

# **Valuing the Attributes of Renewable Energy Investment in Scotland**

Presented by

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## INTRODUCTION

- \* Scotland has committed itself to a massive expansion of renewable energy (electric) projects.
- \* The public is expressing preference for some types of technology over other types.
- \* This paper attempts to identify and quantify the underlying characteristics (attributes) of renewable energy that make some technologies a superior social choice.

## Current Profile of power generation in Scottish, 2002

_____ Nuclear	37.0%
Coal	32.4%
Gas and Oil	21.0%
Hydro*	8.7%
Other**	1.1%

\* Figures for hydro include the net electricity generated by pumped storage

\*\*Includes landfill gas and wind power



# Renewables Obligation (Scotland)

Demand-Pull and  
Supply-Push Legislation

## Demand

\_\_\_\_\_ Obligation on retail electric suppliers to source 3 % of sales (by quantity – MWh) from eligible renewables generation companies

3.0 %	2002-03
4.3	“ 03-04
.....10.4	“ 10-11

Extention is proposed:

1% additional each year until 1016	
.....15.4%	2015-16

Proof of meeting obligation is by supplying ROCs or paying 'buy-out'

(Large-scale hydroelectric is not eligible)

## Supply

### Renewable Obligation Certificates (ROCs)

Government issued to genco's for each MWh of production

Sold separately from electricity produced

Average price in " 02-03 was £45-50/certificate (MWh);  
in Spring 2004 auction £49+

wholesale electricity was selling at £16 to £22/ MWh



## Theoretical Foundations

Thurstone(1927)      Random Utility Theory

Lancaster(1966)      Characteristics of Goods Theory

McFadden(1974)      Logit Analysis to Consumer  
Choice

## Stages of Choice Experiments

- determination of issues
- identification of attributes and levels
- development of survey and data  
collection instrument
- model estimation
- policy analysis

# ATTRIBUTES

Table 1.

## Attributes and attribute levels

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
<b>Wildlife Impact</b> Slight	Change in habitat can influence the amount and diversity of species living around a project.	Slight Improvement, No impact, Harm
<b>Air Pollution</b>	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
<b>Jobs</b> 20-25	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,

# ATTRIBUTES

(continued)

**Table 1.**

## Attributes and attribute levels

<u>Attribute</u>	<u>Description</u>	<u>Levels</u>
<b>Price</b> £29, £45	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,

## Alternate specific constants

**ASC-A**  
that Takes value of 1 for Plan A, 0 otherwise. Acts to represent variations cannot be explained by the attributes or socio-economic variables.

**ASC-B**  
that Takes value of 1 for Plan B, 0 otherwise. Acts to represent variations cannot be explained by the attributes or socio-economic variables.

# COVARIATES

Table 1.1.

Covariate socio-economic characteristics used in model

<u>Characteristic</u>	<u>Description</u>
<b>Income</b> 16	Gross household income. Mid-point value used from categories of income level, ranging from, £10,000 to £80,000, by £5,000 brackets.
<b>Education Attainment</b> 0 otherwise	1 if higher education attained (university or college),
<b>Age</b> 0 otherwise	1 if respondent 40 years of age or younger,

## COVARIATES OMITTED:

- \* Location
- \* Energy sector employment
- \* Conservation group member
- \* Education by three categories (used as two categories)
- \* Children
- \* Recent electric bill
- \* Age by five categories (used as two categories)

# SAMPLE POPULATION

**Table 2.**

## Descriptive Statistics of Respondents

Variable Description (percentages unless otherwise noted)

<b>AGE</b>	<25	25 – 40	41 – 54	55 – 65	65>
Sample	5	27	27	17	24
Scotland	10	23	20	20	27

<b>INCOME</b>	<£16,000	£16,000 - £36,000	£36,001>
Sample mean <b>£22,412</b>	33	34	

20

(12% did not respond)

Scotland mean **£26,988**

<b>LOCATION</b>	Urban	Towns	Village/Countryside
Sample	42	16	41
(2% did not respond)			
Scotland	70		30



Table 5.

Model	Unrestricted: Attsw/covariates			Restricted: Attributes only		
Descriptor	Coef. / Implicit Price(£)(s. e.)			Coef. / Implicit Price(£)(s. e.)		
	(95% conf. interval)			(95% conf. interval)		
Moderate						
Landscape	0.29	<b>5.58</b>	(2.99)	0.20	<b>4.07</b>	
	(2.99)					
Low						
Landscape	0.15	<b>2.82</b>	(3.56)	0.16	<b>3.21</b>	(3.56)
None						
Landscape	0.42*	<b>8.10*</b>	(1.94)	0.39*	<b>7.88*</b>	(1.94)
None						
Wildlife	0.22**	<b>4.24**</b>	(2.18)	0.27*	<b>5.51*</b>	(2.18)
Improved						
Wildlife	0.63*	<b>11.98*</b>	(1.88)	0.50*	<b>10.11*</b>	
	(1.88)					
None						
Air pollution	0.74*	<b>14.13*</b>	(1.88)	0.71*	<b>14.40*</b>	(1.88)
Employment	0.02	<b>0.32</b>	(0.22)	0.01	<b>0.23</b>	(0.22)



# RESULTS (continued)

Table 3.

Model    Unrestricted: Attsw/covariates    Restricted: Attributes only

<b>ASCA</b>		<b>2.80*</b>		<b>2.96*</b>
<b>ASCB</b>	<b>2.73*</b>		<b>2.80*</b>	
<b>IncomeA</b>		-0.01		
<b>IncomeB</b>	-0.01			
<b>Higher educationA</b>		0.99*		
<b>Higher EducationB</b>		0.85*		
<b>Under age 40-A</b>		1.06**		
<b>Under age 40-B</b>		0.88***		
<b>Log-likelihood</b>	-434		-509	
<b>No. of respondents</b>	739			836
<b>Pseudo-R<sup>2</sup></b>	<b>.31</b>			<b>.29</b>

\*significant at 1% level  
level

\*\*significant at 5% level

\*\*\*significant at 10% level

## Table 4: Implicit Prices from the model with co-variates

\* **Landscape Impact** Households are WTP £8.10 to decrease high impact landscape changes to having no landscape impact.

\* **Wildlife Impact** WTP of £4.24 to change a slight increase in harm to wildlife from renewable projects to a level that has no harm. However, households would be **WTP £11.98** per annum to change a slight increase in harm to wildlife from renewable projects to a level that wildlife is improved from the current level.

\* **Air Pollution Impact** Households are WTP £14.13 to have renewable energy projects that have no increase in air pollution, compared to a programme which results in a slight increase in pollution.

## Table 4. Implicit Prices of Attributes comparing respondents

Model – Attributes Only (standard error and 95% confidence intervals)

	Full Sample Set		Rural Subset		Urban Subset	
Descriptor	Implicit Price(£)		Implicit Price(£)		Implicit Price(£)	
Moderate						
Landscape	<b>4.07</b>	(2.99)	<b>12.15**</b>	(6.3)	<b>0.50</b>	(3.31)
Low						
Landscape	<b>3.21</b>	(3.56)	<b>-5.68</b>	(7.09)	<b>7.15</b>	(4.03)
None						
Landscape	<b>7.88*</b>	(1.94)	<b>5.32</b>	(3.32)	<b>8.73*</b>	(2.41)
None						
Wildlife	<b>5.51*</b>	(2.18)	<b>6.18</b>	(3.71)	<b>4.43</b>	(2.69)
Improved						
Wildlife	<b>10.11*</b>	(1.88)	<b>15.23*</b>	(3.16)	<b>7.62*</b>	(2.42)
None						
Air pollution	<b>14.40*</b>	(1.88)	<b>19.08*</b>	(3.73)	<b>11.77*</b>	(2.08)
Employment	<b>0.23</b>	(0.22)	<b>1.08*</b>	(0.44)	<b>-0.19</b>	(0.26)

**Table 4. Implicit Prices of Attributes comparing  
respodents (continued)**

Model – Attributes Only (standard error and 95% confidence intervals)

<u>Subset</u>	<u>Full Sample Set</u>	<u>Rural Subset</u>	<u>Urban</u>
Log-likelihood	-509	-200	-290
No. of observations 475	836	349	
Pseudo-R <sup>2</sup> 0.27	.29	0.34	

\*significant at 1% level

\*\*significant at 5% level

# Table 5. Welfare Change for Alternative Energy Projects.

Scenario:	Base	A	B	C
D	Case	Large	Large	
Small	Biomass	Fossil Fuel	Offshore	Onshore
Windfarm	Onshore	Power Plant	power station	Windfarm
Windfarm	Windfarm			
	expansion			

## Attribute Levels:

Landscape	Low	None	High	Moderate	
	Moderate				
Wildlife	None	None	None	Improve	
Improve					
Air Pollution	Increase	None	None	None	
Increase					
Employment	+2	+5	+4	+1	+70

## Welfare Change (£/hsld/yr.):

+£7.70      +£3.91      £6.66 + £5.93

## Conclusion:

- 1. It is possible to measure the environmental impact from energy development.*
- 2. And identify design issues of projects to make them more acceptable to the impacted communities*