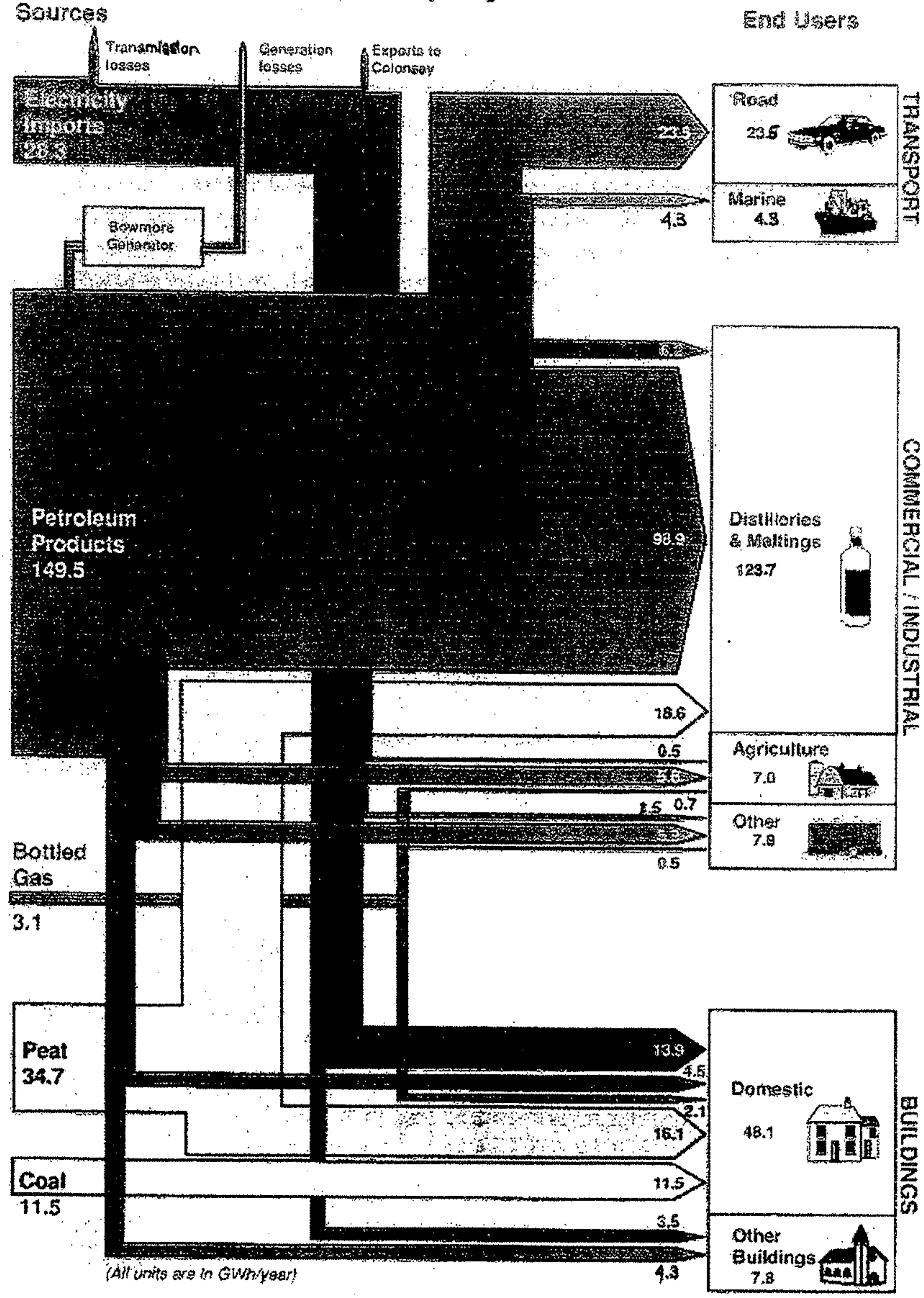
4.2.1 The Electricity Supply Network

The islands electricity is supplied by Scottish Hydro Electric (SHE), from the Port Ann 132/33 kv substation near Lochgilphead. The 33kv circuit supplying the island is 80km long and includes a large proportion of sub sea cables from the mainland to Jura and from Jura to Islay.

In the event of any failure in the sub sea cable or any operational problem on the local distribution network, there is a standby generating plant at the Bowmore Power Station on Islay.

However current supply problems manifest themselves in a number of ways. For consumers the difficulties associated with electricity supply are most evident in the form of voltage imbalances and breaks in supply, whilst for the operational business, the energy losses incurred during transmission continue to be a constant drain on financial resources.

Fig 4.g Sources and End Uses of Energy on Islay (1994/5)
Sankey Diagram



(All units are in GWh/year)

4.2.2 Load Growth

Total annual electricity consumption for the island is currently 19.4GWh, with a customer base of 2110 accounts (Table 4.h).

Table 4.h Islay's Electricity Consumption by Sector

SECTOR	*CONSUMPTION GWh*	*No. OF CUSTOMERS*
Domestic	13.9	1789
Commercial	3.5	228
Agricultural	0.5	83
Industrial	1.5	10
TOTAL	19.4	2110

The main use of electricity in the domestic sector is for space and water heating therefore considering the absence of a mains gas supply and the relatively high price of local imported fuel oils, it is thought that the domestic sector will be the main source of load growth in the future, as consumers switch from peat burning to clean and efficient use of electricity.

In the event of an increase in demand, SHE expect the network to become increasingly strained, as has been the case in several other areas of its operating region. Thus the rising consumer base will only serve to exacerbate the difficulties which have already beset the 80km supply circuit operated from Port Ann. Consequently SHE has faced increasing pressures to find a solution to the energy supply difficulties currently facing Islay.

Possible solutions include:-

- *The development of local renewable energy scheme.*
- *OFFER funding for energy conservation schemes under Standards of Performance in Energy Efficiency.*
- *Reinforcing the capacity of the existing supply circuit, either by duplication on the present route or by a new circuit on a different route.*
- *A new approach to manage supplies using energy storage.*
- *Supply conditioning using power electronics to improve supply quality.*
- *Containing demand growth by greater energy efficiency investments*

Obviously the optimal choice of investment would necessitate a cost benefit appraisal of all possible solutions, however our interest will focus upon the renewable technology alternative and its role as a driver for local employment and income opportunities.

4.2.3 Renewable Energy Technology Appraisal

SHE have identified a number of reliable and indigenous renewable energy technologies which could equally serve to supplement existing electricity imports as well as to alleviate the increasing pressure imposed on the current electricity supply network[31]. The potential technologies investigated include:-

1. **Wastes**	Anaerobic digestion of distillery wastes, which may be supplemented by farm waste and sewerage sludge.
2. **Hydro**	Programmes may be sited on rivers or connected to the distribution network.
3. **Waste Heat**	Waste process heat from the distilleries may be used for industrial development which will be beneficial to Islanders.
4. **Wind**	Turbines may be connected to the electricity distribution network or directly to the load.

The original feasibility study [ETSU (1995)] concluded that the first three options were unlikely to make a significant contribution to the island's supply network in the immediate future due to the limitation of resources, environmental legislation and expense.

Conversely, wind power has by far the greatest potential on Islay within the immediate future; a single site of 3MW capacity could supply between 30% and 40% of the island's electricity requirements.

Evidently in pure MW terms, a windfarm will go along way in easing the increasing burden placed on the existing supply network. However our interest lies in whether its installation will procure additional socio-economic benefits and whether these benefits will form as persuasive an argument for the renewable lobby as have the environmental influences of previous years.

To this end we shall detail the windfarm development, its cost structure and its respective expenditure payments with a view to identifying those sectors in receipt of windfarm monies. Thereafter an attempt will be made to determine both the long and short term income and employment multipliers.

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[31] The amount of power which the Islay network can absorb is critical to the impact of any renewable energy scheme. Some renewable options may either require augmented electricity imports to meet peak demand whilst others could exceed local demand at non peak times and lead to power exports. Under such a varying load and varying performance, the result could produce power flow oscillations between imports and exports Thus tending to exacerbate the existing situation and disrupt supplies still further.

Where precise expenditure details are not available, estimates have been made in accordance with previous windfarm practices and informal discussion with both National Windpower and North Energy Associates.

4.3 The Windfarm

Islay is a particularly exposed region of the UK and is characterised by high wind speeds, this together with its isolation from the mainland supply network and the relatively low population density, make it particularly predisposed to windfarm developments.

Using a general approach ETSU have already established an estimate of the largest possible available resource (735MW/2395GWh/year). This is far in excess of the islands' consumption requirements but once environmental restrictions are imposed, the maximum available resource reduces to (301MW/951GWh/year).

Unfortunately the nature of the electricity network limits the amount of variable generating capacity that can be connected without detriment to the quality of supply to 3MW or less. Consequently the construction of a 3MW windfarm on the island would inhibit all future wind developments thereafter unless energy storage facilities are installed.

It is assumed that the windfarm will consist of six, 500kw commercially available turbines, which will be located on exposed upland areas in line with environmental and grid network requirements.

As an island the costs of transporting materials and equipment to Islay are likely to exceed those for equivalent sites on the mainland, in that the turbines themselves must be transported to the island as will the cranes required to erect them. Consequently some allowance has been made for the higher delivery and installations costs which will therefore add to the long run cost of wind derived electricity.

The construction of the windfarm development is not expected to exceed 1 year, whilst the turbine life expectancy and operational phase is expected to last 25 years.

4.3.1 Windfarm Expenditure

The estimated cost structure of a 3MW development is detailed below, and includes both construction and operational phases.

Table 4. i Constructional and Operational Expenditure

Phase 1: Construction and Installation Expenditure (duration 1 yr)

	£
Ex factory Costs and Delivery of 6 Wind Turbines	*1 620 000*
Commissioning and Installation	*80 000*
Civil Engineering	*285 000*
Electrical Engineering	*395 000*
Accommodation for Main Contractors	*7 000*
Rent and Rates	*30 000*
District Council Rates	*11 000*
Miscellaneous	*61 000*
Total	***2 490 000***

Phase 2 Operation and Maintenance (annual expenditure)

	£
Labour	*41 346*
Local Rates	*3 322*
Land Rental	*25 000*
Insurance	*15 000*
Miscellaneous	*7 214*
Total	***91 882***

Using the above expenditure details, the long and short term income and employment multipliers can now be determined.

The estimation of the relevant coefficients takes place in Appendix A, but as with the expenditure payments, where data is unobtainable at island level, proxies have been determined using district/regional information. The result of this is that some of the co-efficients should only be taken as a tentative first estimate of plausible values only and consequently the conclusions drawn, should be drawn with caution.

Thereafter both the long and short term effects are derived in Appendix B by using the projected expenditure details in conjunction with the regional multiplier model derived in the previous chapter. The main points of the impact assessment are discussed in the following sections, with particular comment being made to the windfarms impact on Islay's existing socio-economic structure.

4.4 Total Employment Effects

It appears that both the windfarm's construction and especially its operational stage do not yield significant employment benefits.

Within the construction stage, up to 18 full time jobs will be created locally, which given Islay's current high unemployment rate, will make a significant contribution to the island's economy. However the construction stage is only temporary and therefore the level of full time posts will subside towards the end of the plant's installation, leaving the island's unemployment rate to regress to its former profile.

Thereafter, long run labour requirements are minimal and will only create three full time appointments for the duration of the operational stage. Of these three posts, only one is likely to involve an immigrant worker (notably, the manager's position), therefore it is doubtful whether his/her long term residency will induce any public or private sector investment, since it is assumed that Islay has sufficient excess capacity to accommodate and support one additional island worker and his/her family.

In conclusion the brevity of phase 1 and the minimalism of phase 2, act as a considerable brake on induced investment opportunities and the creation of indirect employment in the public sector thereafter. Consequently, it appears that the primary catalyst of secondary employment will originate from the additional spending of primary and secondary income in the private sector rather than in investment in public or private capital provision.

Using the employment multiplier of the previous chapter, it appears that the initial phase provides the greatest scope for the creation of indirect employment; it estimates that the development's spending, in conjunction with that of its employees will generate up to nine (8.6) new jobs, although whether these jobs remain *ex post* is as yet undetermined.

Conversely the income derived from the plant's long term operation and maintenance fails to make a significant impact upon the indirect job market, resulting in possibly one job at best.

Together both phases give rise to an employment multiplier of 1.48, although it would have been significantly larger had the construction period been longer and the reliance on long term immigrant labour necessitated a greater degree of induced investment.

In reference to the programme's effect upon the local labour market, a further point concerns the employment associated with the farming community. Whilst the windfarm will not create any direct jobs in this sector, merit should be given on account of its contribution to the long term financial viability of many upland farms. As indicated earlier, the vast majority of hill farms are just on the margin of financial profitability, therefore not only will rental payments contribute to the long term survival of such farms but it will also help to maintain the jobs therein and prevent some tenant farmers either leaving the island or becoming formally unemployed.

4.5 Total Income Effects

The recurrent income streams from the windfarm include; direct income payments made to landowners in respect of land rental; wages paid to direct employees, and substantial payments made to the district council in lieu of business rates on the turbines and substations. From these payments, by far the largest sources of LVA are those held within the windfarm's expenditure on labour. In all it accounts for 85 and 64% of the total LVA derived from the plant's short and long term expenditure respectively.

The other major source of LVA stems from those payments made to farmers in respect of land rental and access routes. Together payments of this nature account for 11% of total LVA within the first round, rising to 34% of total LVA during its operational phase.

By summing the LVA content contained within the windfarm's expenditure, Table 4.j estimates the total income benefits accruing to the local economy during the first five years of operation. As suspected, the high sunk costs of the investment mean that the initial first round impact is much greater than that of any subsequent round, despite the fact that phase 1 experiences a capital leakage of almost 80%.

Table 4.j Change in Regional Income (5 Year time horizon)

	Construction	*Phase 2: Operational with Induced Investment*	*Phase 2: Operational without Induced Investment*	*Year 3*	*Year 4*	*Year5*
Windfarm Expenditure	*2,490,000*	*91,882*	*91,882*	*91,882*	*91,882*	*91,882*
Direct Income	*585,150*	*116,419.09*	*64,317.4*	*64,317.4*	*64,317.4*	*64,317.4*
Secondary Income	*27,267.99*	*5,192.29*	*2,868.56*	*2,868.56*	*2,868.56*	*2,868.56*
Tertiary Income	*1,270.69*	*231.58*	*127.94*	*127.94*	*127.94*	*127.94*
Total Change in Regional Income	*611,247.9*	*121,611.38*	*67,185.96*	*67,185.96*	*67,185.96*	*67,185.9*

Total Change in Regional Income (No induced investment)	***£879,991.74***
Total Change in Regional Income (With induced investment)	***£934,417.16***
Multipliers (based upon $k_i = 1.0446$)	$k_i^1 \quad < k_i^2 \quad > k_i^{2.....n}$ $0.245 \quad < 1.32 > 0.731$

Column two details a hypothesised induced investment component allowing for an influx of immigrant workers weighted at 50%. Inarguably it does make a significant contribution to both direct and indirect income generation to the tune of an additional £50,000. However the paucity of long term immigrant employment (only one appointment) would suggest that the induced investment component is largely redundant in the context of the Islay windfarm, since it is expected that Islay's existing capacity would be able to sustain one additional worker (and his/her family). Similarly, the induced investment coefficient cannot be applied to the reliance upon immigrant labour during the construction stage because their stay is only temporary; whilst they may contribute to local income via their expenditure on bed and board, it is doubtful that the island would experience any investment in capital provision to support the temporary increase in the workforce.

Conversely the same may not be true with respect to other renewable technologies where:-

1. The construction period extends over one year.
2. Both operational and construction phases exhibit a greater reliance upon immigrant labour.

The change in regional income therefore includes all direct monies paid by the windfarm and thereafter the indirect income effects derived from the multiplier expansion. As primary recipients of direct income spend their earnings on existing goods and services, so will the recipients of this additional spending do the same. These secondary effects on the regional economy are detailed as secondary income in Table 4.j and are based upon a primary income multiplier of 1.0446.[32]

Assuming no induced investment takes place , then an estimated £879,991 will accrue to the local economy over a five year period, with the major impact taking place within the first year of the programme's implementation.

In summary, the computation of the total change in regional income necessitates 3 multipliers, each applicable to varying stages of the investment, but each being based upon the simple income multiplier, $k_i = 1.0446$

During the construction stage, the capital injection is subjected to a multiplier of 0.245, which ultimately reflects the high percentage of expenditure allocated to the purchase of imported capital equipment.

Secondly, if we had included the induced investment co-efficient, then a multiplier of 1.324 would be applied to the first year of the plant's operation, or rather to those years during which the immigrant's capital requirements are still being met[33]. In reference to the Islay windfarm, this stage is not expected to extend further than one year due to the particularly low reliance upon immigrant labour.

Consequently, in the absence of any induced investment, the long term capital injections are subject to a multiplier of 0.731, thus reflecting the fact that only 70% of the capital injection translates into regional direct income and as such it is only this proportion that can be subjected to multiplier expansion.

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[32] The primary regional income multiplier seems a little small compared to other multipliers of similar studies e.g. 1.10-1.30 This however is primarily attributable to two factors 1)The inclusion of u, λ, t_i, within the income multiplier formula and 2) the heavy reliance upon imported consumer goods.

[33] With reference to Islay we have assumed that all capital requirements will be met in full within the first year of the immigrant influx. Had the influx taken place over several years then the coefficient applied to the level of induced investment would depend upon the proportion immigrants received during the respective years.

In conclusion, Islay's income is expected to rise by an estimated £879,992 over a five year period as a result of both the windfarm's construction and operational stages. Moreover if the induced investment component were to be included within the income formulation then the change in regional income could rise by a further £55 000.

4.6 Growth of Related Activities

If previous windfarm experiences throughout the UK are to be considered, then there remains two additional economic outlets worthy of discussion. Firstly that of tourism or rather eco-tourism and secondly the potential growth of other complementary economic activities.

The potential tourist element primarily stems from windpower's novelty status (albeit a receding one). The potential impact that eco tourist spending may have on the local economy is difficult to quantify at this point but by extrapolating some potential impacts experienced at similar developments the outlook appears favourable[34].

The majority of windfarms in the UK have attracted between 15,000 and 30,000 visitors a year, [Stevenson and Jones (1995)]; many have been tourists although there is a strong educational contingent. Whether the Islay windfarm will attract the same numbers is impossible to gauge at this time and will very much depend upon the island's existing tourist facilities and the accessibility of similar windfarms located on the mainland (it being doubtful that visitors would undertake a 2hr ferry crossing to see six turbines if similar developments were available in close proximity).

Nevertheless Jones and Stevenson (1995) have estimated the potential impact that visitor spending may have on the local economy. Using upper and lower bounds of between 16,000 and 30,000 visitors they derive an estimated additional income of between £2,800 and £10,500 per annum, all of which accrues to the island economy. Moreover we would expect that the additional spending would further induce indirect employment opportunities and private investment if tourist numbers so justified.

Secondly renewable technologies, especially windfarms, have often been sited in rural and remote regions; regions which are commonly known as being economically disadvantaged. Nevertheless their establishment has resulted in small pockets of complimentary economic activity within the renewable energy field. Indeed this trend is especially prevalent in the Mid Wales region where satellite activities have mushroomed in response to the large scale adoption of wind energy in the area. Whilst it is difficult to speculate upon the

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[34] However, as a consequence of the windfarm's environmental and visual impact, one must bear in mind however that the potential increase in tourism could be mitigated by a fall in the tourism associated with the natural wildlife of the island,. Although no figures are available to chart this impact, we do recognise that as the novelty value of the development subsides then windfarm will constitute a greater threat to traditional tourism in the area.

entrepreneurialism that the windfarm may initiate at this stage, it should be acknowledged that the growth of related activities on Islay is not entirely unfeasible.

4.7 Conclusion

In purely monetary terms the Islay windfarm is expected to enhance the local economy by an estimated £879,991 over a five year period, (not including monies from visitor spending). Yet in addition to the pure financial forecasts there are a number of supplementary considerations which span both employment and income distributions.

Previously the twin effects of brevity and minimalism have been critically highlighted as being considerable constraints on induced investment in both the private, but especially the public sector. Nevertheless this should not in any way detract from the importance of the windfarms's contribution to increasing the island's employment. In total the installation will create up to 20 full time jobs in the area[35]; if this is viewed in the context of Islay's isolated labour market and the considerable shortfall of full time male employment, then it will constitute a valuable injection into the island economy. Even more so if one considers that other measures which have been used to attract manufacturing into rural areas have been expensive and largely ineffective.

Furthermore, despite the lack of investment in capital provision, the spending of direct and secondary income during phase 1 does generate an additional 8/9 jobs. These too are quite significant, especially within the context of the island's existing industrial distribution; the exact allocation of subsequent indirect employment is uncertain at this juncture, but given that the majority of additional spending is likely to accrue to the service sector, then it is feasible to suppose that the growth in employment will also take place in this sector. Consequently, in view of the male/female distribution within the service trades, it is likely that the contribution made by indirect employment will make significant in roads into the female unemployment rate, (although whether these will remain *ex post* is uncertain).

A final comment regarding employment generation, concerns the economies of speculation associated with windfarm developments. If the installation of the windfarm proceeds, then it is possible that Islay could nurture the growth of related renewable energy activities. These could involve the development of technical expertise and other support services which could facilitate the installation of windfarms on other Western Islands, or it could involve the development of the tourist aspect and could promote Islay as a Eco-Isle. The extent of these economies of speculation are undefinable at this time, but Islay could have the potential employment base to allow these subsidiary activities to mushroom.

Furthermore, both the model and the subsequent case study highlight the importance of the induced investment component in influencing the expansion of employment and income

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[35] Although 18 of those are of a temporary nature.

multipliers. Therefore if the growth of satellite industries attracts a significant influx of immigrant workers, then their long term residency could encourage investment momentum

Finally the recurrent regular benefits associated with the operational phase should not be underestimated. Direct payments to farmers could make a substantial contribution to their annual income, to the point of exceeding farm revenue. In such cases windfarm payments will secure the long term viability of the farm unit as well as the employment it thus generates. This is perhaps one of the more significant factors of the windfarm expenditure, especially in view of the declining farming community, the heavy reliance upon government subsidies and the prevalence of agricultural businesses within the area.

.To conclude the case study, we should note that the Islay wind farm was initially chosen according to very narrow financial boundaries. In economic terms, the installation of a 3MW windfarm is one of many cost-effective measures considered within the overall Islay energy strategy, but whether it is the optimum driver of indigenous economic development is as yet undetermined.

Although the construction phase could provide scope for induced investment (in terms of providing capital provision and services for each immigrant worker) its time span is all too short and the immigrant workers are all too temporary, whilst in the long run, the windfarm's labour requirements do not yield significant employment benefits. Nevertheless compared with other electricity supply measures, the installation of a windfarm devolves rather more benefits to the local community compared with the other SHE strategy options.

Cases in point include some of the measures cited earlier, such as energy conservation, supply management and energy efficiency. In such cases it is doubtful whether such measures would procure any additional income or employment opportunities in the long term.

Similarly, conventional electricity supply options provide very little scope for the procurement of long term economic benefits. Whilst the upgrading of the existing supply circuit may involve some short term employment, (assuming SHE employ local firms rather than a main contractor), it offers no long term income or employment opportunities.

Furthermore, although no mention was made of the installation of conventional fuel generators, Table 4.k highlights the favourable employment profile of a number of renewable energy technologies[36].

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[36] Figure include all persons involved with design, manufacturing and project planning, therefore the employment profile will tend to suffer from the 'head office' syndrome, in which case the total direct jobs within the immediate locality can only be guessed at.

Table 4.k A Comparison of Energy Impacts upon Employment

	Jobs per Twh
Nuclear	*100*
Geothermal	*112*
Coal Including Mining	*116*
Solar Thermal	*248*
Wind	*542*

Source Flavin C & Lenssen N (1990)

Consequently if SHE wish to simultaneously supply electricity, whilst contributing to the growth of a local community, then its cause would be better served by the implementation of an indigenous renewable energy supply source. One which is able to maximise the LVA content contained within the expenditure budget and which is able to devolve many of the income and employment opportunities associated with energy generation..

To this end, the renewable energy supply options cited earlier, (anaerobic digestion, small scale hydro and waste heat processes) should be reconsidered on regional impact grounds. Despite being termed uneconomic in the short term, they may appear more attractive than windpower if they have a greater propensity to effect positive economic benefits to the local economy. Thus to maximise the economic boons arising from energy generation, renewable energy technologies will need to involve local labour and products in both the short and long run.

With this said, a *prima facia* assessment of competing renewable energy options would conclude that in the short term, small scale hydro could make a significant impact upon the local labour market, but as with windpower, it is likely to suffer from long term minimal labour requirements. Similarly, whilst anaerobic digestion and waste heat processing can make use of waste products from the distilleries, these options don't devolve many of the income benefits to the local community, and therefore the additional income cannot be subjected to the multiplier expansion.

Conversely, energy derived from biomass could accrue significant benefits to the local economy if the farming community involved itself with the production of coppice and willow harvests.. Although this form of energy generation wasn't mentioned in the original feasibility report [ETSU (1995a)], the benefits of biomass could be twofold. Firstly by creating direct employment, and secondly by providing a supplementary income for an already established but struggling industry, thus supporting the jobs therein.

Inevitably however the choice of electricity supply will rest with the decision makers and will hinge upon their own policy objectives. Socially, the optimal supply choice would be determined by a systematic ranking of supply options in accordance with their propensity to effect positive benefits for the community, but for private companies like SHE, it is likely to be the financial aspect which is the driving force behind capital investment decisions. Therefore, if Islay wishes to benefit from the economic boons arising from energy generation, then it will have to find a way of reconciling the two, but for the moment the installation of a windfarm has shown itself to be a positive addition to the island economy.

CHAPTER 5

APPLICATION OF THE MODEL IN LDCs

5.0 The LDC Scenario

In returning to the original discussion regarding rural electrification programmes, the case study of the previous chapter can in part act as a touchstone for further discussion regarding the model's application within developing countries.

At the beginning of this study, renewable energy technologies were credited with being able to devolve many of the income and employment opportunities associated with energy generation to the local community. Since then, this propensity has been partially substantiated by the outcome of a regional impact study pertaining to the effects of the installation of a 3MW windfarm on the Isle of Islay.

However, whether the same economic gains would materialise within the context of a decentralised development in a developing country is as yet undetermined. Nevertheless, it is evident from the case study that the success of renewable energy installations and their subsequent impact upon local economies rests upon well directed energy policy. Policy, which not only compensates for the infrastructural inadequacies of rural areas, but which also exploits key variables within the development process which can strengthen the multiplier expansion.

Consequently the following sections attempt to detail the changes incurred by the transition of the application to a less developed country.

5.1 The Regional Income Multiplier

Whilst the switch from an '*integrated*', yet marginal supply system to a '*decentralised*' one will not effect any changes in the multiplier formula *per se*, the change in the socio-economic profile will exert a significant influence over the value of the relevant variables held within the multiplier.

Initially the regional income multiplier is defined as :-

$$k_i = \frac{1}{1 - \lambda - c^*(1-t_d-u)(1-m-t_i)}$$

where the denominator incorporates a number of socially orientated leakages; these include unemployment benefits, public sector services, direct and indirect taxes etc. However whilst we would not expect the majority of LDCs to exhibit the same social provisions or indeed the same comprehensiveness, they cannot be simply excluded on the basis of generalisations. It is therefore the respective site-specificity of the regional impact study which will determine the magnitude of these variables, but it should be noted that their values will approach either zero or unity as the multiplier is applied in increasingly subsistent areas.

e.g. $\lambda, t_d, u, m, t_i \rightarrow 0$ " *as proposed areas approach*
$c \rightarrow 1$ " *subsistence level*

Following on from this it would appear that in purely subsistent areas the income multiplier may reduce to:-

$$k_i = \frac{1}{1 - c^*(1-m)}$$

thus reflecting both the low level of consumer imports and the lack of social infrastructure. At this point a simple *prima facia* sensitivity analysis (see table 5.1) demonstrates the strength of the regional income multiplier as it is applied in increasingly self reliant communities; indeed in particularly extreme scenarios the regional income multiplier may be as strong as 5.26 . Thus indicating that the introduction of an income generating development would have a significant impact upon secondary incomes and secondary service growth, since it is assumed that the majority of the additional income would be spent within the local economy.

Table 5.1 Sensitivity Analysis

c^*	m	k_i
0.75	0.25	1.78
0.8	0.2	2.78
0.85	0.15	3.6
0.9	0.1	5.26

5.2 Capital Leakages

As before, the capital leakage component will be by far the greatest draw on the programme's potential for driving local development. This being especially problematic for renewable RE programmes, which combine highly specialised capital equipment with areas of little or no industrial/commercial infrastructure. Indeed, whilst the 'goods and service' capital import leakage (m) might only be 10-15%, due to the high level of self sufficiency in remote areas, the capital injection leakage, (m^*) may be in excess of 90% during the actual lead time, (although this would decline in subsequent rounds due to the drop in fixed capital expenditure and the long term use of local inputs).

Again a simple sensitivity analysis provides some indication of the potential income outflow which could reduce the multiplier to a marginal reflection of its former value.

Table 5.2 Sensitivity Study

c^*	m	k	m^*_1	m^*_2	k_i^1	k_i^2
0.75	0.25	1.78	0.95	0.2	0.09	1.83
0.8	0.2	2.78	0.96	0.25	0.11	2.09
0.85	0.15	3.6	0.97	0.3	0.11	2.52
0.9	0.1	5.26	0.98	0.35	0.11	3.42

Despite the comparatively high first round capital import leakage, the case study of the previous chapter highlighted the fact that the first round income effect could still be in excess of any subsequent round. This being a consequence of the high sunken costs associated with energy generation. Therefore, in cognisance of the potentially damaging effect of the first round capital import leakage, the energy supply strategy should try to implement a technology which can maximise local involvement throughout both short and long run phases. A practice which is especially important with respect to rural development and electricity load growth since the extent of the local involvement and the corresponding levels of LVA are central to effecting changes in local income and employment distributions.

5.2.1 Local Labour

The importance of local involvement has been vehemently emphasised in a number of studies [Martinez and Huacuz, (1995), Kozloff and Shobowale, (1994)] including our own regional impact study. In terms of labour impacts, the benefits may be threefold:

- Previous application of the model suggests that wages paid to local workers will constitute the larger part of LVA for both the construction and operational stage of the network. This being particularly evident in LDCs where the utility may be forced to rely on a larger share of local workers because the lack of labour mobility often precludes any substantial influx of immigrant workers. As a result the reliance upon immigrant labour (z) will be less than that of similar programmes in industrialised countries, (even after the provision of any wage bias). Therefore the negative effects of a marginal worker influx would be partially mitigated by the fact that a greater percentage of the investment's expenditure will remain in the local economy. Thereafter the additional regional income could be subjected to the rural income multiplier, with the final impact being significantly larger if the area is characterised by a subsistence economy.

- Moreover, during the primary stages of construction and operation the plant will inevitably employ a core body of skilled workers, who are then augmented by local labour. Whilst this scenario could be highly problematic, (in view of the worker's limited literacy and their lack of familiarity with modern technology) it does in fact constitute a prime opportunity to transfer skills and diffuse new working techniques. In turn the acquisition of new skills and technologies may enhance the productivity of existing services etc. or may go on to fuel developments in related activities at a later date.

- Finally, if the reliance upon immigrant labour (z) is initially weighted to account for their skills and subsequently their higher wages, then after their withdrawal we could expect the wage bias to transfer to those local workers who had achieved some pre-defined level of training. In which case the additional income could thereafter be subjected to the income multiplier to fuel secondary incomes and secondary service growth.

In conclusion the greater the reliance upon local labour the greater the benefits accruing to the local economy. This being confirmed by the sensitivity analysis shown in table 5.3.

Table 5.3 Sensitivity Study

c^*	m	k	m^*_1	m^*_2	n	z	k_i^1	k_i^2
0.75	*0.25*	*1.78*	*0.95*	*0.4*	*0.5*	*0.2*	*0.09*	*1.89*
0.8	*0.2*	*2.78*	*0.96*	*0.5*	*0.5*	*0.25*	*0.11*	*2.95*
0.85	*0.15*	*3.6*	*0.97*	*0.6*	*0.5*	*0.3*	*0.11*	*3.82*
0.9	*0.1*	*5.26*	*0.98*	*0.7*	*0.5*	*0.35*	*0.11*	*5.54*

However the reduced reliance upon immigrant workers will partially negate the positive effects of the long run income and employment multipliers since the absence of immigrant labour will render the induced investment component largely redundant, as was the case with the Islay windfarm.

Nevertheless the benefits of local involvement are not only experienced in income and employment terms, but they also influence the dissemination of new skills and working practices. Indeed skill and technology transfers of this nature coupled with the introduction of electricity may be intrinsic to the future development of local industries not only in related activities, but in service and production activities also.

5.2.2 Training and Education

Although training will not always lead to financial reward, it remains an important factor within the overall energy strategy. Any decentralised network will need repair or servicing at some time, therefore the provision of maintenance becomes a decisive factor in determining the success of any supply network. As Foley (1992) points out *"if supply systems are liable to lie idle for months waiting for repairs, the community dare not allow itself to be dependent upon them for any important uses."* (Ref 9)

With this said, the exact nature of repair and maintenance will not only be site-specific but will also depend upon the technology employed. For example, if we consider the installation of hundreds of domestic photovoltaic systems, it would be impractical and costly for the utility to operate and maintain thousands of small generating units. Therefore the training of end-users or key community players is intrinsic to the survival of the system and may take place at several levels. eg.

1. **User level** For domestic systems. Has traditionally focused upon women, since it has been assumed that it is they who spend the majority

of time in the home. (Raises questions regarding the empowerment of women.)

2 **Community level** One or two younger members of the community are selected to receive formal training in order to assume the positions of local servicemen.

Moreover if the system is marketed and serviced by trained entrepreneurs, then there is every possibility that the system will promote indigenous technological capacity. USAID (1993) emphasised this point when it observed that "*all too often RE programs have focused upon a single technology, but local consumers are better placed to adapt the technology options to their own social, economic, physical and institutional conditions*". (Ref 10) Therefore, with formal training in hand, community employees may go on to develop further network adaptations for uses elsewhere, although as with Islay the quantification of these economies of speculation is as yet undetermined.

The potential for entrepreneurship also extends beyond the development of further energy sources, in that it may equally permeate demand and supply-side activities, including requisite technology and technological infrastructure for the conversion and utilisation of the energy supply. As a result, rising technological capabilities and market expansion could be mirrored by concurrent increases in LVA, which may be further consolidated upon, if any project were to maximises the use of local inputs, (i.e. the '*materials*' and '*overhead*' categories of LVA which may include payments for land rental, coppice and willow harvests or animal residue etc.)

5.3 Induced Investment

Formally, induced investment was attributable to the provision of capital requirements for immigrant workers. Whilst this may also be the case in developing countries, additional comment should be reserved for the induced investment arising from the introduction of electricity *per se* . And whereas the former will depend upon existing excess capacity, the latter will be governed by end-users' disposable income and their willingness to pay for the services electricity can provide.

5.3.1 Induced Investment: Capital Requirements

A multiplicity of factors govern the induced investment in capital stock provision; previous application of the model indicated that the brevity of the construction stage and the minimalism of long term labour requirements posed significant problems for renewable energy's ability to generate induced investment opportunities. However whilst the short lead time may remain, or may even reduce still further (due to the lower levels of electricity required and therefore the lower generating capacity required), it does not mean that the same negative ramifications will result in similar drawbacks in an LDC electrification programme.

Primarily the lack of labour mobility will often preclude any significant influx of immigrant workers, and although this may present a stumbling block for the development of induced investment, on the positive side, the RE project will give a major impetus to the local labour market and bolster the corresponding levels of LVA.

Furthermore we would assume that remote subsistence villages offer little, if any excess capacity, therefore in spite of the negative long and short term characteristics of decentralised grids (i.e. the short lead time and the minimal reliance upon skilled immigrant labour) at least some induced investment will be required to accommodate the needs of temporary immigrant labour. The exact length of their presence in the community will be determined by the construction period itself, although in some instances it may be extended for training purposes, depending upon the type of assistance given[37].

A further consideration regarding the installation's lead time, concerns the modular nature of many renewable energy technologies. Modular off grid renewable energy systems allow the utility to stagger capital investment to concur with user load growth. Consequently, this practice can extend phase 1 type activity, which, as we have seen, gives rise to greater income effect than any subsequent operational round. Therefore although the long-term employment requirements will be minimal, the local economy can anticipate further investment injections as and when load growth demands.[38] This would further imply that the induced investment component may exhibit a fluctuating profile which will decline in magnitude with each round due to the compound training of local workers.

Invariably the future income streams from this type of activity will also be channelled into the local economy, but a growing consumer and production base may incur their own impacts upon the multiplier process. For example as the community diverges from a subsistence economy, the local MPC (c^*) may decline as external consumption becomes more accessible, whilst the import leakage (m) will rise in concurrence with people's purchasing power. Conversely the growth of an indigenous technological capacity and supplementary skills base may induce a decline in the capital import leakage (m^*) and reliance upon immigrant labour(z).

5.3.2 Electricity Demand

Electricity load growth and its resulting impact upon induced investment are not directly included in the regional impact study, yet it deserves discussion because it will clearly affect the form development takes. A study looking at the effects of RE in India noted for example that, "*it is virtually guaranteed that in a village with electricity, a new industry will start with electricity*". [Barnes (1988), Ref 11]. And by the same token, the availability of electricity is also likely to stimulate new demand for electrical goods and services which electricity makes possible.

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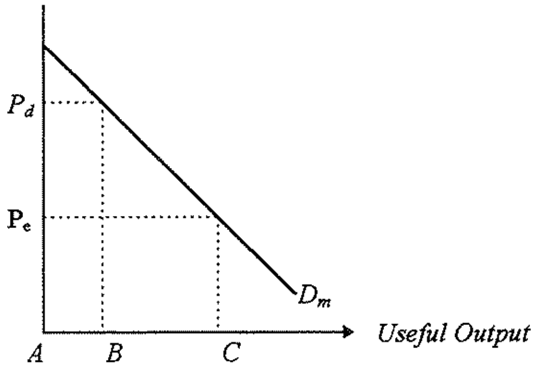
[37] In the absence of any indigenous technological capacity, many RE programs have relied upon turnkey contracts. The failings of which include the lack of any long term commitment to either repair, service or train

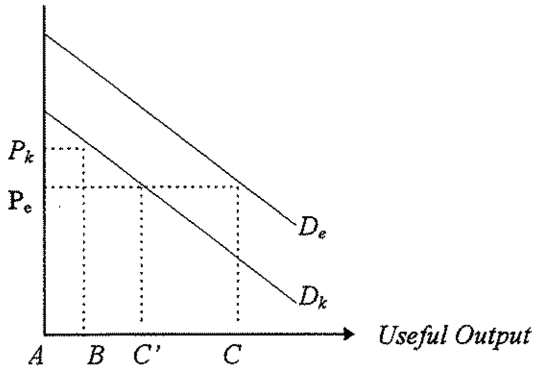
[38] With each subsequent modular addition, we would expect immigrant labour to fall due to the increasing reliance upon trained indigenous workers and the use of previously invested in capital provision. Consequently, the local economy may experience sporadic injections of induced investment which will mirror the intermittent upgrading of generating capacity and the subsequent influx of immigrant workers.

However electricity take-up or even load growth will only occur when people have reached a certain level of disposable income at which, they want and can afford the services it provides. In terms of productive end-uses, investors must decide whether the productivity gains exceed the financial costs of installation and long run supply, whilst in the domestic sector, load growth will be determined by householder's willingness to pay and their available disposable income[39].

Hirschman (1958) was the first to argue that the investment in electricity will lead to induced investment in directly productive activities. He contends that an appropriate development strategy would be to create strategic imbalances, which would induce easily made or even automatic investment decisions. This is known as Hirschman's Imbalance Effect and was later re-inforced by Rostow (1986) who further suggested the existence of external economies and secondary benefits. For example the availability of a reliable and adequate electricity supply in rural areas could induce the development of rural industries which use electricity as a productive input. Examples of this type of activity are described by Munasinghe (1988) and take the following form.



The diagram details the demand for an output such as mechanical energy, where the new electricity supply can substitute for another with no significant change in the quality of the productive end use. Since the overall cost of mechanical energy derived from a network based supply is much cheaper than that of diesel operated generators, demand rises from AB to AC.



Similarly the diagram demonstrates the demand arising from the displacement of other energy forms but with a significant improvement in output. Consequently the demand curve shifts outwards with a subsequent rise in output from AB to AC

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[39] In developing countries the switch to electricity raises the question of the Marginal Rate of Substitution between fuels or practices. In many instances, women's work is of little value, therefore the change in utility moving from woman's work to electricity has zero value, whilst the financial cost is high, thus reducing utility, (although, not for the woman!)

Inevitably any induced investment and subsequent load growth will depend upon the comparative costs of other energy sources and local demand for the services electricity can provide. Therefore to gauge the extent of future load growth, some degree of demand forecasting is required, within which consumer's marginal propensity to consume electricity will play a major role. The results of this forecast can then act as a proxy for the levels of induced investment undertaken within the area.

5.4 Non-Quantifiable Benefits

A supplementary comment should be reserved for the intangible benefits derived from developing country's RE programmes. As yet the majority of these are unquantifiable and as such they cannot be internalised under the social demand curve, nevertheless they remain a an important factor in justifying the provision of rural electricity.

The rise in living standards which comes from an electricity supply can be quite dramatic, but of all the social benefits, household lighting has been cited as being the most important in a number of studies [Rady (1992), Raganathan (1993)]. It extends the day and provides opportunities for work and entertainment more effectively than any other lighting source. A survey in Peru found that for women, "*having light at night enables them to spin, sew, knit, separate seeds, etc, activities which had only been accomplished previously with great effort under the light of a kerosene lamp or a candle*"[40].

Attempts have been made to capture such benefits using calculations based upon the sum of revenues and consumer surplus[41], but on the whole they have tended to underestimate the benefits of domestic lighting.

In addition the fact that electric light makes it easier for children to study is again listed by families as one of the major benefits of electrification. This being the verdict of 80% of the families responding to a survey of the social impact of RE in Malaysia[42]. It is particularly problematic to gauge the impact of RE on such variables but ex-post studies may be able to identify a correlation between RE schemes and education by using standard statistical techniques and academic results as proxies for academic achievement.

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[40] Valencia, A.F & Seppanen, M. (1987) Electrification and Rural Development: The Installation and Immediate Impact in Rural Casco, Peru, Institute of Geography, Helsinki University, Finland

[41] Consumer surplus comprises of, the cost saving over kerosene at current consumption, the cost saving in respect of additional lighting because since it is cheaper per unit then agents will consume more, and the value of the superior quality of lighting.

[42] Omar, F.H. & Zin, M.Y. (1988) RE in Malaysia, Paper at ESCAP Seminar on the Socio-Economic Impact of RE, Hangzhou, People's Republic of China.

5.5 Conclusion

In conclusion the installation of decentralised renewable technologies can obviously have a substantive and catalytic impact on regional development but only if the right combination of demand and supply are present. If this depends upon monetary factors, then renewables can in part accelerate rural development by maximising the use of local labour and services to inject additional income into the area. As indicated income generating projects can have a very positive effect on secondary income and service growth but development assistance must learn from the past. All too often programs have implemented immature technologies and have paid too little attention to the development of indigenous institutional capacity. Not only would this serve to commercialise and deploy renewable energy technologies, but it would also bolster the investment's LVA content via the wages paid to local service engineers. Indeed in the absence of this type of institutional backup, renewable energy technologies have been characterised as being "little more than technical research exercises masquerading as energy assistance" Foley (1992).

Consequently if renewable energy technologies are to fulfil their role as catalytic drivers of rural development, energy planners must not fall into the chicken or the egg syndrome but must identify the best local energy sources and then seek to maximise local involvement. Since it is ultimately this interaction which will procure the additional income used to fuel load growth.

CHAPTER 6

CONCLUSION

In conclusion the following sections present a discussion of the study's overall findings in relation to the original research aims. The concluding comments therefore include an assessment of the model's application and limitations, policy implications and further research prescriptions.

6.0 Purpose of Study

The primary aim of this study was to evaluate the socio-economic impact of a renewable energy technology on local employment and income distributions. Thereafter it was suggested that the results of such a study could contribute to the wider context of ex-ante RE cost-benefit appraisals. Whilst the study never intended to enumerate and internalise the net economic gains under the electricity/social demand curve, it does underline the pertinence of partially replacing the traditional derivation of benefits, (based upon over optimistic demand forecasting) by regional impact projections, thus providing a much improved insight into the benefits derived from local energy programmes and subsequent indigenous growth.

6.1 The Model; Application and Results

The model used in the regional impact study follows a simple Keynesian multiplier methodology, although its specification was greatly improved upon by the addition of labour market extensions and induced investment factors. Admittedly other models appear to provide a more comprehensive assessment, with input-output analysis being a particular case in point, but the availability of regional data and the process of technical change pose as considerable stumbling blocks against their implementation. Consequently the choice of the Keynesian multiplier has sacrificed a degree of disaggregation which would have perhaps provided a greater insight into the linkage effects between the supplier and producer core.

Moreover the lack of involvement with both forward and backward demand and supply linkages renders the multiplier ineffective in identifying the jobs displaced in sectors affected by the new energy substitute. But whilst I acknowledge its limitations in reflecting regional economic complexities, it is reliant upon minimal data requirements and has been adopted on the basis of its concise and progressive format which can concur with the differing stages of the installation's development.

The model was thus applied to the construction and operational stages of a 3MW windfarm on the Isle of Islay. Employment wise, the regional economy is defined by a heavy reliance upon agricultural holdings, whose profits are becoming increasingly marginalised due to a continual decline in government subsidies. Furthermore in view of Islay's isolated nature, the majority of income earned locally is spent within the island economy although the low industrial infrastructure necessitates considerable consumer imports.

The employment effects emanating from the windfarm's installation and operation are not found to be substantive, although in the context of Islay's existing economic structure they are significant. If we include all direct and indirect jobs associated with the windfarm, its installation creates about 9 jobs per MW of installed capacity. However the majority of these take place during the primary stages of capital investment, therefore the direct jobs are of a temporary nature and whether the indirect jobs remain *ex post* cannot as yet be determined.

Direct income effects from the windfarm are expected to greatly impact upon the farming community. Despite consisting of only 6 wind towers, the monies received in respect of land rental will contribute to the long term financial viability of the farms involved. Moreover, the majority of the direct income received in lieu of wages and land rental will be spent within the immediate locality.

In addition, the installation of the windfarm has the potential to initiate the development of related activities in either tourism or technological and service support for similar renewable energies. This aspect is particularly feasible in view of Islay's current fuel mix (i.e. the use of peat and the recent installation of a wave energy device) since the additional installation of a windfarm will serve to compound Islay's image as an *'Eco-Isle'*, and therefore it could be promoted as such. However the extent of these subsidiary activities can only as yet be speculated upon.

A final note in reference to the Islay windfarm concerns the involvement of the induced investment component. To a large extent this is relatively superfluous to the model's application in Islay because the brevity of the construction period (within which the majority of the immigrants are felt) coupled with minimal long run labour requirements render it largely redundant in an economy having sufficient excess capacity for an additional island worker.

In conclusion, the results of the study indicate that, although the employment effects are not substantive, the development of a windfarm on Islay would be beneficial to the local economy, but whether it would be the optimal choice in terms of being an engine for rural growth is as yet undetermined.

6.2 Research Insights and Policy Recommendations

The primary message from the model's application is that if energy planners wish to simultaneously drive rural development, whilst delivering the electricity needed to enhance productive end uses, then not only must the technology reconcile a region's natural resource base with local energy requirements, but it must also maximise local participation. To this end the case study highlighted the fact that the majority of LVA is held within the labour and overhead components of the cost structure, therefore the optimum driver of regional development will involve an energy technology which can make the best use of local labour and which will involve long term use of local inputs, such as land, animal residue, willow harvests etc.

Indeed this will be a necessary energy strategy throughout the industrialised and developing world. Primarily because in the former, the additional employment and income implies that the local population will be more apt to accept adverse environmental impacts if they also recoup some of the financial benefits. Whilst in the latter, the additional income can help to alleviate some of the adjustment inertia associated with energy use in poor regions.

Furthermore in the absence of any influx of skilled immigrant workers, the utilities will need to establish a local technical support and service system. This factor is especially beneficial for developing country applications, since not only will the employment of local service engineers compound LVA content but it will also serve to diffuse new working practices and promote the development of indigenous technical capacity.

The imposition of the induced investment coefficient is a particularly arbitrary practice and will depend upon short and long run labour requirements, the length of the construction period, labour migration and mobility and excess capacity. With this said, one of the failings of renewable energy's role as a catalyst for rural growth lies in the short lead times and minimal long run labour requirements. As a consequence, the induced investment in capital provision is limited with the result that it tends to weaken development momentum.

Conversely the modularity associated with renewable energy technologies allows utilities to stagger capital investment in generating capacity to concur with user load growth. This therefore means that phase 1 type activity (which procures the greater impact) can be extended over time. As such the benefits are twofold:-

- Firstly, phase 1 type activity has the greater impact upon local labour and income distributions, therefore its extension would procure significantly increased net economic gains.
- Secondly, if a region has little excess capacity then extending phase 1 will necessitate the inclusion of the induced investment coefficient to capture the investment in immigrant labour's capital provision.

The result of both these effects is a substantive increase in both regional income and employment opportunities. However in cases where in-migration is marginal (e.g. in LDC's where labour mobility is poor) the induced investment component may be rather ineffective if excess capacity exists, although the case study of the previous chapter showed that when, in fact it is applied, it has a significant impact upon local incomes.

Consequently in the absence of any induced investment on capital provision, the primary source of indigenous growth will stem from additional consumer spending and the growth of related activities. Moreover the impact of income will be particularly strong in increasingly subsistent economies, although this will decline over time as consumer imports become more accessible financially. In LDCs this may ultimately result in increasing load growth, although a rise in electricity consumption will depend upon the marginal rate of substitution between fuels and the extent of energy adjustment inertia.

To conclude, the model has thus identified key areas within a renewable energy programme which can be exploited and manipulated to strengthen the local multiplier expansion. However, any potential renewable energy option must be subject to the same financial rigour as any other competing supply system, with the resultant choice being dependent upon government social and energy objectives.

6.3 Further Research Prescriptions

Further research pertaining directly to the case study involves the commissioning of additional regional impact studies relating to the effects procured by other electricity supply options. These include those detailed in the original feasibility study [ETSU(1995a)] as well as others such as biomass, whose production would target the farming community, thus providing supplementary income whilst supporting the jobs therein.

Furthermore, conjectures pertaining to the growth of tourism and related activities will require substantiating. To this end speculative impacts may be forecast using historical data from sites of similar size and technology. However results based upon regression analysis or some other statistical technique should be accepted with caution, since the site specificity of renewable technology installations will preclude any definite conclusions.

Regarding the model's application in other instances, a particular noteworthy addition would be the incorporation of spatial analysis. Although this wasn't strictly relevant in the Islay case study due to the insular nature of the local economy, for mainland application a spatial sensitivity analysis would be useful in defining the boundaries of the multiplier expansion. This would be best achieved using commuting or gravity effects; both being of relevance to development studies since they would establish the areas within which growth is likely to occur and furthermore what characteristics are specific to those areas which accelerate development momentum.

A final point concerns the wider context of socio-economic impact studies or rather their internalisation under the social/electricity demand curve. Traditionally the benefit component of cost benefit analysis has been determined on purely commercial terms, however future research will require a method of enumerating the socio-economic impact and thereafter reconciling the outcome with demand forecasting, since additional local income could become a factor in the derivation of load growth projections. Moreover similar studies must be realised for traditional rural electricity supply options (e.g. Grid connected power), although it is doubtful that they will generate as many local benefits as renewable energy technologies.

In conclusion the incorporation of socio-economic impact studies into overall energy planning appraisals may offer a much improved measure of indigenous rural growth, but whether the benefits derived from renewable energy technologies will form as persuasive an argument for the renewable lobby, as have the environmental influences of previous years is as yet undetermined and will require further detailed analysis. However for the moment, the present study has laid down the foundations upon which further research can build.

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APPENDIX A

Parameters of the Income Multipliers

A.1	(t_d)	*The Direct Tax Rate*
A.2	(t_i)	*The Indirect Tax Rate*
A.3	(c^*)	*The Marginal Propensity to Consume Locally*
A.4	(u)	*Proportion of Unemployment Benefit to Income*
A.5	(m)	*Marginal Propensity to Import*
A6	(λ)	*Income of Public Sector Employees Expressed as a Proportion of Total Income*
A.7	(n)	*The Induced Investment Co-efficient*
A.8	(θ)	*Ratio of Public Service Employees to Total Workforce.*
A.9	(l)	*Average Cost to an Employer of an Additional Employee*
A.10	(v)	*Proportion of an Increase in Income which is LVA*
A.11	(W_p)	*Average Wage of Public Sector Workers*
A.12	(W_d)	*Average Wage of Direct Employees*

The value of the income and employment multipliers is obtained by attributing appropriate values to the relevant variables included within the multiplier formula

A.1 The Direct Tax Rate (t_d)

The value of the direct tax rate (t_d) is taken to be *25%*, on the assumption that:

1. No provision has been made for junior or part time workers
2. No relief is given for mortgage allowance, married couples allowance etc.
3. National Insurance contributions have been discounted

A.2 The Indirect Tax Rate (t_i)

Similarly we shall assume an indirect tax rate (t_i) of *17.5%*, thus discounting all consumer durables which have no VAT component.

A.3 The Marginal Propensity to Consume Locally (c^*)

In view of the paucity of information concerning the islands accounts, c^* is very much an estimate determined by regional accounts rather than localised data. However whilst we acknowledge its limitations in defining island expenditure patterns we would underline the fact that the value of c^* is an arbitrary figure and its value will ultimately depend upon the availability of goods and services within the defined area.

To derive the local MPC (c^*), we may use the Family Expenditure Survey (CSO 1995) to investigate the relationship between Scottish disposable income and household expenditure.

Table A3.a ***Consumers Expenditure and Disposable Income in Scotland (1984-94)***

Year	*Consumers Expenditure (£m)*	*Price Indices*	*Real Disposable Income (£m)*
1984	*17499*	*74.6*	*19348*
1985	*18780*	*78.6*	*20936*
1986	*20194*	*81.7*	*22912*
1987	*21896*	*85.2*	*24598*
1988	*24814*	*89.5*	*26673*
1989	*26598*	*94.8*	*29405*
1990	*28613*	*100*	*33230*
1991	*29896*	*107.4*	*35958*
1992	*31415*	*112.4*	*39319*
1993	*33830*	*116.9*	*41293*
1994		*119.3*	

Source: Family Expenditure Survey (CSO 1995)

The above data gives rise to a national MPC of ***0.827***. To convert this value into a local one for the Argyll and Bute area we assume that county disposable income is proportional to national disposable income: e.g.:-

*Household Disposable Income **(Argyll)*** = *Household Disposable Income **(Scotland)*** * *Ratio of County to National Earnings*

Table A3.b ***Ratio of County to National Disposable Income***

Year	*Argyll and Bute Weekly Disposable Income (£)*	*Scottish Weekly Disposable Income (£)*
1989	*162.1*	*189.7*
1990	*171.9*	*201.3*
1991	*182.6*	*214.6*
1992	*193.3*	*233.3*
1993	*210.2*	*251.2*
1994	*236.6*	*276.4*

Source: Regional Trends 1995

Applying this ratio to the national MPC gives an estimated local MPC of ***0.804*** for the Argyll and Bute area. This implies that every £1 increase in disposable income will induce a 0.8 rise in consumer spending, which means that the marginal propensity to save is taken as the residual of this and is given by 0.196

With respect to the Isle of Islay, it would be misleading to believe that this increase in spending would accrue entirely to the island economy. Indeed the real increase in local spending will depend upon the service base available on the island.

In the absence of any socio-economic study of the islander's purchasing habits and their service base, we shall assume, that in view of their isolated location up to 80% of goods are bought on the island itself, whilst up to 100% of goods are bought within the Argyll and Bute area.

From these values we must further detract a small percentage in respect of service charges for fuel, water, vehicle tax etc., the expenditure for which will accrue entirely to sources outside the district. Combining all these considerations, we may suppose that only 75% of household disposable income will be spent within the immediate locality, whilst 95% will be spent in the surrounding county. Therefore the marginal propensities to consume for the respective areas are:-

$0.804 * 0.75 = 0.603$ For the island
$0.804 * 0.95 = 0.764$ For the mainland county

A.4 Proportion of Unemployment Benefit to Income (u)

To determine (u) we assume that all local workers involved with the plant had been previously unemployed and in receipt of unemployment benefit and other support payments. Consequently any increase in local employment resulting from the plant will lead to a substantial decline in government transfer payments.

Using a 90:10 ratio of male to female employees, the value of u is based upon the ratio of average gross weekly earnings of full time employees to the unemployment benefit received by claimants[1] Although the figures are not directly related to specific industry or manufacturing sectors they are nevertheless applicable to regional level for the year 1995.

Table A4.a Average Gross Weekly Full Time Earnings

	Male	*Female*
Scotland	*£335.6*	*£244.1*
Strathclyde	*£332.3*	*£245.3*

Using the above weekly averages in conjunction with the 90:10 ratio of male to female employees, u is computed to be ***0.33***

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[1] For men we will assume a benefit payment of £114.15 in respect of a family of 4 persons inclusive of 2 children, whilst women are assumed to be in receipt of a weekly payment of £46.50 based upon a single persons allowance

A.5 Marginal Propensity to Import Goods and Services (m)

If m is taken to be the marginal propensity to import goods and services, then the residual $(1-m)$ represents that proportion of goods and services that are derived locally. This is called ***Local Value Added*** (LVA), and its magnitude will depend upon the islands commercial and manufacturing base.

To calculate the LVA component applicable to the island it is necessary to deconstruct total expenditure into its respective cost categories and attribute an estimated value of LVA[2] .

Table A5.a Estimated LVA Content

Category	*% of Regional Expenditure*	*Estimated LVA*	*Total LVA per Category*
Housing	*14.3*	*0.18*	*2.574*
Fuel, Light, Power	*5.3*	*0.23*	*1.219*
Food	*19.8*	*0.41*	*8.118*
Alcohol	*4.7*	*0.07*	*0.329*
Tobacco	*2.9*	*0.09*	*0.261*
Clothing and Footwear	*7.9*	*0.1*	*1.027*
Household goods	*8.5*	*0.1*	*0.935*
Household services	*4.6*	*0.28*	*1.288*
Motoring	*14.8*	*0.25*	*3.7*
Personal Goods	*3.8*	*0.27*	*1.026*
Leisure Goods	*4.4*	*0.23*	*1.012*
Leisure services	*8.4*	*0.35*	*2.94*
Miscellaneous	*0.6*	*0.2*	*0.12*
			24.549

Source: Regional Trends 1995

From the above computation it would appear that the LVA component accounts for only 24.549% of expenditure on regional goods and services. This implies that m assumes a value of ***0.7184***, reflecting the high percentage of goods which are manufactured outside the district and which ultimately have to be imported on to the island.

Obviously the greater the manufacturing base then the smaller the value of m.

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[2] Estimates of LVA are taken from Grieg (1971) which relates to the impact of a wood mill on the local economy in the Highlands of Scotland. Consequently it is thought that both economies will exhibit similar import leakages

A.6 Income of Public Sector Employees Expressed as a Proportion of Total Income (λ).

The Strathclyde ratio of public sector employment[3] to total workforce (34.1%) is taken as the basis for the derivation of λ. However due to Islay's isolated location, we would suspect that the island average would exhibit a marked difference to that of its regional counterpart. This is because much of the social service infrastructure present on the mainland would not be present on the island, whilst those services that are offered would only be a marginal reflection of their mainland counterparts, (e.g. higher education, hospital facilities, policing etc.).

Therefore it is necessary to deflate the initial ratio of 34.1% to a value of 25%, although it should be acknowledged that this is only a very arbitrary value which may be corrected in the light of an island census.

Consequently if λ follows the relationship given below and the average annual salary of public sector workers is taken to be £12,737 then the value of λ is equal to 0.025

$$\lambda = \frac{V!}{l!\,(V-l)!} \,.\, \theta \,.\, W_p$$

A.7 The Estimation of the Induced Investment Coefficient (n)

The derivation of *n* is made on two basic assumptions:-

1) Existing service capacity is already fairly fully utilised

2) Regional immigrants will have the same relative capital requirements as the population for the UK as a whole.

Since the full range of statistics needed for this approach is only available at UK level, these are used throughout, although we recognize that rates, earnings and type and quantity of capital requirements will vary between regions.

The capital requirements per immigrant are estimated below using estimates of the UK population between 1984 and 1994 in conjunction with figures for the capital stock at current replacement cost over the same period. By manipulating this data, an estimate of the capital stock per capita may be obtained.

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[3] Public sector services include: Public administration , policing, social services, education, sanitary services and medical care etc.

Table A7.a Capital Requirements per Immigrant

Year	*UK Population (M)*	*Net Capital Stock at Current Replacement Cost (£m)*	*Net Capital Stock per person (£000's)*
1984	*56.506*	*923.6*	*16.345*
1985	*56.685*	*984.3*	*17.364*
1986	*56.862*	*1056.7*	*18.584*
1987	*57.009*	*1154.3*	*20.248*
1988	*57.158*	*1305.3*	*22.837*
1989	*57.358*	*1465.8*	*25.555*
1990	*57.561*	*1547.3*	*26.881*
1991	*57.808*	*1529.3*	*26.455*
1992	*58.006*	*1515.2*	*26.121*
1993	*58.191*	*1549.7*	*26.631*
1994	*58.395*	*1668.7*	*28.576*

Source: CSO Blue Book

Although this is a far from perfect estimation it is nevertheless a usable proxy for capital requirements per immigrant[4].

The next stage in the estimation of n will be to estimate the total capital requirements needed to provide for an immigrant influx of say 100 persons[5]. In view of the comparatively short construction period, we will assume that the greater part of the immigrant influx would have occurred within the first year of the capital injection, with their capital requirements having been met within the first 2 year period.

Assuming that the capital is provided in a constant and even flow, it would imply that for any group of immigrants, 1/2 of their capital requirements would be installed within any given year. Moreover we further assume that the immigration influx also takes place at a steady and constant flow, implying that after two years of compound in-migration, the total capital investment levels off at a figure equal to the total capital requirement for any single years group of immigrants.

If we assume an influx of 100 immigrant workers and their families to the region, then an estimate of the total induced investment is calculated in the following way.

Initially we will have to estimate the total annual income resulting from the immigrant labour (ΔZ). To do this we must calculate the percentage of the immigrants who are likely to be in paid employment and how much on average would they earn.

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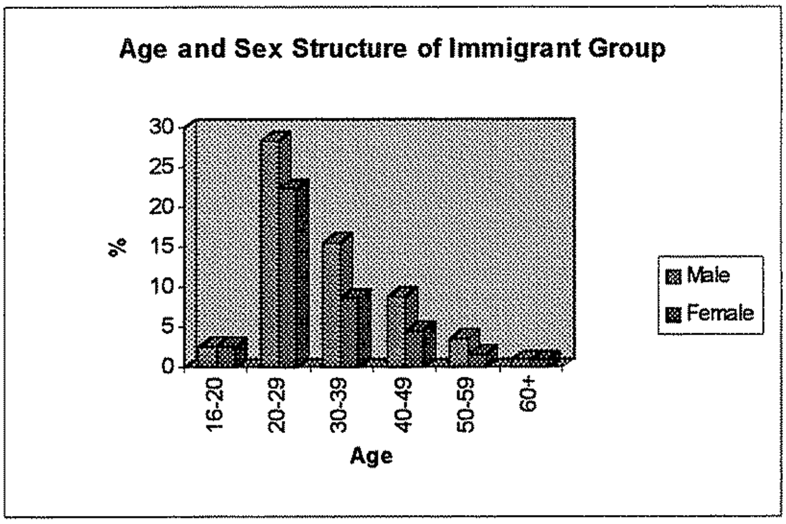
[4] Although the capital requirements in the receiving region involves induced investment in both private and public sectors $(\Delta I + \Delta G)$ no attempt will be made to allocate ΔN between these sectors).

[5] An immigration influx of 100 persons is used initially but this can be changed accordingly to reflect a greater or reduced in-migration trend.

Research on migration flows indicates that the typical age structure of migrants is rather younger than the nation as a whole, therefore had we applied Scottish activity rates to the immigrants as a whole, the result would have tended to underestimate the total value of earnings. To overcome this problem, it is assumed that the migrants have the same age and sex structure as that given by the Office of Population Census and Surveys (Migration Studies) 1991 (Fig A7.b).

Fig A7.b



To this breakdown it is necessary to apply the specific age and sex activity rates for Scotland, although we do acknowledge that differences may occur between national Scottish figures and both those prevalent on Islay and the Argyll area. This computation gives rise to the following results:-

Table A7.c   Estimates of the total earnings of Immigrant Employees

Year	*Activity Rates For Immigrant Workers*	*Immigrants Employed*	*Average Earnings Per Capita (£)*	*Total Earnings Of Immigrants (ΔZ)£*
1984	*62.1*	*62*	*11,556.97*	*716532.14*
1985	*62.2*	*62*	*12,433.60*	*770883.2*
1986	*62.1*	*62*	*13,479.70*	*835741.4*
1987	*62.5*	*63*	*14,221.10*	*895929.3*
1988	*63*	*63*	*15,331.60*	*965890.8*
1989	*63.9*	*64*	*16,405.90*	*1049977.6*
1990	*64*	*64*	*17,863.20*	*1143244.8*
1991	*63.6*	*64*	*19,633.90*	*1256569.6*
1992	*62.9*	*63*	*21,247.60*	*1338598.8*
1993	*63*	*63*	*22,486.20*	*1416630.6*
1994	*62.8*	*63*	*23,400.40*	*1474225.2*

Having derived values for ΔZ *and* ΔN, the induced investment co-efficient may now be computed using regression analysis. See Table 4.

Table A7.d Estimates of the Induced Investment Co-efficient

Estimate of Total Immigrant Earnings (£)	*Estimate of Annual Capital Requirement Provision N (£m)*
716532.14	*1.635*
770883.2	*1.736*
835741.4	*1.806*
895929.3	*2.025*
965890.8	*2.284*
1049977.6	*2.552*
1143244.8	*2.688*
1256569.6	*2.645*
1338598.8	*2.612*
1416630.6	*2.663*
1474225.2	*2.857*

Using regression analysis it would seem that the value of n is taken to be ***0.763***. However in view of the absence of information at a very local level, *vis a vis*, existing capacity, industrial structure, additional capacity provision or precise regional levels of earnings, it is apparent that this estimate may only be taken as a very tentative first estimate of a plausible value for a regional capital and output ratio.

A.8 Ratio of Public Service Employees to Total Workforce (θ).

The Strathclyde ratio of public sector employment[6] to total workforce (34.1%) is taken as the basis for the derivation of θ. However due to Islay's isolated location, we would suspect the island ratio to exhibit a marked difference to that of its regional counterpart. This is because much of the social service infrastructure present on the mainland would not be present on the island, whilst those services which are available, would only be a marginal reflection of their mainland counterparts, (e.g. higher education, hospital facilities, policing etc.).

Deflating this ratio to a level of 25% will therefore take account of the lower level of public service provision, although it should be acknowledged that this is only a very arbitrary value which may be corrected in the light of an island census.

Furthermore application of this variable in subsequent rounds require it to be grossed up by a factor of [25/(100 + 25)]*100% which will allow for the fact that public sector workers themselves will require these services. Therefore θ will become $\theta_1 = 0.2$ in subsequent rounds.

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[6] Public sector services include: Public administration , policing, social services, education, sanitary services and medical care etc.

A.9 Average Cost to an Employer of an Additional Employee (l)

Using the Scottish Abstract of Statistics 1995, it would appear that the average gross annual wage/salary in the county of Strathclyde is £21,186 for men and £14,445 for women[7]. Unfortunately the average service sector wage is unobtainable at island level therefore to these values we shall apply the Scottish ratio of total service sector wages to total wages. The result of this calculation implies that the average service sector salary is £15,901 for men and £10,834 for women.

To these estimates of service sector wages we shall now apply the regional activity rates according to sex within the Argyll and Bute area. According to Regional Trends (1995) it would appear that the female working populus within the service sector is almost double that of males, having values of 64.8% and 35.2% respectively. Consequently the average wage within the service sector industry is given to be £12,617. Thus implying that the average cost to an employer of one additional employee is £12,617 per annum.

A.10 *Proportion of an Increase in Income which is LVA (v)*

v is taken to exhibit the following relationship:-

$$v = (1 - s - t_d)(1 - m)$$

where s is the marginal propensity to save. If s is defined as being 0.196 from appendix A, then the value of v is ***0.157***.

A.11 (W_p) Average Wage of Public Sector Workers

Having accounted for the male female ratio in the public sector services, the average wage in this sector is given to be £12,737.

A.12 (W_d) Average Wage of Direct Employees

After consultation with national windpower, the average wage of direct windfarm employees is taken to be £17,000.

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[7] Includes employers NI contributions, overtime bonuses and redundancy pay

APPENDIX B

Income and Employment Multipliers

Estimates of income and employment effects are derived using the coefficients estimated in Appendix A, in conjunction with projected expenditure payments (as detailed in 4.3.1) and direct labour requirements.

Long and short run impacts are estimated using the model derived in chapter 3 and are detailed overleaf. Thereafter, a detailed analysis is given of the windfarm's expenditure and labour requirements, which in part explain the derivation of the capital import leakage, the reliance upon immigrant labour and the appropriateness of the induced investment coefficient.

Employment and Income Multiplier Variables

Income Multiplier Variables

t_d	t_i	c^*	λ	m	u	n	z	$1-m_1^*$	$1-m_2^*$
0.25	0.175	0.603	0.025	0.755	0.33	0.763	0.5	0.235	0.7

Employment Multiplier Variables

v	s	θ	θ_1	Δv_1	Δv_2	l	W_d	W_p	${}^1E_d$	${}^2E_d$
0.136	0.196	0.25	0.33	41533	6922	12617	17000	12737	18	3

Employment and Income Multipliers

ΔE_1	ΔE_2	k_i	k_i^1	k_i^2	$k_i^{2..n}$	k_e
8.621	1.438	1.045	0.245	1.324	0.731	1.479

t_d	*The Direct Tax Rate*
ti	*The Indirect Tax Rate*
c^*	*The Marginal Propensity to Consume Locall*
s	*Marginal propensity to save*
u	*Proportion of Unemployment Benefit to Inc*
m	*Marginal Propensity to Import*
λ	*Income of Public Sector Employees Express* *Proportion of Total Income*
n	*The Induced Investment Co-efficient*
θ	*Ratio of Public Service Employees to Total Workforce.*
l	*Increase in Local Value Added (LVA) neces* *create one extra job in the service trades*
m^*_1	*Capital Import Leakage (Construction Phase*
m^*_2	*Capital Import Leakage (Operational Phase*
E_d	*Local Direct employment*
E_i	*Indirect Employment*
W_d	*Average earning of DIRECT employees*
W_p	*Average earnings of PUBLIC SECTOR emp*
v	*Proportion of an increase in income which i* *value added (LVA)* $v = (1-s-t_d)\ (1-m)$
ΔV	*Increase in LVA created by direct employees* $\Delta V = E_d . W_d . v$
k_i	*Keynesian Income Multiplier*
k_i^1	*Construction Phase Income Multiplier*
k_i^2	*Operational Phase Income Multiplier (with* *Investment)*
$k_i^{2...n}$	*Operational Phase Income Multiplier (witho* *Induced Investment)*
k_e	*Employment Multiplier*

Using the aforementioned values, the income and employment multipliers may now be derived using the formulas given below.

The Keynesian Income Multiplier

$$k_i = \frac{1}{[1 - \lambda - c^*(1-t_d-u)(1-m-t_i)]}$$

The Change in Regional Income

$$\Delta Y_r = k_i \{J_1 (1 - m^*) + J_2[1 + nz(1-m^*)]\}$$

Indirect Employment

$${}^nE_i = {}^nE_d\,\theta + [(\Delta V)/l](1 + \theta)$$

Gross up of Public Sector Service Employees

$$\theta_l = [\theta/(100+\theta)].100$$

Change in Indirect Employment

$$\Delta^1E_i = {}^1E_d\,\theta + \{(\Delta V)/l\}.(1 + \theta) + \{{}^1E_d\,w_d\,(k_i-1)\}$$

$$/\,\{l(100-\theta_l)+w_p\theta_l\}$$

Employment Multiplier

$$k_e = 1 + \{(\Delta^1E_i + \Delta^2E_i)\,/\,({}^1E_d+{}^2E_d)\}$$

B.2 Direct employment

The construction stage is only expected to create 25 full time jobs at most. From those twenty five, two positions are likely to suffer from what Jenkins (1995) called *'head officism'* and will therefore bear no influence upon the regional income and employment multipliers. Another five jobs will be allocated to the main contractor's core employees, although it is doubtful whether they will be resident on the island during the entire year long construction period. The remaining jobs (eighteen in total) will be contracted to the local labour market[1], although it should be acknowledged that had the island not had a sufficient skills base then the region could have expected an even greater, albeit temporary influx of immigrant workers.

During the operational phase of the investment it is expected that the windfarm will engage three full time employees, but of those three, only the manager's position is likely to involve someone from outside the locality.

Consequently the brevity of phase 1 and the minimal labour requirements of phase 2, present further ramifications for the induced investment coefficient.

During the construction stage, the temporary and relatively brief residency of the main contractor's core employees is unlikely to make a significant impact upon the first round multiplier process, other than to contribute to the LVA content contained within their expenditure on bed and board. Furthermore their stay is too brief and their numbers too few to warrant any induced investment in the public sector to support the increased workforce during their stay.

Furthermore the ramifications of the operational stage are two fold:

- Firstly, the long term dependence upon immigrant labour will account for 1/3 of the plant's employment. However because the manager's position will require a comparatively more skilled and experienced employee, then the value of z (the dependence upon immigrant labour) should be weighted to reflect the higher salary that he/she will yield. Consequently rather than $z = 0.33$, we now have $z = 0.5$ which will impact upon $J_2.....J_n$ and the induced investment component to a greater degree than the previous value.
- Secondly it is unlikely that the advent of one long term immigrant employee would necessitate any public or private investment, it being assumed that Islay's

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[1] It being assumed that those people employed by the plant were previously unemployed.

current capacity is able to support at least one additional island worker and his/her family.

In conclusion, whilst the windfarm could offer short term employment, the relatively short construction period, coupled with the minimal long term employment opportunities act as a considerable brake on induced investment opportunities and any indigenous growth thereafter. With this said the value of the relevant employment variables are given by:-

$^{1}E_d = 18$

$^{2}E_d = 3$

$z = 0.5$

B.3 Capital Investment Leakages (m^*)

Many previous studies Grieg (71) Brownrigg (71) ETSU (1995) have tended to use a constant value for m^* throughout the expansion, however with respect to the installation of renewable energy technologies, this methodology could be quite misleading. The initial construction stage will require highly specialised equipment and engineering, thus necessitating a greater proportion of consumer and labour imports. Accordingly this implies that m_1^* within the construction phase will be greater than that in the operational stage[2].

Taking the Islay windfarm as a case in point, the turbines alone will account for up to 70% of the initial capital injection, thus the entirety of that particular expenditure element will accrue to a source outside the locality. Consequently the value for m^* applicable to each stage will not only depend upon the respective cost structure of direct labour and materials etc. but also upon their availability within the area[3].

In attempting to evaluate m^* we must firstly estimate the 'Local Value Added' (LVA) component contained within each of the investment's cost categories, thereafter the estimations may be combined to derive an estimate of the Local Value added component, $(1-m^*)$ which is the residual of the capital import leakage.

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[2] Although we have assumed that the cost structure of phase 2 is similar to that of the induced investment

[3] Obviously the type and volume of constructional and service imports will vary between regions reflecting not only the industrial structure of the region but also its geographical structure in relation to constructional supplies.

To begin, some of the primary sources of LVA are those payments made to landowners in return for the use of their land. Although the windfarm will only consist of 6 wind towers, each farmer having turbines on his land is expected to receive a lump sum payment (c£1000) in lieu of compensation and signing-on fees. Additional lump sum payments are also made with regard to on-site quarrying rights, access improvements, construction of sub station and general inconvenience caused by heavy vehicles crossing farmland.

Finally, further payments are expected to be paid to other landowners who will be affected by the plant's traffic and construction operations, but on whose land wind towers are not erected[4]. Initial one off payments of this type are estimated to total some £30,000, although landowners can expect an annual income stream from the investment for the entire duration of the plant[5], the size of which will depend upon both the revenue generated per turbine and the number of turbines per farm unit.

The other primary source of LVA is expected to come from the plant's direct expenditure on labour services, but the magnitude of this component will depend upon the working practices of both the windfarm and the main contractor.

Payments made in respect of Non Domestic District Council Rates will also contribute to LVA, but they have been organised on a national system whereby the local authority collects the rates which are then pooled and redistributed on a per capita basis by the Scottish Office. Thus the contribution made by the windfarm via these particular rates is rather complicated and the benefits to the local community are indirect.

Additional LVA is incurred on board and lodging for temporary immigrant workers, but it is expected that only 60% of this will accrue as income to hotel proprietors, whilst recurrent payments to the community contribute to a 'social' fund which attempt to make the windfarm more acceptable to the local community.

Using a variety of sources both formal and informal, the average cost breakdown for the construction of a windfarm is given below. These are very much estimates rather than precise values and can be changed according to technology type.

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[4] The exact magnitude of these payments are yet to be confirmed, but are currently estimated in line with previous windfarm practices.

[5] To make the initial payments comparable with the recurrent income streams received by the farmers, each lump sum payment should be converted into an annuity or equivalent annual income stream by discounting, i.e.:-
Annuity = (Lump sum received)/ $\Sigma(1+r)^{-t}$

Phase 1		***Phase 2***	
Direct Materials	*10%*	*Direct Materials*	*10%*
Direct Labour	*25%*	*Direct Labour*	*45%*
Plant	*60%*	*Plant*	*15%*
Overheads	*5%*	*Overheads*	*30%*

Therefore, using the details above to deconstruct the investment's expenditure patterns, we may obtain estimates of the LVA content contained within each part. These are given accordingly, although initial details refer to phase one:-

a. Materials

LVA will only be attributed to direct materials which were purchased or manufactured locally. In reference to the initial construction stage, past experience would suggest that the project planners use a mix of main contractors and sub contractors who exhibit a marked difference in policy; the former will normally import all their materials into the subregion from a main external depot, whilst the latter being typically indigenous to the area, will rely upon local purchases.

If we assume a 40:60 ratio between contractor and sub contractor, taking the contractor first it would seem that only 10% of their direct material costs are from local purchases. However since these purchases are of goods held locally but which are ultimately imported, then only a margin of say 20% is LVA, i.e. only 2%. Adjusting this margin in line with the 40:60 ratio implies that only 0.8% of the total direct material costs will be LVA.

Alternatively sub contractors will purchase about 70% of their materials locally, which when subjected to the same margin of firstly 20% and then the 40:60 weighting device the estimate for the LVA of direct material costs is 8.4% for sub contractors.

Taking manufactures and purchasers together, the LVA component accounts for less than 10% of direct material costs and therefore only 1% of the total construction expenditure.

b. Labour

Brownrigg (1971) indicates that much of the same problems of differing behaviour between main and sub contractors apply to direct labour costs. In that main contractors have a central core of workers which is then augmented by local labour.

Taking the construction phase first, experience has shown that the main contractors recruit about 50% of their labour force from the region, which when applied to the working ratio of contractors the local labour will account for 20% direct labour costs during construction.

Furthermore sub-contractors are expected to employ a greater proportion of local labour, even up to 100%. Applying this to the same methodology implies that the LVA accounts for 60% of direct labour costs.

Taking sub and main contractors together gives rise to an LVA value of 17.5% LVA for the initial expenditure on labour.

c. Plant

Plant and equipment costs tend to have zero LVA because they are nearly always imported.

d. Overheads

Some of the most unsatisfactory data concerning LVA content falls within this category. Not only does it include the expenditure on all feasibility reports, planning applications, environmental impact assessments but it also contains that part of expenditure which is paid to farmers in the form of compensation payments and sign-on fees etc.

Unfortunately the former payments are likely to suffer from what Jenkins (1995) calls 'head officism', therefore the LVA contained within these payments will be minimal. Conversely payments made to the latter group i.e. farmers and landowners, will embody a substantial element of LVA, if not 100%.

Due to the absence of an expenditure breakdown detailing the magnitude and distribution of these payments we will assume that 50% of the expenditure spent on plant overheads remains in the local economy as LVA. Translating this into the context of total plant expenditure results in a final value of 2.5% LVA for phase 1.

Consequently within the first round of the plant's expenditure, the LVA content assumes the following structure:-

Direct materials	1%
Direct labour	20%
Plant	0
Overheads	2.5%
	23.5%

The above computation implies that just under a quarter of construction expenditure will impact upon the local economy, whilst over 70% will accrue to sources outside the locality. This therefore means that m_1^* assumes a value of 0.765 whilst (m_1^* -1) is equal to 0.235.

Inevitably the cost structure attributable to the construction phase will differ substantially from that applied to the operational stage and the induced investment component, as will the respective working practises.

Taking the labour component first it is expected that all of the plant's expenditure on labour will remain in the local economy since the operational employees are expected to be resident on the island.

With respect to the overhead payments, we would anticipate that a greater proportion of the expenditure would be attributable to LVA due to the annual payments made to land owners and the district council. Unfortunately precise figures detailing these payments are unobtainable at this time, therefore we shall assume an LVA value of 80% in line with previous windfarm practices, [Stevenson & Jones (1995)]. When put in the context of total expenditure the LVA content contained within overhead payments accounts for only 24% of long term total expenditure.

Again combining the respective expenditure categories, the LVA content contained within each is determined to be:-

Direct materials	1%
Direct labour	45%
Plant	0
Overheads	24%
	70%

which implies that above computation implies that just over two thirds of the windfarms long term expenditure will impact on the local economy, whilst almost 40% of the plants expenditure will accrue to sources outside the locality.

Combining the various elements which contribute to LVA, we find that only 23.5% of construction expenditure impacts upon the local economy whilst this rises to 70% in phase 2.

Translating this into capital leakages we find that 76.5%, of construction spending accrues to sources outside the region, although this drops to 30% during the subsequent operational phase.

As we had previously anticipated $m^*_1 > m^*_2$, This being a consequence of the disproportionate drop in expenditure on capital equipment between phases. Ultimately however any value of m^* will be a reflection of the district's goods and service base relative to the requirements of the development. The lower the availability of the necessary goods and services within the area, then the higher the value of m^* .

Consequently the value of the capital import leakages are given by:-

m_1^*	76.5%
m_2^*	30%

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