Presented at:

The Agricultural Economics Society's 81st Annual Conference, University of Reading, UK

2nd to 4th April 2007

The Social-Environmental Impacts Of Renewable Energy Expansion In Scotland.

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Abstract

Investments in renewable energy, such as new wind farms and hydro schemes, are being promoted as a new means of diversifying rural employment in Scotland*. However, such investments are associated with a range of environmental impacts which might be detrimental to other economic activities, such as those based on nature tourism. When designing policy instruments for more sustainable energy futures, therefore, the main goal is to generate the lowest possible adverse socio-economic and environmental impacts ensuring a certain degree of economic efficiency. We use a Choice Experiment to quantify peoples' preferences over these multiple impacts of renewable energy in Scotland. We find that landscape, wildlife and air pollution impacts are all significant for both urban and rural respondents. Only rural respondents, however, value job creation. We also show the differences in the welfare gain associated with alternative renewable energy investments between rural and urban households.

We thank the Scottish Economic Policy Network for part-funding this work

* Renewable energy investment is mainly driven by factors other than the need for rural diversification. Renewable energy technologies contribute to mitigate climate change and, when locally produced, decrease the national dependence of imported energy and increase (local) employment. There are as well security reasons that bring policy maker increasingly assign high priority to renewable being lee prone to terrorist attach than, say, nuclear power stations or oil supply infrastructures.

Introduction.

Investments in renewable energy, such as new wind farms and hydro schemes, are being promoted as a new means of diversifying rural employment in Scotland[*]. However, such investments are associated with a range of environmental impacts which might be detrimental to other economic activities, such as those based on nature tourism. When designing policy instruments for more sustainable energy futures, therefore, the main goal is to generate the lowest possible adverse socio-economic and environmental impacts ensuring a certain degree of economic efficiency. We use a Choice Experiment to quantify peoples' preferences over these multiple impacts of renewable energy in Scotland. We find that landscape, wildlife and air pollution impacts are all significant for both urban and rural respondents. Only rural respondents, however, value job creation. We also show the differences in the welfare gain associated with alternative renewable energy investments between rural and urban households.

Promotion of renewable energies in UK.

UK government confirmed its commitment to reduce carbon emission by 60% by 2050. To accomplish this goal the government declared that by 2010, 10% of the UK's electric energy needs will by supplied by clean renewable energy sources. The government has also expressed an ambition to double this supply by 2020. To contribute to this commitment, the Scottish Executive has set a challenging target for development of renewable energy. By 2010, the proportion of electricity generated from renewable sources in Scotland is scheduled to be 18%; by 2020, the Scottish Executive aspires for the portion to be 40%.

Currently only 12% of electric energy produced in Scotland comes from renewable sources, mainly from large scale hydro schemes which are close to their maximum development. The increase of clean energy production will thus need to come from new energy projects and technologies. Due to cost advantages, wind energy will be the principal source developed to reach the 2010 target, but new technologies, e.g. tidal and wave energy will also be required to meet the 2020 target.

The principal policy instrument used by the Scottish Executive to improve renewable energy expansion is the Renewable Obligation (Scotland) (ROS). The ROS places a legal obligation on every electricity supplier in Scotland to match a percentage of their electricity sales with

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renewable obligation certificates (ROC). The ROCs represent renewable energy electricity that has been produced and sold into the electric grid. The original requirement on retailers to match quantity sold with ROCs, was set at 3% for 2002-2003, rose to 4.3% for 2003-2004 and will rise annually to 10.4% in 2010-2011. This has created a huge demand for renewable electricity supplies, motivating a dramatic expansion in the number of proposed projects.

Methodology

Renewable energy investment is mainly driven by factors other than the need for rural diversification. Renewable energy technologies contribute to mitigate climate change and, when locally produced, decrease the national dependence of imported energy and increase (local) employment. There are as well security reasons that bring policy maker increasingly assign high priority to renewable being lee prone to terrorist attach than, say, nuclear power stations or oil supply infrastructures

Choice Experiment (CE) analysis is an economic valuation method which is particularly well suited for investigating the impacts of environmental changes and the costs or benefits imposed on people. The essential concept underlying CEs is that any good can be described in terms of its attributes, or characteristics, and the levels of these attributes or characteristic take. A renewable energy project, for example, can by described in terms of the potential impacts on the environment, the effect on local economies and the consequent change in electricity prices. This study does not restrict the investigation to a specific technology but includes hydro, on-shore and off-shore wind power and biomass combustion as the main renewable energy alternatives being currently promoted in rural areas. Furthermore, differences in preferences between urban and rural residents are explicitly studied, with the objective of identifying positive and negative impacts from specified environmental attributes that may be affected by expansion of renewable energy projects into rural areas.

We consider the following attributes: landscape visual impact, effects on wildlife, air pollution, effects on electricity prices and on local employment; a random parameter logit model specification was used to include in the estimation respondents' taste heterogeneity.

Results

Overall, high landscape impacts considerably detracts utility to an alternative. Also, the effect of renewable energy projects which may have on *wildlife* is very important, and projects that may cause slight harm to wildlife are less likely to be chosen. People care a lot about the effect projects can have on *air pollution*. Interestingly, the *jobs* attribute is not a significant determinant of choice: that is, generally there are other more important issues than jobs which motivate people to support renewable energy projects. Heterogeneity arises from different values being held by respondents about the potential impacts of renewable energy projects. Considering landscape impacts, for example, there are individuals who firmly believe that wind mills are "beautiful and gracefully", whilst others believe that they destroy the quality of the landscape.

Focusing on the urban and rural sub-sample models we observe that preferences do differ between the two groups. Urban residents prefer projects that have low or no landscape impact (in spite of the existence of heterogeneity in this attribute), do not harm wildlife and do not generate air pollution. Creation of new permanent jobs is not a concern for urban respondents. Rural residents can be inferred to have greater support for renewable energy projects by having more significant coefficients which are positive in value and a smaller negative coefficient on the price attribute. Interestingly, rural respondents are very influenced by projects that create new permanent jobs, unlike the urban sample. This reflects the perception that main renewable energy projects will be constructed and maintained in rural areas.

From a policymaker's perspective, deriving welfare estimates of different renewable energy investments is the most useful aspect of choice experiments for use in benefit-cost analysis. The following four different energy project scenarios were considered as the outcome of the implementation of specific renewable energy technologies.

A. Large Offshore Windmill Farm – 200 MW, 100 turbines each at 80 meters nacelle hub height, 6-10 kilometres from shore.

B. Large Onshore Windmill Farm – 160 MW, 80 turbines each at 80 meters nacelle hub height.

C. Moderate Windmill Farm – 50 MW, 30 turbines each at 60 meters nacelle hub height.

D. Biomass Power Plant – 25MW, emissions stack height up to 40 meters, portions of building up to 30 meters, fuelled by energy crops.

Scenario:	Base Case	A	B	C	D
	Fossil Fuel power station expansion	Large Offshore Wind farm	Large Onshore Wind farm	Small Onshore Wind farm	Biomass Power Plant
Attribute Levels:					
Landscape	Low	None	High	Moderate	Moderate
Wildlife	None	None	None	None	Improve
Air Pollution	Increase	None	None	None	Increase
Employment	+2	+5	+4	+1	+70

The whole sample places the greatest value on offshore wind farms, with the major determinant the welfare change being the absence of air pollution and landscape impacts. Urban residents show a positive willingness to pay for only the large offshore wind farm, whilst they show negative welfare for all other types of renewable energy projects. Rural respondents welfare estimates are rather different and reveal a positive willing to pay for all the renewable projects proposed.

Conclusions

Scottish citizens generally support the expansion of renewable energy projects, in spite of the existence of heterogeneous preferences in regards to the potential costs and benefits of these projects. In terms of ranking renewable energy projects, the whole sample population would prefer large off-shore wind farm projects, followed by small on-shore wind farm projects. We also find important differences between urban and rural responses in this choice experiment. The urban group show a significant positive willingness to pay only for the large offshore wind farm project, whilst the rural sample stated a much higher willingness to pay for all the renewable project alternatives.

1. Introduction

Scotland is primarily a rural country with large expanses of land with either no occupancy or low population densities. Some 89 per cent of its land is classified as rural and 29 per cent of the population lives in this region. Rural areas are an integral part of the country's economy, environment and culture, and governments over the recent past have been concerned with providing economic incentives for population to remain in (and in fact re-locate to) rural areas. Falling employment in land-based industries such as farming and forestry, and recent changes in support mechanisms for farming, mean that alternatives need to be investigated, and indeed diversification of economic activities is a key element of rural development strategy. Examples of this diversification are nature- and culture–based tourism, aquaculture, and, more recently, the development of renewable energy resources such as wind power and small-scale hydro (Hanley and Nevin, 1999).

Renewable energy investment is mainly driven by factors other than the need for rural diversification. Renewable energy technologies contribute to mitigate climate change and, when locally produced, decrease the national dependence of imported energy and increase (local) employment[*]. The UK government has recently committed itself to a reduction of its greenhouse gas emissions to a level 12.5% below its 1990 emissions (Kyoto protocols). As a partial contribution to meeting this target, the Scottish Executive has set ambitious targets for the expansion of the fraction of electricity produced from renewable resources, of 18% by 2010 and 40% by 2020 (see below). Scotland is blessed with huge renewable energy potential (Hassan et al., 2001) and expansion of a renewable energy commercial sector holds the promise for a better economic future in many rural areas. Nevertheless, the development of renewable energy sources has multifaceted impacts that need to be taken into account to promote sustainable development in rural communities. These impacts differ widely across renewable energy sources (Abbassi and Abbassi, 2000; Tsoutsos et al., 2005).

When designing policy instruments for more sustainable energy futures, therefore, the main goal is to generate the lowest possible adverse socio-economic and environmental impacts ensuring a certain degree of economic efficiency. By using the Choice Experiment (CE) method, this paper estimates the positive and negative impacts from development of renewable energies in Scotland. CE is an economic valuation method particularly suited for estimating the trade-offs between goods, allowing policy alternatives to be evaluated, and respondent’s valuations of multiple impacts to be estimated. The approach followed in this

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paper does not restrict the investigation to a specific technology but includes hydro, on-shore and off-shore wind power and biomass combustion as the main renewable energy alternatives being currently promoted in rural areas.

In this investigation, differences in preferences between urban and rural residents are explicitly studied, with the objective of identifying positive and negative impacts from specified environmental attributes that may be affected by expansion of renewable energy projects into rural areas. The valuation of impacts is of interest because rural communities will be the population most directly effected by many of these impacts, such as the visual effects of wind farm construction in upland areas. As renewable energy projects proceed from the construction phase to operational status, communities will have to live with these projects and their associated infrastructures for 15 to 50 years. However, consideration must be given to urban residents who will be indirectly impacted by expansion of renewable energy projects by the environmental changes they will experience during travel through or visits to rural areas[i]. Furthermore, urban residents represent 71% of the Scottish population and are major stakeholders from a policymaker's point of view. It is also of interest to identify the difference in preferences between urban and rural residents, understand the source of these differences, and reflect on the implications of any differences for policy towards renewable energy.

The rest of this paper is structured as follow: the following section presents a profile of rural Scotland, and reviews studies related to the impact of renewable energy development; Section 3 sets out the government's policy towards renewable energy expansion; Section 4 summarises the choice experiment method; Section 5 describes the choice experiment design; and Section 6 presents the main results of the study. The final section presents some conclusions.

2. Rurality and Renewable Energy in Scotland

"Rurality" is a difficult concept to define; the Scottish Executive's rural development plan (Scottish Office, 1999) recommends the rural population be divided into the three groups. This designation is based on characteristics such as remoteness from a population centre, settlement pattern, population density, demographic structure and employment trends. The groups identified are:

Commuter - those with a 1 hour or less travel time (by either road or rail) to the nearest settlement with a population that can vary in size from small villages to small towns of about 10,000 habitants.

Intermediate - those within 1 to 2 hours travel time from a principal centre, typically with an ageing population and low population density.

Remote - those with greater than 2 hours travel time from the nearest principal centre, typically with a static or decreasing population.

These three distinct groups are facing different problems: commuter areas have increased in population during the last decade, but now have to cope with demands for developing additional land for new houses, businesses and infrastructure. For intermediate areas the main issue is diversification of the primary economic sector, agriculture, in an attempt to enhance the local economy. These areas are characterised by ageing populations and low population densities. Remote areas are faced with decreasing populations, poor employment opportunities, with a high dependency on the agricultural sector, and a net out migration of young people.

There are many benefits associated with rural life in Scotland, such as those associated with the physical environment (e.g. landscape quality), low noise levels and low crime rates. As counterpart, problems like isolation and distance from basic services, lack of amenities, poor public transport, and fewer job opportunities cause a continuous flow of people out of rural areas and towards urban centres or abroad[ii]. This outward flow has particular relevance to the hill and uplands areas of Scotland and the Western Isles, (Fleming, 2003) where the population has decline 3% in the last 10 years.

Rural communities still depend heavily on the agricultural sector. In Scotland agriculture contributes approximately 2% of GDP and is responsible for the direct employment of approximately 70,000 people overall (Scottish Executive, 2000), but this contribution is much higher in rural areas, both in its own right and for the contribution it makes to other sectors[iii]. As well as agriculture being part of the social and environmental infrastructure of rural Scotland, it is part of Scottish rural identity. During the last decade the agricultural sector experienced several crises ranging from an outbreak of Foot and Mouth disease, occurrences of BSE in the food chain and a review of the Common Agricultural Policy, all of which caused a net fall in farmers' incomes (Scottish Executive, 2005).

The nature of Scotland's rural economy has always evolved and diversification continues across rural Scotland. This has involved local economies branching out into activities such as bed and breakfast provision, rural or green tourism, and using the land for recreation and leisure pursuits (fishing, riding, mountain biking, etc.). In some instances farms have transitioned from traditional crops and livestock management to innovative products such as raising ostriches and llamas to growing hemp and crops that can be used for producing energy, e.g. coppiced willows. New opportunities arise from new technologies. Of central concern to this paper is the development of renewable energy technologies. This sector may provide significant support in the future to local economies, especially if most land-based renewable energy projects are located in the remote rural areas as predicted (Hassan et al., 2001).

Some renewable technologies such as wind farms are unlikely to provide a large number of jobs, but many of the jobs that are created will be in rural areas. Since renewable energy projects tend to be physical capital intensive, there exist opportunities to develop and manufacture renewable energy equipment for domestic use and export. Logistic problems occur when transporting some of this equipment, but the close proximity of sea-born transportation to many of the remote Scottish areas favours these locations and reduces the need for road transportation. Examples of manufacturing investments in rural Scotland for renewables exist: Vesta, a major manufacturer of wind turbines, recently opened a factory in Campbeltown, Argyll, creating over 100 high skill jobs, whilst a new wind turbine and offshore manufacturing and assembly firm (Cambrian Engineering) will bring 65 jobs to Arnish, Lewis, in the Western Isles. The Scottish Executive (Scottish Executive, 2002) estimates there are currently around 1000 people in Scotland who owe their jobs to new renewable energy development or expansion, and it expects the number of jobs to increase in the years ahead. Unfortunately, the report does not specify the share of jobs between rural and urban areas, but we expect most of the jobs will be in rural areas. A significant amount of temporary jobs will also be created during the construction phase of new projects such as wind farms.

Like any development proposal, renewable energy projects have the potential to increase environmental concerns; this is especially true when considering that average renewable energy projects require large amounts of land to capture the energy in wind, water or solar radiation in sufficient quantities to be commercially viable. The expansion of renewable energy, besides bringing economic development and reducing greenhouse gas emissions, will impact the landscape and wildlife of rural communities. It also may impact the tourism sector in areas where tourism has become an integral and substantial part of the local economy. It is therefore important to identify public opinion about renewable energies and public awareness of the potential harms and benefits from expansion.

Previous Studies

Although there are many studies that look at the technological and power supply aspects of renewable energy, there are rather few studies that investigate the social and environmental effects of renewable energy investments. Madlener and Stagl (2005) using a multicriteria evaluation approach accounted for the environmental, social and economic impacts of the renewable energy technologies and found that by considering these impacts it can strongly increase gains achievable from using such technologies. Also using multicriteria approach, Polatidis and Haralambopoulos (2007) describe an agenda and present a case study on increasing social participation and planning of renewable energy project that can lead to greater social acceptance. Bikam and Mulaudzi (2006) investigated the social and policy issues that need to be addressed to assure the long-term success of deploying renewable energy systems in rural areas. They concluded that pilot projects with relatively new technology input in a rural area should reconsider the importance of culture, capacity development and the level of income of the end users at the initial planning stage and implementation.

Regarding social acceptance of renewable energy project, Braunholtz, (2003) found that concerns of local residents reduce considerably once a development is in place, compared to during its planning. In Scotland, a study by MORI (Mori, 2002) found that 80 per cent of tourists said they would be interested in visiting a wind farm in Argyll, if it were open to the public and had a visitor centre. Wind farms are used for marketing purposes in certain areas of Denmark, where hotels, guest houses and camp sites use wind turbines for "green tourism" promotion to meet tourists' growing interest in environmental issues and new technologies. Hanley and Nevin (1999) found that local people in the Northwest Highlands were on the whole in favour of development of renewable energy projects, whilst no substantial negative impacts on future tourism revenue was found. However, there is evidence of opposition to renewable energy projects; Bishnu and Horst (2004) found that environmental arguments were insufficient to convince local residents to accept a biomass electricity plant.

Renewable electricity generation costs are currently greater than those for traditional electricity generation (coal-fired, oil, gas, conventional hydroelectric, and nuclear) (DTI 2006) and will create higher electricity prices for all Scottish residents[iv]. This fact is not considered in the most studies listed above, where only non-monetary preferences have been obtained from the general public. Hanley and Nevis (1999) included electricity costs and specifically accounted for the extra costs that implementation of three proposed renewable energy options would have brought to residents of one particular area in the Highland Region of Scotland. However, with the methodology used, it was impossible to identify respondents' trade-off rates between goods and bad impacts of renewable energy investments. It would be interesting to investigate how people actually trade-off benefits and costs of renewable energy projects, so that information could be obtained in a policy making context, with the objective of achieving socially optimal investments. The CE method provides this kind of information and is particularly suited for the economic evaluation of trade-offs between the effects which arise from building new renewable energy projects. The resulting estimates are supported by the consumer theory of demand and can be used in a cost-benefit analysis. Our paper uses the CE method for this reason.

It is important to note that this approach determines the public's valuation of impacts from renewable energy project deployment into communities. This is distinct from conducting a comparative financial analysis of the potential costs and revenues from deploying different types of renewable energy technologies.

3. Promotion of renewable energy in Scotland

In the recently published Energy White Paper (The Stationery Office, 2003) the UK government confirmed its commitment to reduce carbon emission by 60% by 2050. In setting this target the government established its intention to carry on with an energy policy aimed at reducing greenhouse gases emissions, with the goal of meeting Britain's commitment to the Kyoto Protocol. The 1997 protocol mandates a UK reduction of emissions of a basket of greenhouse gases by 12.5 % below the 1990 levels by 2008-2010. To accomplish this goal the government declared that by 2010, 10% of the UK's electric energy needs will by supplied by clean renewable energy sources. The government has also expressed an ambition to double this supply by 2020. To contribute to this commitment, the Scottish Executive has set a challenging target for development of renewable energy. By 2010, the proportion of electricity generated from renewable sources in Scotland is scheduled to be 18%; by 2020, the Scottish Executive aspires for the portion to be 40%.

Currently only 12% of electric energy produced in Scotland comes from renewable sources, mainly from large scale hydro schemes which are close to their maximum development. The 100MW Glendoe hydropower plant beside Lock Ness was approved in 2005 and is likely to be the last large conventional hydro power schemes to be built in Scotland (SEPA, 2005). The increase of clean energy production will thus need to come from new energy projects and technologies. Due to cost advantages, wind energy will be the principal source developed to reach the 2010 target, but new technologies, e.g. tidal and wave energy will also be required to meet the 2020 target. The European Marine Energy Centre

(EMEC 2004) opened in the Orkney islands in 2004 and represents the world's first wave and tidal power test facility.

The principal policy instrument used by the Scottish Executive to improve renewable energy expansion is the Renewable Obligation (Scotland) (ROS). The ROS places a legal obligation on every electricity supplier in Scotland to match a percentage of their electricity sales with renewable obligation certificates (ROC). The ROCs represent renewable energy electricity that has been produced and sold into the electric grid. The original requirement on retailers to match quantity sold with ROCs, was set at 3% for 2002-2003, rose to 4.3% for 2003-2004 and will rise annually to 10.4% in 2010-2011. This has created a huge demand for renewable electricity supplies, motivating a dramatic expansion in the number of proposed projects.

By mid-year 2005, the UK became the eighth country in the work to have installed over 1,000 MW of wind energy (DTI, 2006a), of which 22% was located in Scotland. The growth was even greater in 2006 with Scotland leading the UK. By November 2006 Scotland had over 900MW of operating wind farms, an additional 550MW were under construction and over 1,000MW had planning consent to be built. Included in the consented projects were 180MW of offshore wind capacity (BWEA, 2006). This represents one-half of all actual or scheduled wind farm deployment in the UK. Construction of a 44MW dedicated biomass power plant was also started in 2006 at Locherbie, Scotland. This is the largest plant of its type in the UK (DTI, 2006a).

Wind farm proposals are primarily located away from population centres in Scotland, with over 70 of the 86 projects mentioned above being in counties classified as rural.

4. The choice experiment method

Choice Experiment (CE) analysis is an economic valuation method which is particularly well suited for investigating the impacts of environmental changes and the costs or benefits imposed on people. The essential concept underlying CEs is that any good can be described in terms of its attributes, or characteristics, and the levels of these attributes or characteristic take. A renewable energy project, for example, can by described in terms of the potential impacts on the environment, the effect on local economies and the consequent change in electricity prices. Potential impacts on the environment may be in terms of landscape quality, effects on wildlife, and reduction in greenhouse gas emissions due to a wind farm installation, whilst effects on local economies include the creation of jobs.

It is difficult to completely describe any good in terms of its attributes. There will always be some unknown, intangible or un-observable characteristic of the good which may provide beneficial utility to people. Random utility theory (Mansky, 1977) is thus the other underlying foundation of the CE method, and addresses this problem by allowing the mathematical utility function of a person to be decomposed into observable and unobservable, or stochastic, parts:

$$U_{in} = V_{in} + \varepsilon_{in} \qquad (1)$$

where U_{in} is the true, unobservable utility for project *i* held by individual *n*, V_{in} is the observable portion of the utility, and ε_{in} is the unobservable portion of the utility, which is treated as a random variable.

In a choice experiment, respondents are presented with a set of project alternatives described in terms of the attributes and the levels they take, and are asked to choose their most preferred. The modelling approach is focused on the probability that each project alternative has of being chosen, given the assumption that individuals will choose the alternative that maximises their utility. Project alternative *i*, for instance, will be chosen if the utility it gives to an individual is higher than the utility of any other alternative presented to him/her. So the probability alternative *i* to be chosen by individual *n* (amongst the C alternatives presented to him /her) is equal to the probability that it has the highest utility:

$$P_{in} = P\,(U_{in}\ 7\ U_{jn}) = P\,(V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}) \qquad \forall\, j \in C \qquad (2)$$

To empirically estimate equation 2, an analyst has to define the functional form of V and the statistical distribution of the random parameter ε. It is common to assume that function V is linear in parameters:

$$V_{in} = C_i + \sum_k \beta_{ik} X_{ik} \qquad (3)$$

where C_i, is a constant; X_{ik} is the *k* attribute value of the alternative *i*; and β_{ik} is the coefficients (the weight) associated to the *k* attribute. The random component, ε, is typically assumed to be independently and identically distributed with a Weibull distribution. These assumptions allow the estimation of the probability of choice by means of the multinomial logit model (also called conditional logit model), where:

$$P_{in} = \frac{\exp(V_i)}{\sum_j \exp(V_j)} \qquad \forall i \neq j \qquad (4$$

Focus groups and preliminary analysis of respondents' choices showed that existed a high degree of heterogeneity in preferences. In this instance, it is appropriate[v] to specify the choice model in a manner which accounts for this heterogeneity. A "random parameter logit" model was therefore used (Train, 1998) in the analysis. The random parameter logit (RPL) model is a generalization of the multinomial logit model. RPL assumes that for each attribute there exists a mean and a standard deviation effect on utility. In other words, we can think of utility as being determined according to:

$$U_{in} = \beta' x_{in} + \phi'_{in} x_{in} + \varepsilon_{in} \qquad (5)$$

where β is the population mean impact of attribute *x* on utility for person *n* choosing alternative *i*, ϕ is a vector of deviation parameters which represents the individual's tastes relative to the average, and ε is a random error term which is independent of the other terms in the equation, and which is identically and independently distributed. A researcher can estimate β and ϕ; the ϕ deviation terms, as they represent personal tastes, are assumed constant for a given individual across all the choices they make, but not constant across people. Significant deviation terms in the estimation indicate that people hold different preferences for the attributes under consideration.

By means of the maximum likelihood estimation method it is possible to estimate the empirical magnitude of the β utility parameters. These represent the relative importance, or weight, of each attribute (landscape, wildlife, jobs, etc.) in the respondent utility. They can be used to estimate the trade-offs between attributes that respondents would be willing to make. This estimate is found by simply by dividing one attribute by another. For example, by dividing the coefficients for the landscape attribute and job attribute, it is possible to estimate how much negative landscape impact will be tolerated by an energy project if it creates additional jobs.

In a choice experiment where the cost or price of choosing an alternative has been included as an attribute, it is also possible to estimate implicit prices. Implicit prices are the marginal willingness to pay for increasing the quality or quantity of any attribute;

$$\text{Implicit price for attribute a} = -(\beta_a / \beta_{price}) \quad (6)$$

Since the implicit prices are expressed for all attributes in monetary terms, this allows for some identification of the relative importance that respondents place on attributes and can provide information for potential alternative allocation of resources.

Instead of just focusing on individual attribute values, choice experiments offer the ability to estimate the economic value of alternative projects which change the levels of some or all attributes simultaneously. The utility of any alternative project is calculated by subtracting it from the utility of the reference project (the no-increase in renewable energy in this case); this result is then divided by the negative of the cost coefficient to convert from utility units to money-equivalent units of measurement (Bennet and Blamey, 2001).

$$\text{Welfare Change} = - 1 / b_m (V0 - V1). \quad (7)$$

where b_m is the estimated coefficient on the monetary attribute from the choice model, Vo is the value of the indirect utility associated with the reference project and V1 is the value of the indirect utility associated with any other alternative. In this context, alternative renewable energy projects can be compared to the "no increase in renewable energy source alternative" (reference case). The resulting monetary value is the welfare change that results from the particular alternative project as compared to the reference project.

5. Study Design

Two criteria which are used here to identify attributes for use in the Choice Experiment are that selected attributes should be 1) significant for analytical purposes, so the findings will provide useful information for policy making and 2) be meaningful to respondents. In this study, the attributes had to describe the negative and positive impacts arising from a wide range of renewable energy projects that will be developed in the near future.

To identify the relevant attributes, a series of focus groups (Dewar, 2003) and informal interviews were conducted in urban and rural locations. The first goal of these meetings was the identification of potential effects and impacts from renewable energy production. Several technologies were initially considered: windmills, hydro schemes, tidal and wave power, solar (photovoltaic and hot water panels), geothermal and biomass or waste combustion. For each technology individuals were asked to identify the most important effects and these were subsequently ordered by importance. Three characteristics dominated all others: 1) renewable energy projects should have a lower environmental impact on air pollution than gas, oil and coal; 2) projects should not harm wildlife; 3) projects should be aesthetically pleasing. This last characteristic was more controversial. There were heterogeneous preferences for this attribute, some people considered a wind farm or a reservoir for a hydro scheme as a beautiful feature of a modern landscape, whilst others considered them as negative aberrations on the landscape. Other important characteristics which were identified were the creation of high skill jobs, a possible increase in electricity prices, the abundance and sustainability of resources, and more opportunity for localised control and responsibility of the project.

From the focus groups and the existing literature, five attributes were finally selected for the choice experiment: impacts on landscape, impacts on wildlife, impacts on air pollution, creation of long term jobs and increases in electricity prices. Table 1 shows a description of each attribute, together with the levels each took in the experimental design. These attributes and their respective levels form a collection of 360 different possible combinations[vi]. Such a large number of combinations is too difficult to manage, so an orthogonal fraction of 24 profiles (Louviere et al., 2000) was withdrawn from the full factorial using SPSS, V. 12.0. The selected profiles were then duplicated and randomly paired to form the choice cards. An example of the choice cards presented to respondents is shown in Table 2. The card presented two renewable project alternatives and a fixed alternative that described a "no new renewable projects" option[vii].

The mail survey questionnaire had three parts. The first section presented the problem of climate change and introduced the government's commitment to deployment of renewable energy projects. The goal of the survey was described, as being that "….this survey aims to find out what people would prefer to happen in Scotland from all the new renewable energy construction and development that will occur during the next 10 to 15 years…". Subsequently, the five attributes were described. The second part of the survey contained an example of a choice card with an explanation of how to complete it, than a set of 4 choice cards were presented. The final part of the questionnaire was concerned with collecting standard socio-economic information of the participants. The questionnaire and other survey materials can be found in Hanley et al. (2004).

6. Results

A total number of 547 surveys were mailed out to a random population sample in the districts of Aberdeenshire, Highlands and Islands, Western Isles, Edinburgh, Glasgow, Stirling, Galloway, Borders and Dumfries, during the first week of September 2003. Among the 547 surveys, approximately 320 were sent to urban areas and 230 to rural areas. A proportional sample would have required more surveys be distributed in urban areas, but we chose to over-sample the rural group to give sufficient statistical power to the rural residents model. The response rate was 43%, an acceptable percentage compared to other similar studies (Ek, 2002). Comparing socio-economic data of the surveyed sample population with socio-economic data of the general Scottish population, the null hypothesis of equality cannot be accepted. Specifically, the sample is not representative of the whole Scottish population having lower income than the national average and being more rural. This information is consistent, as these two variables are actually correlated: rural populations experience lower income levels that the Scottish average.

The estimated coefficients derived from the random parameter logit model are shown in Table 3. In Table 3, the second column describes the estimated coefficients of the entire sample population, whilst columns 3 and 4 show the estimated coefficients of the sub-sample populations: urban and rural residents. When interpreting the coefficients, the reader needs to consider that the coefficients describe the contribution of the attributes to choice probabilities: positive coefficients reveal an increase in the choice probability, negative coefficients a decrease. Qualitative variables were coded using effect codes, so that the value of the omitted level is equal to the negative of the sum of the included levels.

Overall, each model is highly significant and shows a very good fit when comparing the log likelihood values at zero and at convergence[viii]. The signs of all coefficients are consistent with a priori expectations. Starting with the "total sample" model the significance and positive value of the constant indicates, everything else equal, respondents support renewable energy expansion. In choice experiment the constant is interpreted as the effect of systematic factors not included as attributes; a positive constant indicates respondents derive utility from the implementation of renewable energy projects even when all the considered impact are zero. The *landscape change* coefficients specify that only a change from high impact to the absence of any impacts significantly affects choice. Note that a high landscape impact considerably detracts utility to an alternative being the coefficient equal to the negative sum off all the lanscape coefficients (= - .881). The effect of renewable energy projects which may have on *wildlife* is very important, and projects that may cause slight harm to wildlife are less likely to be chosen. On the other side, projects that produce a slight improvement on wildlife are preferred to ones that have no impact on it. This is demonstrated by the coefficient for "*wildlife: slight improvement*" being larger than the coefficient for "*wildlife: no impact*". People care a lot about the effect projects can have on *air pollution*. Interestingly, the *jobs* attribute is not a significant determinant of choice: that is, generally there are other more important issues than jobs which motivate people to support renewable energy projects. The negative sign on the *price* attribute reveals the negative effect that people perceive from electricity price increases. The higher the cost associated with any alternative, the lower the probability that alternative has of being chosen. This is consistent with standard consumer theory.

The socio-economic variables which were included in the model show that both age and education influence choices. People who are younger than 41 years and/or have earned a higher education degree are more likely to support renewable energy projects. Income was not a significant determinant of choice. This lack of significance is possibly the result of the modest increased in electricity prices in the experiment still being affordable to all respondents.

Most coefficients' standard deviations are significant. This is a clear indication that respondent's preferences are indeed heterogeneous. Heterogeneity arises from different values being held by respondents about the potential impacts of renewable energy projects. Considering landscape impacts, for example, there are individuals who firmly believe that wind mills are "beautiful and gracefully", whilst others believe that they destroy the quality of the landscape. This was already observed in focus groups: our model results provide evidence of this variation in preferences.

A comparison of urban and rural responses

The urban and rural sub-sample models show preferences do differ between the two groups. Urban residents prefer projects that have low or no landscape impact (in spite of the existence of heterogeneity in this attribute), do not harm wildlife and do not generate air pollution. Creation of new permanent jobs is not a concern for urban respondents. Rural residents can be inferred to have greater support for renewable energy projects by having more significant coefficients which are positive in value and a smaller negative coefficient on the price attribute. Interestingly, rural respondents are very influenced by projects that create new permanent jobs, unlike the urban sample. This reflects the accurate perception that a large majority of renewable energy projects will be constructed and maintained in rural areas.

The analysis of the standard deviation terms reveals, for some attributes, the structure of the preferences differs between urban and rural dwellers. Focusing on the air pollution attribute, for instance, we can appreciate that both groups strongly prefer projects that do not cause air pollution, but the urban sample holds heterogeneous preferences and around 10% of this group[*] do not care if renewable energy projects even increase air pollution. In the case of the job attribute the rural sample hold homogeneous preferences towards the importance of jobs creation. This is consistent with the observed interest of the rural people in renewable energy projects that may create new jobs in their area.

The implicit prices of the attributes support the interpretation of the model coefficients. Table 4 lists the implicit prices estimated for the three models, with their 95% confidence intervals[ix]. For the *landscape* attribute a moderate or a low change in landscape quality does not have a positive willingness to pay in all models, since the confidence interval of the implicit prices overlaps zero. The full sample and the urban sample have a positive willingness to pay for projects that do not cause any landscape change, whilst the rural sample have implicit prices for changes in the landscape attribute that are not statistically different from zero. This confirm the willingness to accept some landscape deterioration from renewable energy projects to achieve some other benefits. The *wildlife* attribute has positive values associated with it, and in particular a "slight" improvement in wildlife has a Willingness to Pay value of £10.95. Again the urban and rural groups present differences being the latter more willingness to pay to conserve and enhance wildlife. Respondents are also willing to pay an average of £13.84 for projects that do not increase *air pollution*. Only the rural respondents have a significant and positive implicit price for the creation of new *permanent jobs*. In the rural sample an average respondents would be willing to give £1.08 for creation of each new permanent job. This underlines the importance rural residents place on any development plans that may increase the number of jobs locating in their areas.

From a policymaker's perspective, deriving welfare estimates is the most useful aspect of choice experiments for use in benefit-cost analysis. To achieve this, a comparison of utility can be made between a reference project and a series of alternative projects, as long as each can be described using the attribute levels used in the experiment. This utility comparison is transformed into the impact that different project alternatives have on respondents' welfare by

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[*] This is the probability at 0 of a normal distributed random variable with mean 0.795 and standard deviation 0.612.

applying formula (7). Four different energy project scenarios were considered as the outcome of the implementation of specific renewable energy technologies. The reference project was defined according to the expected conditions in the attributes if there would be an expansion of a fossil fuel power station. The scenarios have the following values:

Reference. Fossil fuel power station – 200 MW expansion of a natural gas power plant resulting in a small marginal increase in the facility's size, air pollution and employment, No change in exhaust stack visibility.

A. Large Offshore Windmill Farm – 200 MW, 100 turbines each at 80 meters nacelle hub height, 6-10 kilometres from shore.

B. Large Onshore Windmill Farm – 160 MW, 80 turbines each at 80 meters nacelle hub height.

C. Moderate Windmill Farm – 50 MW, 30 turbines each at 60 meters nacelle hub height.

D. Biomass Power Plant – 25MW, emissions stack height up to 40 meters, portions of building up to 30 meters, fuelled by energy crops.

Table 5 shows the resulting welfare change for each of the investment scenarios in relation to the reference project, computed using equation 7 from above. Results are presented for whole sample and the two sub-samples representing for urban and rural respondents.

The monetary values are the price representative households are willing-to-pay, on an annual basis, to have different types of renewable energy projects (indicated by different attribute levels), rather than the reference case of expanded fossil fuel power generation. The whole sample places the greatest value on offshore wind farms, with the major determinant the welfare change being the absence of air pollution and landscape impacts. The next most valued type of energy project is a small onshore wind farm. For a large onshore wind farm or a biomass power plant the willingness to pay is not statistically different from £0, with a confidence level of 95%. The most interesting aspects of the findings presented in Table 5 are the comparisons of urban and rural preferences. Urban residents show a positive willingness to pay for only the large offshore wind farm, whilst they show negative welfare for all other types of renewable energy projects. Rural respondents welfare estimates are rather different and reveal a positive willing to pay for all the renewable projects proposed. The highest value is associated with the biomass power plant, with a major determinant being the level of employment associated with plant operation and agricultural production of the energy crops, whilst also of significance is the benefit to wildlife associated with expansion of growing biomass crops. The large offshore wind farm follows in importance, given the absence of negative impacts on landscape, wildlife, air pollution and the creation of 5 permanent jobs. The small onshore wind farm has a high willingness to pay value associated with it. The lower value for the small onshore wind farm is due to a moderate impact on landscape and the diminished creation of jobs. The large onshore wind farm is positively valued, even with the negative value of creating a high landscape impact. This can be interpreted as rural residents being willing to accept some diminished landscape quality to get better air quality and some new job opportunities.

7. Conclusions

Intermediate and remote rural areas of Scotland are facing problems of an ageing population and net out-migration of young people due to stagnant or declining local economies and a shortage of job opportunities. Rural economies can no longer rely on the agricultural sector as a source of employment and wealth. Diversification of the rural economy is thus essential to maintain the viability of rural population. This diversification in Scotland is increasingly coming from renewable energy schemes, encouraged by government intervention which has created financial incentives for renewable investment. However, the expansion of renewable energy sources is likely to have significant environmental and social impacts. In particular, renewable energy projects have impacts on landscape, wildlife, air pollution, electricity prices and job opportunities. The choice experiment method used in this paper enabled these effects to be jointly evaluated in welfare-consistent terms. Conclusions can then be more easily drawn about the net social benefits of different renewable energy investment strategies.

Our results suggest Scottish citizens generally support the expansion of renewable energy projects, in spite of the existence of heterogeneous preferences in regards to the potential costs and benefits of these projects. For the full sample, the implicit prices show the most valued attribute to be a reduction in air pollution. Secondly, respondents indicated significant importance to impacts on wildlife, especially for a change from slight harm to one of improvement. The costs of landscape change are generally significant if the project in question creates a high impact on landscape. There is no willingness to pay to reduce landscape impacts if projects are expected to have a low or moderate impact.In terms of ranking renewable energy projects, the whole sample population would prefer large off-shore wind farm projects, followed by small on-shore wind farm projects. The alternative of a large on-shore wind farm project is given the lowest utility and preference.

We also find important differences between urban and rural responses in this choice experiment. The implicit price analysis indicates that urban respondents have a positive willingness to pay for a landscape change from high impact to no impact, for a slight improvement in wildlife, and for a reduction in air pollution. Urban residents, though, placed an insignificant value on the creation of new permanent jobs from renewable energy projects. There is some evidence that negative landscape impacts from the development of projects are more acceptable to the rural population. Conversely, rural people value wildlife benefits and reductions in air pollution more highly than their urban counterparts (the last issue of air pollution may be from a perception that biomass combustion was more likely in rural areas, i.e., close to the supply of energy crops). Of particular relevance, employment creation is a statistically and economically significant attribute for the rural sample, which would be willing to pay an additional £1.08 per year per household for each additional full time job created by the renewable projects.

The welfare changes associated with the four alternative renewable energy projects reaffirm the differences in preferences between urban and rural dwellers. The urban group show a significant positive willingness to pay only for the large offshore wind farm project, whilst the rural sample stated a much higher willingness to pay for all the renewable project alternatives. The biomass power plant, which is characterised by an increase in air pollution, a moderate impact on landscape, an improvement in wildlife and the creation of 70 new permanent jobs, was given a very high willingness to pay (£ 97.95), especially when compared to the second best option (large off shore wind farm) which was valued at £ 53.71. This supports an interpretation that rural respondents value projects that improve job opportunities in their locale.

References

Abbasi, S.A., Abbasi, N., 2000. The likely adverse environmental impacts of renewable energy sources. Applied Energy 65 (1–4), 121– 144.

Bateman, I., Carson, R., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D., Sugden, R. and Swanson, J. (2002). Economic Valuation with Stated Preference Techniques, A Manual. Edward Elgar, Cheltenhan, UK / Northampton, Ma, USA.

Bennet, J. and Blamey, R. (2001). The Choice Modelling Approach to Environmental Valuation, New horizons en Environmental Economics. Bennet, J. and Blamey, R. (eds). Edward Elgar, Cheltenham, UK / Northhampton, MA, USA.

Bikam, P. and Mulaudzi, D.J. (2006). Solar energy trial in Folovhodwe South Africa: Lessons for policy and decision-makers, Renewable Energy 31 (2006) 1561-1571.

Bishne, R. U. and Horst D. (2004). National renewable energy policy and local opposition in the UK: the failed development of a biomass electricity plant, Biomass and Bionergy 26: 61-69.

Braunholtz, S. (2003). Public Attitudes to Windfarms: a Survey of Local Resident in Scotland, Research Findings No. 12, Scottish Executive.

BWEA (2006). British Wind Energy Association, United Kingdom Wind energy Database. Available at: http://www.bwea.com/ukwed/index.asp

Dewar, M., (2003). Report for the University of Glasgow Renewable Energy Project: Synopsis of Focus Group Responses. Focus Ecosse, New Lanark.

DTI (2006). The Energy Challenge: Energy Review Report 2006, Department of Trade and Industry, HMSO, Norwich.

DTI (2006a). Secure Sustainable Affordable Energy, A DTI Departmental Report 2006, Department of Trade and Industry, HMSO, Norwich. Available at: http://www.dti.gov.uk/files/file28506.pdf

Ek., K. (2002). Valuing the environmental impacts of wind power: a choice experiment approach. Licentiate Thesis, Lulea University of Technology, Sweden, p. 40.

European Marine Energy Centre, EMEC (2004). Description at http: //www.emec.org.uk.

Fleming, A. D. (2003). Scotland's Census 2001, Statistics for Inhabited Island, Occasional Paper N0. 10, General Register Office, Scottish Executive.

General Register Office (2001). Scotland's Census, available at http://www.gro-scotland.gov.uk/statistics/census/censushm/index.html.

Hanley, N. and Nevin, C. (1999) Appraising renewable energy developments in remote communities: the case of the North Assynt Estate, Scotland, Energy Policy: 527-547.

Hanley, N., Bergmann, A. and Wright, R. (2004). Valuing the Environmental and Employment Impacts of Renewable Energy Investment in Scotland. Scotecon, Stirling.

Hassan, Gerald and Partners, Ltd. (2001). Scotland's Renewable Resources, Vol 1 and 2m Research Commissioned by Scottish Executive, Document No. 2850/GR/03.

Hensher, D. (2001). The valuation of commuter travel time savings for car drivers: evaluating alternative model specifications. Transportations 28: 101-118.

Krinsky, I. and Robb, A.L. (1986). On Approximating the Statistical Properties of Elasticities. Review of Economics and Statistics, 68: 715-719.

Louviere, J.J., Hensher, D.A. and Swait, J. (2000). Stated Choice Methods, Analysis and Application. Cambridge University Press.

Madlener, R. and Stagl, S., 2005. Sustainability-guided promotion of renewable electricity generation. Ecological Economics 53: 147-167.

Mansky, C. (1977). The Structure of Random Utility Models. Theory and Decision 8:229-254.

Mori (2002). Tourist attitudes towards wind farm. Summary report of the study commissioned for Scottish Renewable Forum and British Wind Energy Association.

Polatidis, H. and Haralambopoulos, D.A. (2007). Renewable energy systems: A societal and technological platform, Renewable Energy 32 (2007) 329-341.

Scottish Executive (2000). A forward strategy for Scottish agriculture, a discussion document, Scottish Parliament, Research note 00/48.

Scottish Executive (2002). Scotland's Renewable Energy Potential Beyond 2010, A Consultation Paper.

Scottish Executive (2005). Scottisch Agriculture, Output, Input and Income Statistics, Scottish Executive National Statistic Publication.

Scottish Office (1999). Rural Development Plan, National Planning Policy Guideline NPPG15, Scottish Government, Edinburgh.

SEPA (2005). Scottish Environment Protection Agency, An economic analysis of water use in the Scotland river basin district: Summary Report. Available at: www.sepa.org.uk/publications/wfd/html/economic_scotland/annex1h.html .

Strbac, G. (2002) Quantifying the System Costs of Additional Renewables in 2020, A Report to the Department of Trade and Industry, Master Centre fir Electrical Energy & Ilex Energy Consulting Ltd.

The Stationery Office (2003). Energy White Paper - Our Energy Future, Creating a Low Carbon Economy, Department of Trade and Industry & Department of Environment Food and Rural Affair, London.

Train, K. (1998). Recreation Demand Models with Taste Differences over People, Land Economics, 74: 230-239.

Tsoutsos, T., Frantzeskaki, N., Gekas, V. (2005). Environmental impacts from the solar energy technologies. Energy Policy 33(3), 289– 296.

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Table. 1

Attribute	**Description**	**Levels**
Landscape Impact	The visual impact of a project is dependent on a combination of both the size and location.	None, Low, Moderate, High;
Wildlife Impact	Change in habitat can influence the amount and diversity of species living around a project.	Slight Improvement, No impact ; Slight Harm
Air Pollution	Many types of renewable energy projects create no additional air pollution, but some projects do burn non-fossil fuels. These projects produce a very small amount of pollution when compared to electricity generated from coal or natural gas.	None, Slight increase
Jobs	All renewable energy projects will create new local long-term employment to operate and maintain the projects. Temporary employment increases during the construction phase are not being considered.	1-3, 8-12, 20-25
Price	Annual increase in household electric bill resulting from expansion of renewable energy projects. An average household pays £270 a year (£68 per quarter) for electricity	£0, £7, £16, £29, £45
Constant	Acts to represent variations that cannot be explained by the attributes or socio-economic variables.	

Table 2.

option example

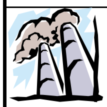
		Plan A	Plan B	Neither
	LANDSCAPE visual impact caused by location and/or size	HIGH	NONE	No increase in renewable energy
	WILDLIFE health of habitat	SLIGHT HARM	SLIGHT HARM	
	***AIR POLLUTION***	NONE	NONE	Alternative climate change programs used
	EMPLOYMENT new jobs in local community	8-12 JOBS	1-3 JOBS	North Sea gas fired power stations instead
£	PRICE OF ELECTRICITY additional rates per year	£16 per year	£7 per year	
	YOUR CHOICE: (please tick one only)	A ☐	B ☐	**I would not want either A or B** ☐

Table 3.

Variables	**Whole sample**		**Urban dwellers**		**Rural dwellers**	
Mean effects						
Constant	3.406	*	3.131	*	4.878	*
Landscape change: moderate	0.186		-0.133		0.587	***
Landscape change: low	0.225		0.698	***	-0.436	
Landscape change: none	0.470	*	0.492	**	0.537	**
Wildlife: no impact	0.331	**	0.313		0.467	***
Wildlife: slight improvement	0.735	*	0.795	*	0.961	*
Air Pollution: none	0.929	*	0.893	*	1.092	*
Jobs created	0.013		-0.011		0.068	*
Price	-0.067	*	-0.086	*	-0.063	*
Age[a]	1.186	**	1.677		1.048	
Education[b]	1.312	**	2.339	*	0.742	
Income[c]	-0.015		-0.032		0.004	
Standard Deviation terms						
Landscape change: moderate	0.460		0.748	**	0.649	***
Landscape change: low	0.972	**	1.183	**	1.387	**
Landscape change: none	0.796	*	0.877	*	0.380	
Wildlife: no impact	0.569	**	0.373		0.853	***
Wildlife: slight improvement	0.295		0.275		0.186	
Air Pollution: none	0.361	*	0.612	*	0.199	
Jobs created	0.031	*	0.037	**	0.010	
Number of observations	828		476		352	
Log likelihood at constant	- 700.23		- 392.79		- 306.24	
Log likelihood at convergence	- 470.30		- 263.69		- 190.12	
Likelihood Ratio	459.86		258.20		232.24	
Pseudo R^2	.473		.487		.497	

Clarification

* Indicates significance at 1 % level, ** Indicates significance at 5 % level, *** Indicates significance at 10 % level.

[a] Respondents' age (Less than 41: 1; More than or equal to 41: 0)

[b] Respondents' education (High Education: 1; General education: 0)

[c] Respondents' income

Table 4.

	Whole sample IP	**Urban dwellers IP**	**Rural dwellers IP**
Attributes			
Landscape change: moderate	2.77 (-2.52; 9.06)	- 1.54 (- 7.69; 5.40)	9.38 (- 1.49; 26.56)
Landscape change: low	3.36 (-4.71; 10.16)	8.08 (-0.91; 14.79)	- 6.97 (- 27.54; 6.88)
Landscape change: none	7.00* (2.73; 11.79)	5.69* (0.88; 11.63)	8.59 (- 0.48; 14.47)
Wildlife: no impact	4.94* (0.96; 10.16)	3.63 (-0.82; 9.13)	7.47* (0.09; 16.59)
Wildlife: slight improvement	10.95* (6.74; 14.61)	9.19* (3.24; 14.52)	15.35* (8.97; 23.27)
Air Pollution: none	13.84* (10.78; 18.45)	10.33* (7.24; 15.30)	17.45* (11.97; 27.64)
Jobs created	0.19 (- 0.25; 0.61)	- 0.13 (- 0.64; 0.38)	1.08* (0.22; 2.09)

* Statistically different from 0 at 95% confidence level

Table 5

Scenario:	*Base Case*	*A*	*B*	*C*	*D*
	Fossil Fuel power station expansion	*Large Offshore Wind farm*	*Large Onshore Wind farm*	*Small Onshore Wind farm*	*Biomass Power Plant*
Attribute Levels:					
Landscape	Low	None	High	Moderate	Moderate
Wildlife	None	None	None	None	Improve
Air Pollution	Increase	None	None	None	Increase
Employment	+2	+5	+4	+1	+70
Welfare Change (£/hsld/yr.):		31.88	11.57	26.91	18.14
Total sample		(19.02, 48.29)	(-2.67, 29.63)	(12.98, 44.52)	(-12.97, 52.80)
Welfare Change (£/hsld/yr.):		17.87	0.08	11.17	12.99
Urban sample		(5.74, 37.57)	(-15.40, 21.65)	(-0.59, 30.57)	(-47.72, 20.73)
Welfare Change (£/hsld/yr.):		53.71	33.04	50.16	97.95
Rural sample		(29.90, 91.82)	(5.70, 70.80)	(24.30, 96.54)	(38.83, 176.63)

[i] All people will experience some direct impact through increased electricity prices and the reduction of greenhouse gases emission. Furthermore, there are no-use values that will impact rural and urban residents independently of any contact with the renewable energy infrastructures. An example of this type of impact could be the negative value an urban resident may attribute to a wind farm from the effects the installation has on landscape or wildlife, even though the urban resident may never visit the impacted area.

[ii] The 2001 Census (General Register Office, 2001) indicated that the Scottish population has declined by 117,000 people over the last 20 years.

[iii] The indirect contribution of agriculture to the Scottish economy is less easily measured. Best estimates suggest that for every worker employed in agriculture another worker is employed elsewhere in Scotland. These jobs are largely in the agricultural supply sector and the food and drink processing industries (Scottish Executive, 2000).

[iv] Moving from a market with 10% renewables, as envisaged from 2010 onwards, to a market with 20% renewable, may increase system costs by approximately £150m and £400m per annum. Extending renewables from 20% to 30 % would increase costs by around a further £200m to £500m per annum (Strbac, 2002)

[v] The Multinomial Logit Model assumes that people tastes are homogeneous throughout the population. If it is not true, the resulting parameter estimates are biased and can no longer be used for preference and welfare estimates (Hensher, 2001)

[vi] The number of combinations is equal to the multiplication of the number of attribute levels, i.e. (4*3*2*3*5) = 360.

[vii] Bateman et al. (2002) advise the inclusion of a “do nothing” alternative at zero cost to obtain welfare-consistent estimates.

[viii] Simulations done by Domenich and McFadden (1975) compare values of pseudo-R^2 between 0.2-0.4 to values between 0.7-0.9 of the R^2 of the ordinary least squares linear regressions.

[ix] The Krisky and Robb (1986) bootstrapping procedure was used for the confidence intervals estimation.