GENERATING GUIDANCE ON PUBLIC PREFERENCES FOR THE LOCATION OF WIND TURBINE FARMS IN THE EASTERN CAPE

By

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Plagiarism Declaration

I, Jessica Lee Hosking (student number: 206009046), hereby declare that the dissertation for the degree of Magister Commercii (Statistics) is my own work and that it has not previously been submitted for assessment or completion of any postgraduate qualification to another University or for another qualification.

Jessica Lee Hosking

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Executive Summary

There is consensus that Eskom, South Africa's main energy supplier, needs to expand its energy generating capacity in order to satisfy the growing demand for electricity, but there is less agreement on how it should do this. The existing supply is heavily reliant on thermal generation using coal, but the combustion of fossil fuels for electricity generation may contribute to climate change because it causes harmful greenhouse gases to be emitted into the atmosphere. This emission is something South Africa has committed itself to reducing. One way of achieving this is by the adoption of cleaner technologies for energy generation. One of these technologies is harnessing wind energy.

The problem with harnessing wind energy is where to locate the turbines to harness the wind because these turbines 'industrialise' the environment in which they are located. They are a source of increased noise, a visual disturbance, cause increased instances of bird and bat mortality and the destruction of flora or the naturalness of the landscape in the areas in which they are located.

The residents located near wind farm developments are most negatively affected and bear the greatest cost in this regard. A proper social appraisal of wind turbine projects would have to take this cost into account. Before such developments are approved there should be an assessment made of the impact on the residents, these impacts should be incorporated into the cost-benefit analysis. The negatively affected residents should also be compensated.

The objective of this study was not to undertake a cost-benefit analysis of such a wind farm proposal, but to estimate the negative external cost imposed on nearby residents of such an industry, and thereby calculate appropriate compensation to be paid to these residents.

Quantifying preferences for proposed, but not-yet developed, wind farms may be done by applying non-market valuation techniques, e.g. through one of the stated preference methodologies, such as a discrete choice experiment.

The selected study site for providing guidance was one where Red Cap Investments Pty (Ltd) has proposed the development of a wind farm - in the Kouga local municipality. The basis

for drawing conclusions was the analysis of the response samples of two groups of Kouga residents, distinguished by socio economic status; 270 from each group, 540 in total. The methodology applied to analyse the responses was a discrete choice experiment. The questionnaire administered included attitude, knowledge and demographic questions as well as a choice experiment section. The choice experiment section of the questionnaire required that the respondents choose between two different hypothetical onshore wind energy development scenarios and a *status quo* option. The hypothetical scenarios comprised different levels of wind farm attributes. The attributes included in the experiment were determined by international studies and focus group meetings. These attributes were: distance between the wind turbines and residential area, clustering of the turbines (job opportunities created by the wind farm development for underprivileged respondent group), number of turbines and subsidy allocated to each household.

Three different choice experiment models were estimated for each socio-economic group: a conditional logit (CL), nested logit (NL) and a random parameters logit (RPL) model. It was found that, in the affluent respondent group, the simpler CL model provided the best fit. In the underprivileged respondent group, the RPL model, with the number of jobs created by the wind farm project as a random parameter[1], explained by the gender of the respondent, provided the best fit. The estimated models identified distance as an important factor in both sampled respondent groups. Both respondent groups preferred that the wind farm be located further away from their residential areas. In addition to distance, the underprivileged respondent group also valued new job opportunities as an important determinant of choice. The affluent respondent group were very sensitive to densely clustered turbines but were almost indifferent between two of the effects coded levels of the clustering attribute “moderately close together” and “widely spaced apart”.

Welfare estimates for the significant attributes in each socio-economic group were computed from the best fit models. Table 1 shows the resulting willingness to accept (WTA) compensation measures for distance in both socio-economic respondent groups.

[1] A random parameter indicates that there is heterogeneity in the mean of the distribution of this parameter. This implies that respondents with similar characteristics choose differently for this attribute.

Table 1: WTA compensation measures for distance away from residential areas for both socio-economic groups

Socio-economic group	Different levels of distance away from residential areas (in km)	Willingness to accept compensation measure	95% Confidence Interval	
			Upper limit	Lower limit
Underprivileged sampled respondent group	2	-R 21.38***	-R 17.83	-R 24.88
	6	-R 38.31***	-R 31.96	-R 44.61
	120	-R 84.51***	-R 70.48	-R 98.38
Affluent sampled respondent group	2	-R 1 088.28***	-R 838.76	-R 1 340.14
	6	-R 1 950.71***	-R 1 503.45	-R 2 402.18
	120	-R 4 302.44***	-R 3 315.97	-R 5 298.18

* 10% level of significance; ** 5% level of significance; ***1% level of significance

Both the underprivileged and affluent groups of respondents were willing to accept increasing reductions in compensation for locations of the turbines greater distances away from residential areas (Table 1). The underprivileged sample respondent group also preferred to locate the wind turbines further away from residential areas, especially moving the wind farm from 0.5 km away to two kilometres away.

It was also found that the underprivileged respondent group were WTA increasing reductions in the subsidy for increasing job opportunities created by the wind farm development, but that there was uncertainty over how many additional job opportunities would be generated. The underprivileged respondent group had consistent marginal returns for each level increase in the number of new jobs created by the wind farm development.

The most important attributes for the affluent respondent group were distance away from residential areas and the clustering of the turbines. The affluent respondents derived the greatest extra social benefit from a relocation of the turbines from 0.5 km away to two kilometres away from their residential areas.

The choice experiment analysis enables estimates to be made of the external cost of different locations of wind turbines within the Kouga local municipality, and shows that locating wind turbines within two kilometres of residential areas sharply increases this cost.

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List of Abbreviations and Acronyms

ASC Alternative specific constant

BCR Benefit to cost ratio

CDF Cumulative distribution function

CL Conditional logit

CM Choice modelling

CSI Corporate social investment

CVM Contingent valuation methodology

Db Decibels

DCE Discrete choice experiment

EIA Environmental impact assessment

HPM Hedonic pricing method

IIA Independence from irrelevant alternatives

IID Independent and identically distributed

IPP Independent power producer

IV Inclusive value

KWh Kilowatt hour

LL Log-likelihood

LR Likelihood ratio

Ltd Limited

MLE Maximum likelihood estimation

MNL Multinomial logit

MWh Megawatt hour

MWTA Marginal willingness to accept

MWTP Marginal willingness to pay

NIMBY Not in my backyard

NL Nested logit

OLS Ordinary least squares

NPV Net present value

PJ Petajoule

Pty Proprietary limited company

REFIT Renewable energy feed in tariff

RPL Random parameters logit

RUT Random utility theory

TCM Travel cost method

TWh Terawatt hour

WTP Willingness to pay

WTA Willingness to accept

Chapter One: Electricity generation options for South Africa

1.1 Introduction

Concerns over out-dated energy generating technologies, future coal resources, electricity supply shortages and South Africa's increasing carbon emissions have encouraged the transition toward renewable and sustainable energy production (Beyer, 2012).

South Africa is the 13th largest emitter of carbon dioxide worldwide (DME, 2004). The reason for the high level of these emissions is that 86%[2] of South Africa's current nominal installed capacity for electricity generation is through coal-fired power stations (Biyala & Research Unit of Creamer Media Pty (Ltd), 2012). The combustion of coal for energy produces carbon dioxide, a greenhouse gas that has been linked to climate change (DME, 2003). In order for South Africa to reduce its carbon emissions and comply with the UN Framework Convention on Climate Change and the Kyoto Protocol, Eskom (South Africa's leading electricity supplier) is required to diversify its energy mix (DME, 2004).

Recognition that the country is over-reliant on (and over using) coal to generate electricity, and contributes to climate change, has coincided with challenges to South Africa's security of supply of electricity (Kiratu, 2010). The country has experienced energy shortages as Eskom has struggled to meet the growing demand for electricity and improve the country's electrification rate[3]. The supply shortages have been experienced in the form of long periods of power outages and frequent load shedding[4]. The main causes of the country's supply inefficiencies are poor planning and lack of maintenance (Calldo, 2008).

In order for South Africa to reduce its emissions without jeopardising electrical energy supply, the country has been forced to look at employing a new balance of electrical energy production technologies – a more efficient, sustainable and less carbon intensive balance. Within this

[2] Current nominal installed capacity is 44 145MW. Coal-fired stations generate 37 745MW.
[3] The electrification rate (percentage of households supplied with electricity) for South Africa is predicted to be at 80% for 2013 (Bekker & Eberhard, 2012).
[4] A planned rolling black-out that occurs over periods when supply is threatened. It is a way to rotate the availability of electricity to different consumers so as to prevent a collapse of the electricity system and spread the shortage of supply across a broader spectrum of consumers.

balance, wind energy is an attractive option because the technology is readily available and, once a wind energy generating facility is established, it has very low running costs.

Wind energy is a realistic energy option for South Africa because the country has rich wind resources. South Africa's coastline experiences wind speeds of between 4 – 9 m/s, which is considered high (Hagemann, 2008). The total wind energy generation potential for South Africa is approximately 81TWh (Hagemann, 2008). The country currently has 3MW of wind energy facilities installed and a number of wind energy projects underway in both the Eastern Cape and Western Cape (de Bruyn, 2008). It is against this background that wind energy has been mooted as an efficient resource from which to generate electricity in South Africa (Beyer, 2012), at least over some range of production - for instance greater than E_1 in Figure 1.1.

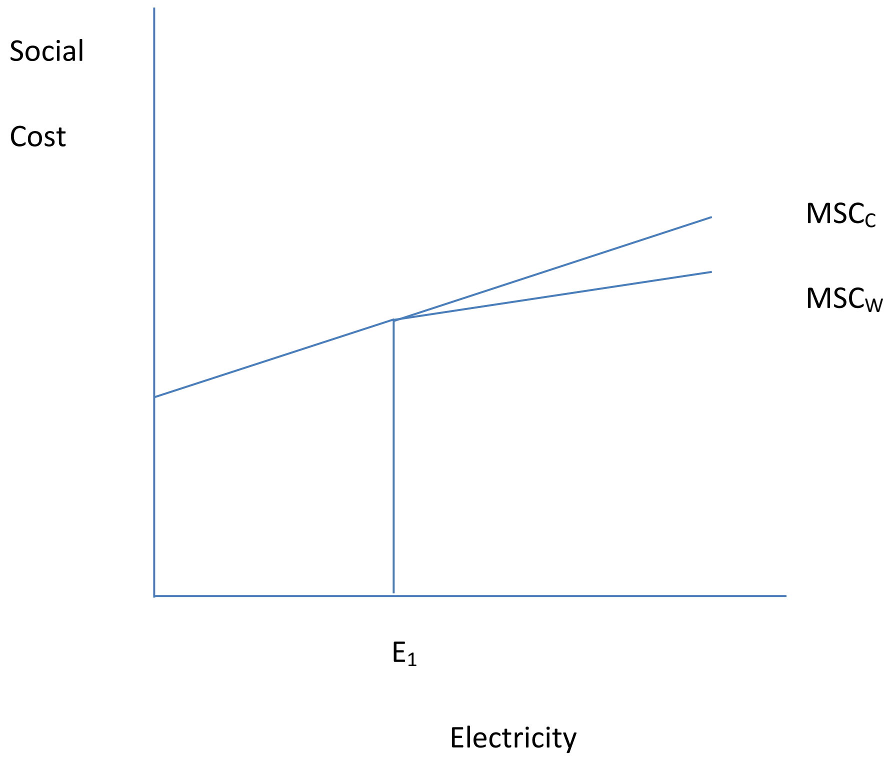

Figure 1.1: When wind energy becomes efficient

Within the model described in Figure 1.1 wind energy is an efficient electricity generating technology above level of electricity E_1, where the marginal social cost of electricity generation through wind (MSC_W) is less than through using coal (MSC_C). The main reason why wind energy has been suggested as an efficient resource by which to generate electricity in South Africa is not because it is less costly at all levels, but because it may be less costly at the margin, after taking into account the external cost of greenhouse gas emissions into the atmosphere (DEA, 2010; Menzies, 2011).

That said, wind turbines are not neutral to the environment. Greenhouse gas is still emitted during the production of the turbine equipment and facility, and, perhaps more importantly, the facilities themselves reduce the naturalness of the area, increase industrial noise and road development and negatively affect fauna and flora in the area (Binopoulos & Haviaropoulos, 2010).

The determination of when wind energy becomes an efficient technology to employ to generate electricity has been the subject of several investigations. Two conducted in the Eastern Cape were those of Menzies (2011) and Beyer (2012). They both employed cost benefit analysis to argue the efficiency case for generating electricity using wind energy. In a parallel development there have been a number of applications to initiate wind farm projects in the Eastern Cape, suggesting that after the government subsidy, harnessing wind energy to generate electricity may also be privately profitable.

Wind turbine farms with the capacity of approximately 6000MW are currently in the environmental impact assessment (EIA) phase of approval in the Eastern Cape (Metro Minutes, 2011). In the Kouga local municipality a company called Red Cap Investments Pty (Ltd) has proposed the construction of a 300MW wind turbine farm (Red Cap Investments, 2011). The wind farm will comprise approximately 121 turbines with a maximum height (from base to tip of blade) of 100 meters (Red Cap Investments, 2011).

The efficiency of such developments is not so much the subject of this dissertation, as the estimation of an appropriate level of compensation of those negatively affected by such developments, and more specifically, those negatively affected by the Red Cap Investments project. Some of the residents of St Francis Bay in the Kouga local municipality, although supportive of renewable energy, are discontented about the siting of the wind turbine farm in their vicinity (SFBRA, 2010) - mainly because they stand to incur costs, but also because they perceive that the wind farm will change the aesthetics of the landscape, create noise pollution and cause bird and bat mortality.

The impact of a wind farm typically affects the residents and businesses that are located in the vicinity of the wind farm, more negatively than residents living further away (Acoustic Ecology

Institute, 2010). The local opposition arising from new wind farm developments is most often due to the location of the wind farm, rather than an objection to wind power use, in principle – a phenomenon known as the NIMBY (not-in-my-backyard) syndrome. The opinions of the opposing parties are important because the public rejection of proposed wind turbine farms create barriers to new renewable energy developments (Devine-Wright, 2005). Affluent residents in the vicinity of the proposed wind farm often pose the greatest resistance to wind energy projects (Martin, 2010). Poor residents do not have the resources or knowledge to oppose commercial developments and therefore are often the most imposed upon by these and other undesirable industries (Faber & Krieg, 2002). For this reason, it is important to include both socio economic groups' perspectives toward new wind energy developments to gauge the impact that the wind farm will have on the population.

Expression of opposition to wind farms typically takes place under South African Law within the framework of an EIA and local government building regulations and approval procedures. The processes and activities covered by the EIA are detailed in Section 21 of the Environmental Conservation Act (Number 73 of 1989). The EIA process is intended primarily as a guide to government on the merits of project or policy approval. It does not provide guidance on issues such as compensation. Similarly, local government approval processes do not deal with such issues either. Providing the National Building Regulations and Building Standards Act and other laws are complied with, a local authority is virtually obliged to grant approval of building plans. According to Ghost Digest (2012) the Supreme Court of Appeal case of Clark vs. Farraday 2004 ruled that:

'The value attached to (another) property cannot be derogated from where the "offending structure" is constructed in accordance with the provisions of the Act and applicable law, particularly where the possibility of the same should have been foreseen by the landowner.'

The compensation for the costs of environmental damage is provided for in Section 28 of the National Environmental Management Act (NEMA) Number 107 of 1998. This section adopts the globally accepted *polluter pays* principle – imposing life-cycle responsibility for any impacts on the environment and responsibility on the party causing the environmental damage to pay for remedial actions. However, this Law does not provide clear guidance on who may receive this compensation and the processes that should be followed to receive it.

In addition to the legal principles being aligned to the polluter pays principle, there is also the economic principle - efficiency requires losers to be compensated (fairness too). For this reason, Beyer's (2012) argument that the Red Cap Investments project is efficient is only valid in so far as the project will compensate those who experience losses due to it. Only after this is paid is the project efficient.

How much should be paid as compensation? Presumably, the answer to this question is how much the residents are prepared to trade-off their environmental losses for. This estimation problem can be addressed through choice modelling analysis – both economic and statistical.

The economic modelling of the choice being imposed upon the residents in the area where the wind farm is proposed can be employed to identify the nature of the cost being imposed, and the statistical modelling of the choice with respect to these costs can be employed to quantify these costs. This dissertation affords the latter type modelling greater emphasis than the former.

Statistical modelling of choice or choice experiment methodology is a statistical technique that enables the quantification of consumers preferences based upon stated responses (Hosking, 2009). It is applied by requiring a specific group of respondents (representative population) to make choices based on hypothetical scenarios presented (Davies, Laing & Macmillan, 2000). The hypothetical scenarios are presented as a combination of attributes and levels. By choosing between the alternatives presented, the respondents make trade-offs between the attributes and levels. An analysis of these trade-offs allows for the determination of marginal willingness to pay/accept (MWTP/A) for a change in attribute levels, the implied WTP/A for a change in a combination of attributes and levels, the ranking of attributes and the significance of the attributes (Davies *et al.*, 2000).

1.2 Current energy situation in South Africa

Electricity is a basic service that the South African government (through the state-owned company Eskom) provides to approximately 80% of all South African households (Zuma, 2011). The amount of electricity generated for distribution in South Africa is 238 272 GWh, of which 95% is produced by Eskom and the remainder is produced by Independent Power Producers (IPPs) (Edkins, Marquard & Winkler, 2010; STATSSA, 2011).

The bulk of primary energy produced in South Africa (approximately 93%) is generated from the combustion of coal resulting in the energy supply for the country being carbon-dioxide intensive (Edkins *et al.*, 2010). As South Africa has ample coal reserves, the price of electricity has been historically low and the demand for energy has been significantly higher than most developed countries with demand in 2010 sitting at 248,914 GWh (Eskom, 2011). The average household in South Africa consumes 1100 kWh (1.1 MWh) of electricity each year (Ebrahim, 2010).

1.3 South African policy toward renewable energy

In 1994 South Africa adopted the international sentiment toward climate change by signing the United Nations Framework Convention on Climate Change (UNFCC, 2000). In 1997 South Africa ratified the Convention, committing South Africa to the objectives set forth by the Convention, in the same year the Kyoto protocol was introduced (UNFCC, 2000). The Kyoto Protocol is a legal document which specifies that all developed countries are required to take steps to reduce greenhouse gas emissions by at least 5% from their 1990 levels (UNFCC, 2000).

As South Africa is classified as a developing county, the Kyoto Protocol does not require the same stringent commitments to climate change as those imposed on developed countries. However, South Africa is obliged to adopt cleaner technologies and production, mitigation options and create a policy toward climate change. In compliance with the protocol the South African government (optimistically) committed itself in 2009 to reduce below current levels its harmful carbon emissions by 34% by 2020 and 42% by 2025 (DEA, 2010). The development of an appropriate mitigation strategy for the energy sector is fundamental to realising these targets. It is for this reason that the South African government released the National Climate Change Response Green Paper in 2010 (DEA, 2010). Some of the most significant objectives with regard to mitigation strategies in the energy sector, as outlined in the Green Paper are:

- Actively promote the development and roll-out of nuclear and renewable forms of energy and identify the most suitable and efficient technologies for energy production.
- Execution of the renewable energy support mechanisms, such as the subsidies for solar water heating and the renewable energy feed-in tariff.

- Ensure that future peaks and declines in the demand for electricity are accounted for by diversifying the energy mix, investing in cleaner technologies and transitioning toward a low-carbon economy.
- Ensure that the price of carbon reflects the external environmental cost it imposes through the use of market-based policy measures such as an escalating carbon tax.
- Resolve the financial, regulatory and institutional obstacles that obstruct the incentives to develop renewable energy technologies.
- Replace old inefficient technologies and invest in cleaner and more efficient coal technologies.
- Create awareness through educational campaigns, corporate commitment programmes and audits.
- Develop and manage a greenhouse gas emissions information management system.

Subsequent to the Green Paper, in 2011 the government released the Response to Climate Change White Paper (DEAT, 2011). This paper complements the National Climate Change Response Green Paper and sets forth the following policy objectives (DEAT, 2011):

- Improvement of energy consumers' access to reasonably priced energy services, particularly for poor households.
- Proper energy governance by creating mechanisms such as the "National GHG Emissions Trajectory Range", "Greenhouse Gas Inventory" and a "Monitoring and Evaluation System".
- Encouragement of competition within the energy sector and assistance with economic development.
- Diversification of mitigation options, policies and actions in order to secure supply.
- Reduction of the negative impacts arising from energy activities.

It is a policy of encouraging mitigating solutions to climate change through monitoring and development of new sustainable and renewable technologies. Improving efficiency in current thermal based electricity generating plants is an attractive short-term application of the policy.

Renewable energy is a promising long-term mitigation and energy capacity building option available to South Africa. Not only does the country have a large untapped potential to produce energy from renewable sources, but the technology is also readily available and easy to implement. The challenge that South Africa faces is to determine which renewable technologies are most suitable for widespread development in the country.

1.4 Renewable energy options

There are several renewable energy options available for implementation in South Africa. The most viable renewable energy solutions are: solar energy, wind energy, hydro energy, biomass, biogas, wave energy, ocean currents and the generation of energy from waste (Davidson, Winkler, Kenny, Prasad, Nkomo, Sparks, Howells & Alfstad, 2006).

1.4.1 Solar

South Africa has an average daily solar radiation of between 4.5 and 6.5 kWh/m^2 one of the highest levels of solar radiation in the world (DME, 2003). For this reason, South Africa has significant potential to harness the solar radiation for energy production. The ways in which the energy from solar radiation can be acquired are through solar water heating, solar photovoltaic and solar thermal power generation (DME, 2003).

One of the major problems with solar power generation (photovoltaic and solar thermal) is energy storage. Another is that, large scale solar power generation is costly and land intensive, but the benefits accrue over a very long period (Beukes, 2011).

1.4.2 Wind

There is significant potential to produce energy from the wind resources along the coast of South Africa as most wind speeds along the coast exceed 6m/s (Diab, 1995; DME, 2003). The potential for onshore wind resources in South Africa were estimated by Diab (1995) and the DME (2003). The wind resources in South Africa were predicted to be sufficient to supply approximately 1% of all the country's electricity needs (19 8000 GWh) in 2002 (DME, 2003). A more recent estimate of South Africa's wind power potential is 81 TWh predicted capacity (Hagemann, 2008). This capacity estimate was determined from annual average wind speeds for South Africa (Hagemann, 2008).

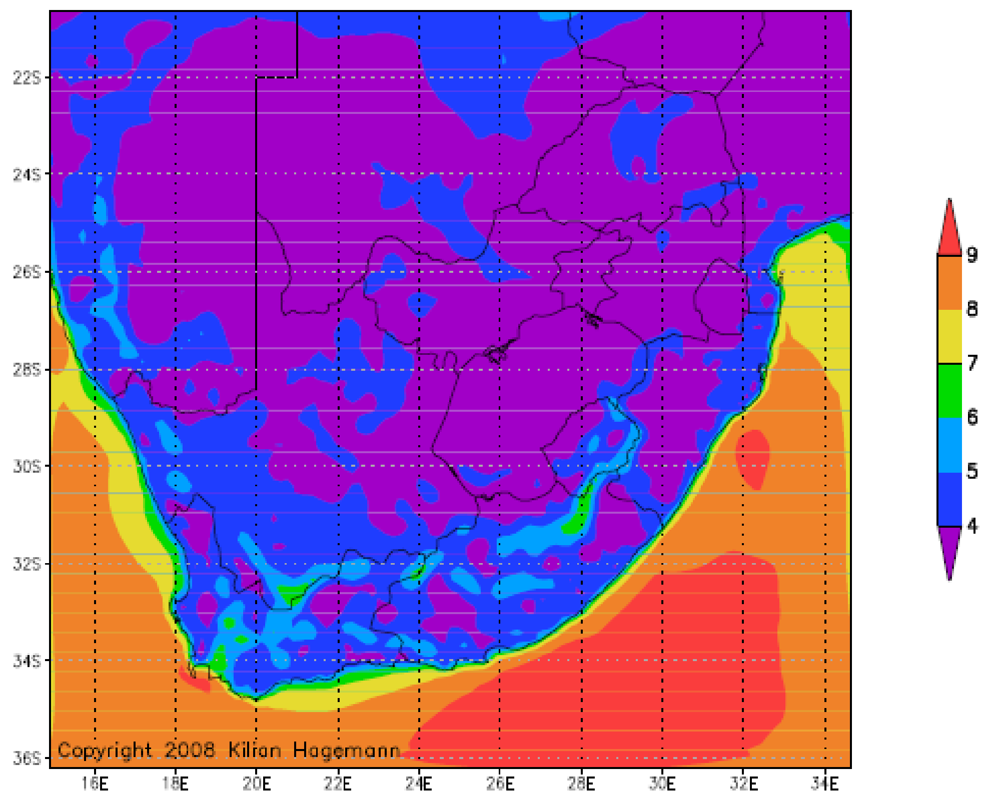

Figure 1.2: Map of average annual wind speeds at 10m above ground in ms^{-1} South Africa

Source: Hagemann (2008)

Wind energy can be connected to local electricity grids, and in this way the electricity generated can supplement electricity supply in the coastal areas, typically otherwise transported over large distances from the Highveld plants, with significant transmission forces (Hagemann, 2008). Water pumped storage schemes are a potential means of storing excess energy generated by the wind farms. With wind energy use there still will remain a need for base load electricity generation using fossil and other energy sources (including possibly nuclear), this is because wind energy technology is currently not able to meet consistent electricity demand requirements.

Other that the space they take up, there are relatively few environmental concerns raised by exploiting wind, but there are significant 'human' impacts. Reports of noise and visual pollution from wind farms are common problems associated with the development of this renewable energy (Rogers, Manwell & Wright, 2002). Wind turbine noise is one of the main human impact concerns for this energy source (Prospathopoulos & Voutsinas, 2007; Clohessy, Sharp & Vorster, 2011).

A study by Clohessy *et al.* (2011) found that the sound level created by the wind turbines was lower than that of normal traffic in a street. The predominant sound made by the wind turbines was aerodynamic (the sound of the air flowing past the turbine blades) and was characterised by a "whooshing" noise. This study emphasised the use of location to help mask the noise made by the wind turbines e.g. where the noise can be camouflaged by others (Clohessy *et al.*, 2011).

1.4.3 Hydro

South Africa has significant small scale hydropower potential (less than 10MW plants). The benefit of hydropower is that it can either stand alone, or it can be combined with other renewable energy sources, e.g. wind power. It can also perform other functions such as irrigation and maintenance of water supply (DME, 2003).

Hydropower is an attractive option for energy supply, but the installation of such technology is expensive and may negatively impact the settlements around the installation site. Additionally, all hydropower developments require authorisation in terms of the National Water Act (DWAF, 2003; DME, 2003) and this authorisation can delay project development and discourage private investment.

1.4.4 Wave energy

Wave energy technology is in the early stages of development. The potential to use this form of energy for production of power is currently estimated at about 56 800 MW for the entire South African coast line (DME, 2003), but the cost and the slow development of this technology have so far rendered it as unviable for investment purposes.

1.4.5 Ocean currents

The Agulhas Current is one of the strongest currents in the world. It is 150 km wide and flows at 6m/s (Lavrenov, 1998) and is estimated to be able to produce approximately 2000 MW of energy for South Africa. However, research on the utilisation of ocean currents for electricity generation is still in its infancy. If this technology were to be implemented in South Africa, it would benefit from greater predictability about flow (DME, 2003).

1.4.6 Biomass

Fuelwood, bagasse from the sugar industry, pulp and paper waste from the forestry industry, energy crops and animal manure are some sources of biomass. The combustion of biomass is a carbon free process, because the carbon dioxide resulting from combustion was captured by the plants and would otherwise be released through decomposition (IEA, 2011).

Sugar cane residue, which is the remains of the sugar cane after it has been processed, is called bagasse. Bagasse, as a source of biomass, offers great potential to independent power producers, especially those that operate processing mills (DME, 2003). Bagasse in South Africa has the potential to generate approximately 1500 GWh of electricity through thermal methodologies (DME, 2004). Fuelwood is also a viable option for electricity generation as it is easily acquired and it helps with alien species eradication.

1.4.7 Refuse (domestic and industrial)

The energy content of both domestic and industrial waste in South Africa is equivalent to 1290.27MWh (40.5 PJ[5]) per annum (DME, 2003). Additionally, the methane derived from sewerage has a net realisable electricity generating capacity of approximately 36 MWh (1.13 PJ) per annum (DME, 2001).

However, the cost to utilise such an energy source in comparison to the net energy creation benefit does not make this energy option economically viable.

Co-firing (combustion of coal and biomass) is the most effective means to generate electricity from biomass, but biomass is a more expensive option than coal alone, after transportation is taken into account (IEA, 2007).

1.4.8 Summary of renewable energy options for South Africa

Potential options for electrical energy production from renewables in South Africa are wind power, small scale hydro power, biomass and solar power. The technologies are well developed to harness them and readily available (DME, 2003). Most of the options are more environmentally friendly and more sustainable than using fossil fuels. The primary factor holding back their adoption is cost.

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[5] PJ= Petajoules (PJ): 1 Petajoule = 10^{15} Joules

Most renewable projects require substantially large initial capital investments, but the running costs are often relatively low and there are negative external cost location impacts.

1.5 Wind energy in South Africa

South Africa's technical potential for generating wind power has been estimated at 80 TWh, but its economic potential is much less (Edkins *et al.*, 2010). Current installed capacity of wind energy is negligible. Most existing wind turbines do not supply electricity to the National Grid. They are installations that form part of pilot projects to test the wind resource potential of the South African coast line. There are three locations in South Africa that have installed operational wind turbines: Klipheuwel (Western Cape), Darling (Western Cape) and Coega (Eastern Cape).

The Western and Eastern Cape coastlines of South Africa are rich in wind resources. One of the largest wind farm proposals in the country has been planned for development in the Kouga local municipality, Eastern Cape. The siting of this wind farm has been a source of great contention among the residents in the area.

1.5.1 The study site: Kouga local municipality

The Kouga local municipality is situated in the Cacadu District within the Eastern Cape Province of South Africa approximately 20 km from Port Elizabeth (Kouga local municipality, 2011). The municipality includes the following urban settlements: Jeffreys Bay, Humansdorp, St. Francis Bay, Cape St. Francis, Oyster Bay, Hankey, Patensie, Thornhill, Loerie, Paradise Beach and Aston Bay. Some of the townships in the municipality are: Kwanomzamo, Tokyo Sexwale, Umzamowethu, Sea Vista, Arcadia, Kruisfontein and Ocean View. A map of the Kouga local municipality and surrounding area is shown in Figure 1.3.

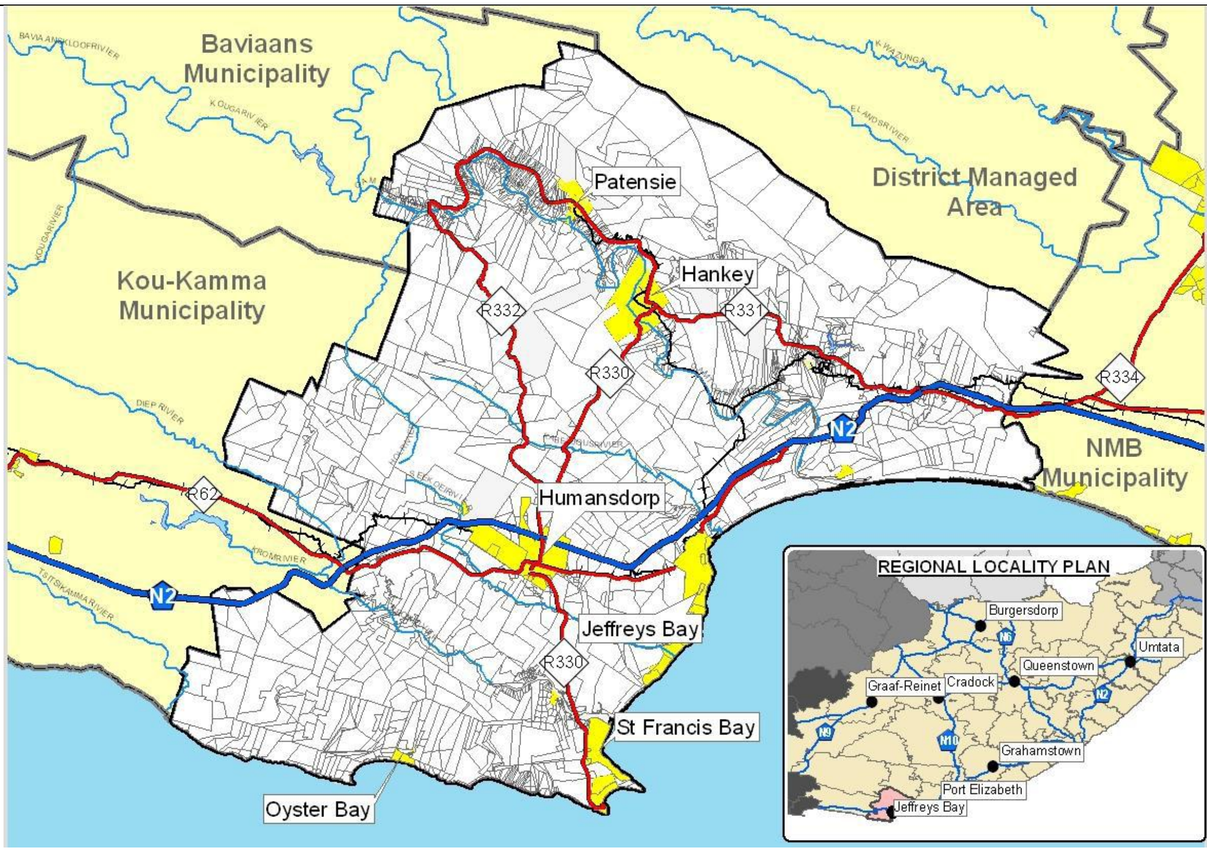

Figure 1.3: Map of the Kouga local municipality

Source: Kouga Municipality (2009)

The largest urban areas in the Kouga local municipality are Humansdorp, Jeffrey's Bay, St. Francis Bay, Patensie and Hankey (Figure 1.3).

The population is estimated at 80 459 (2007) with approximately 70% of the population living in urban areas (Kouga local municipality, 2011). The majority of the Kouga residents are below the age of 35 and are of coloured and African (black) ethnicity (Kouga local municipality, 2011).

The inequality in income of the population of the Kouga municipality in 2010, expressed in terms of the Gini coefficient (a value of 0 indicates total equality whereas 1 indicates total inequality) was 0.5637 (Kouga local municipality, 2011); high by international standards, but lower than the 0.631 average for South Africa, estimated by the World Bank (for 2009).

1.5.2 Kouga local municipality resources

The Kouga municipality is described as having "under-developed natural beauty", with unspoilt beaches and open landscapes (Kouga local municipality, 2011). It is for this reason that the

Kouga municipality is a tourism hotspot along the Sunshine Coast, attracting bird watchers, recreationists, surfers and nature enthusiasts. St. Francis Bay is an upmarket holiday resort, attractive to both foreign tourists and property investors. Jeffrey's Bay is also a tourist hub, with surfers and tourists taking advantage of the beaches and natural surf conditions on offer.

The Kouga local municipality area also has large areas with sufficient wind to make it an attractive location for wind turbine electrical energy generation. As a result there have been a number of proposals to develop wind farms in the Kouga local municipality. Table 1.1 below summarises some of the wind farm proposals for the Kouga municipality.

Table 1.1: Wind farm proposals in the Kouga local municipality

Location	Company	Number of turbines	Electricity Generation capacity	Area affected
Jeffreys Bay	Genesis Eco-Energy Pty (Ltd)	6 – 30	15 MW	20 ha
Oyster Bay	Renewable Energy Systems South Africa Pty (Ltd)	50 – 80	160 MW	23 ha
Humansdorp / St. Francis Bay	Red Cap Investments Pty (Ltd)	27	300 - 450 MW	9382 ha 1 % of 9382 ha (9.382 ha) will be permanently altered
Paradise Beach / Aston Bay		53		
Tsitsikamma / Oyster Bay		41		

Sources: Dippenaar & Lochner (2009), Red Cap Investments (2011), Almond (2011)

In addition to the wind farm projects, a nuclear plant has also been proposed for development in Thyspunt in the Kouga municipality (Eskom, 2008). The development of the wind farms and a nuclear facility may change the balance between tourism and industry in the area, and undermine the former (SFBRA, 2010). As a result those living in the area whose livelihoods depend on tourism may suffer some loss of income but others may gain through income gained by the new industry.

1.5.3 Red Cap Investments Pty (Ltd) proposed wind farm

In June 2011 the South African government gave the company, Red Cap Investments Pty (Ltd), the go ahead to develop a wind farm in the Kouga local municipality (Marshall & Klages, 2012).

Red Cap Investments Pty (Ltd) in partnership with Inspired Evolution Investments Management, Standard Bank, Afri-Coast Engineers SA and Eurocape Renewables has proposed to build a wind farm comprising 100 to 121 wind turbines in three separate locations along the Kouga coastline (Red Cap Investments, 2011).

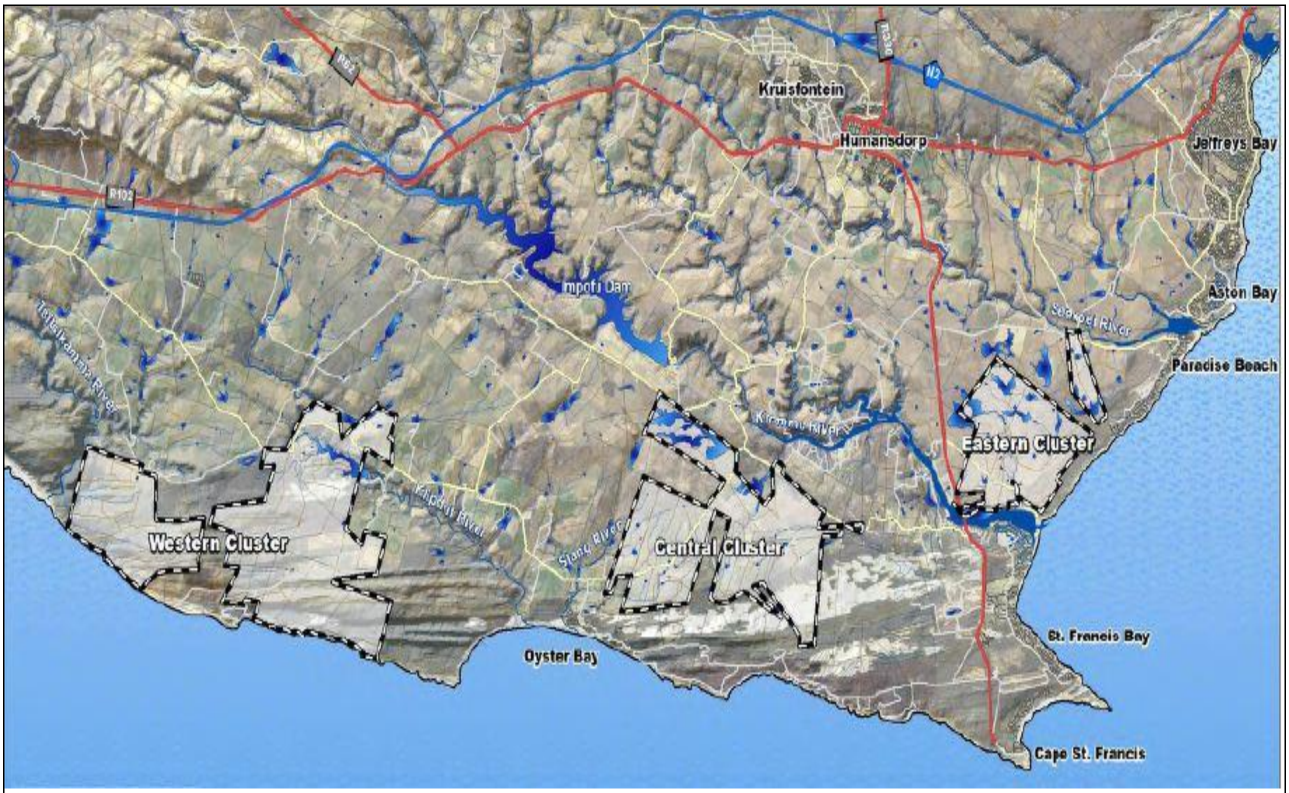

Figure 1.4: Map of the wind farm sites in the Kouga local municipality

Source: Red Cap Investments Pty (Ltd) (2011)

The Eastern cluster comprises approximately 27 turbines and is located halfway between St Francis Bay and Paradise Beach (See Figure 1.4) (Red Cap Investments, 2011). The Central cluster of 41 turbines is planned for development halfway between Oyster Bay and Cape St Francis (Red Cap Investments, 2011). The Western cluster comprising 53 turbines is to be built between Oyster Bay and the Tsitsikamma river mouth (Red Cap Investments, 2011). The capacity of the wind farm development will be approximately 300 MW with each turbine having a rated power of about 2.3 to 3 MW and a hub height of 80 to 110 meters[6] (Red Cap Investments, 2011).

[6] Dependent on the specific turbine used. Vestas Wind Systems A/S or Nordex SE are the possibilities for the turbines that will be used.

The development of the wind farm in the Kouga local municipality will have an impact on the fauna and flora, landscape views, noise levels, uses and value of the land and may affect the tourism industry (a significant revenue source for many residents in this area). It is for these and other reasons, some of the residents have expressed discontent with the current plans for the wind farm development. Although there are a number of perceived external costs brought about by the wind farm development, there are also some hoped for benefits, including job creation and reductions in carbon emissions, decreased power outages and infrequencies in electricity supply.

1.6 Objectives of the study

The main objective of this dissertation will be to apply the choice experiment methodology to assess the residents' preferences for the location of the proposed wind turbine farm in the Kouga local municipality in the Eastern Cape. The conceptual framework for this study is presented in Figure 1.5.

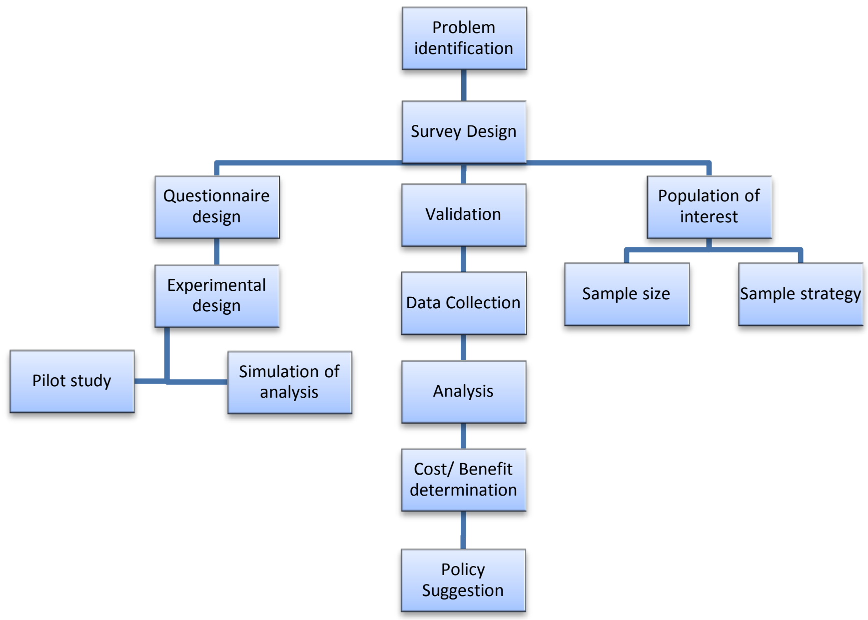

Figure 1.5: Conceptual framework for determining the preference for location of a proposed wind turbine farm in the Eastern Cape

Adapted from: Iamtrakul, Teknomo & Hokao (2005).

Expanding on the conceptual framework shown in Figure 1.5 above, this study has the following aims:

- identify potential regions/sites of wind farms and determining the affected populations involved,
- design an appropriate survey tool and creating an experimental design that includes a combination of relevant attributes and levels (the attributes and levels will be informed by international literature and focus group studies) and the determination of an appropriate sample size,
- administer the survey, screen the data collected, enter the data, clean the data and describe the data,
- estimate appropriate random utility models from this data,
- calculate marginal valuations from these models and interpret the results, and
- guide government policy on location issues relating to wind farm developers.

The application of a choice experiment comprises four stages (Shen, 2005). The first stage, which is the most fundamental in applying choice experiment methodology, is survey design. It involves the selection of attributes, the assignment of levels to each attribute, the experimental design and the presentation of the survey. The second stage is data collection, including sample frame, sampling strategy, selection of sample size and method of response collection. Stage three involves model estimation and assessment. Stage four is an application of the model results (Shen, 2005).

A number of sub-objectives are to be pursued in connection with defining the choices, attributes and the attribute levels in the application of a choice experiment. These sub-objectives are as follows:

- To determine the feasibility and validity of a set of attributes as management options from literature reviews, focus groups and expert consultations. In order for the estimation of marginal willingness to pay (MWTP) one of the attributes has to be a monetary measure (Hanley, Mourato & Wright, 2001).
- To administer a pilot study to determine the respondents' feedback on the plausibility and relevance of the choices and attributes (Louviere, Hensher & Swait, 2000; Shen, 2005), the structure of the survey, the length of the survey, supporting information and

the survey simplicity (Carson, Louviere, Anderson, Arabie, Hensher, Kuhfeld, Steinberg, Swait, Timmermans & Wiley, 1994).

- To limit the number of choices, attributes and levels so as to avoid cognitively burdening the respondents with too many options (Carson *et al.*, 1994).

In order to realise these objectives, the design phase of a choice experiment should include focus groups, pilot surveys, literature reviews and consultations with experts. These are all useful elements to determine which levels of attributes are most relevant (Bergmann, Hanley & Wright, 2006).

1.7 Conclusion and organisation of the dissertation

South Africa is in an electricity generating crisis. More capital and more sources will have to be exploited to satisfy the growing demand. At the same time the country has committed itself to reducing carbon emissions. One technology that is capable of helping meet both of these objectives is that of converting wind energy into electrical energy. With this advantage in mind the government has approved a number of wind farm industrial developments, one of which is in the Kouga local municipality.

The downside of this approval is that there will be negative external costs imposed on nearby residents. How may these costs be estimated and appropriate compensation for the residents be calculated? This dissertation answers the estimation question through a discrete choice experiment (DCE) analysis, in which distance from turbine is a critical element.

The remainder of the dissertation is organised as follows: Chapter Two theoretically overviews the stated preference technique, DCE analysis; Chapter Three defines the steps followed in applying the choice experiment, including a literature review of similar choice experiment studies, the survey design, focus group and pilot study; Chapter Four describes the survey response rates, some demographic data, and an assessment of the choice experiment responses and the choice experiment model results and WTA welfare estimation results, and Chapter Five concludes and makes recommendations.

Chapter Two: The Methodology

2.1 Introduction

Increasing human development has threatened the availability and abundance of environmental goods, which in turn has raised concern over environmental protection. Who pays for the cost of environmental protection and how do we measure these costs? For marketable goods this cost is straight forward. If an individual wishes to purchase a bicycle, the benefit derived from buying the bicycle should outweigh the individual's expenditure (WTP) for the bicycle. This benefit is reflected in the market price. If the individual later decided to sell the bicycle, the selling price reflects the individual's WTA compensation for the loss in utility from the bicycle (Gundimeda, 2005). For environmental goods there are no distinct property rights and therefore there are no clear market prices for these goods (Gundimeda, 2005). They are typically public goods, that is, non-excludable and can be consumed by an additional consumer at no extra cost, and property rights for such goods are non-enforceable (Gundimeda, 2005). There are a number of market and non-market valuation techniques based on the same principle defined above of individuals' WTP for environmental gains and WTA compensation for environmental losses (Gundimeda, 2005). These techniques are useful in some situations but not others.

They would appear to be applicable to the case of estimating the economic value to the individual of the environmental disamenities arising from the construction of a wind power facility in the Kouga local municipality. Why is this the case? This chapter answers this question. It rationalises why residents negatively affected by the development of a wind farm merit compensation and outlines some relevant market and non-market valuation methods for estimating this cost, provides a rationale as to why DCE methodology is the preferred method for this estimation, and sketches the theoretical framework within which DCEs are designed and interpreted.

2.2 The economic rationale for compensating residents for the costs imposed by a wind farm

The economic rationale for compensating a resident for the costs imposed on them by a wind farm may be demonstrated in a utility maximising model simplified to include only two goods and two rational residents. The choice of these two residents is to allocate this income between two goods – electricity purchases (E) and distance of residence from the closest wind farm (D). In this choice they are assumed to wish to maximise their utility. The two residents are differentiated only in terms of the income they earn – one (the affluent one) earning considerably more than the other (the poor one). The affluent resident earns an income of I_{R1} and the poor resident an income of I_P. As both residents have the same preferences, their choices differ only due to the difference in income they earn. Being rational their preferences are complete and transitive.

Their preferences are not homothetic over electricity received (E) and the proximity of residence to the wind turbines (D) because at some point distance ceases to contribute further to their utility. Their utility function is described by function 2.1 and the characteristics listed below it.

$$U = f(E, D) \qquad (2.1)$$

More electricity received increases utility, as would greater distance of residence from the wind turbines, but only up to a point (D_3):

$$\frac{\partial U}{\partial E} \geq 0,\ \frac{\partial^2 U}{\partial E^2} < 0\ ;$$

$$\frac{\partial U}{\partial D} > 0\ , \frac{\partial^2 U}{\partial D^2} < 0\ , \frac{\partial^2 U}{\partial D \partial E} > 0\ , D < D_3\ ;$$

$$\frac{\partial U}{\partial D} = 0\ , D \geq D_3$$

and D_3 is the distance from the wind turbine at which its proximity ceases to impose any negative presence influence, and the marginal rates of substitution cease to diminish .

In the absence of the wind farm, the utility maximising choices of the affluent and poor residents respectively would be for E_2 and E_1 electricity purchases and D_3 and D_1 proximity to the wind turbines (in the form of this model shown in Figure 2.1).

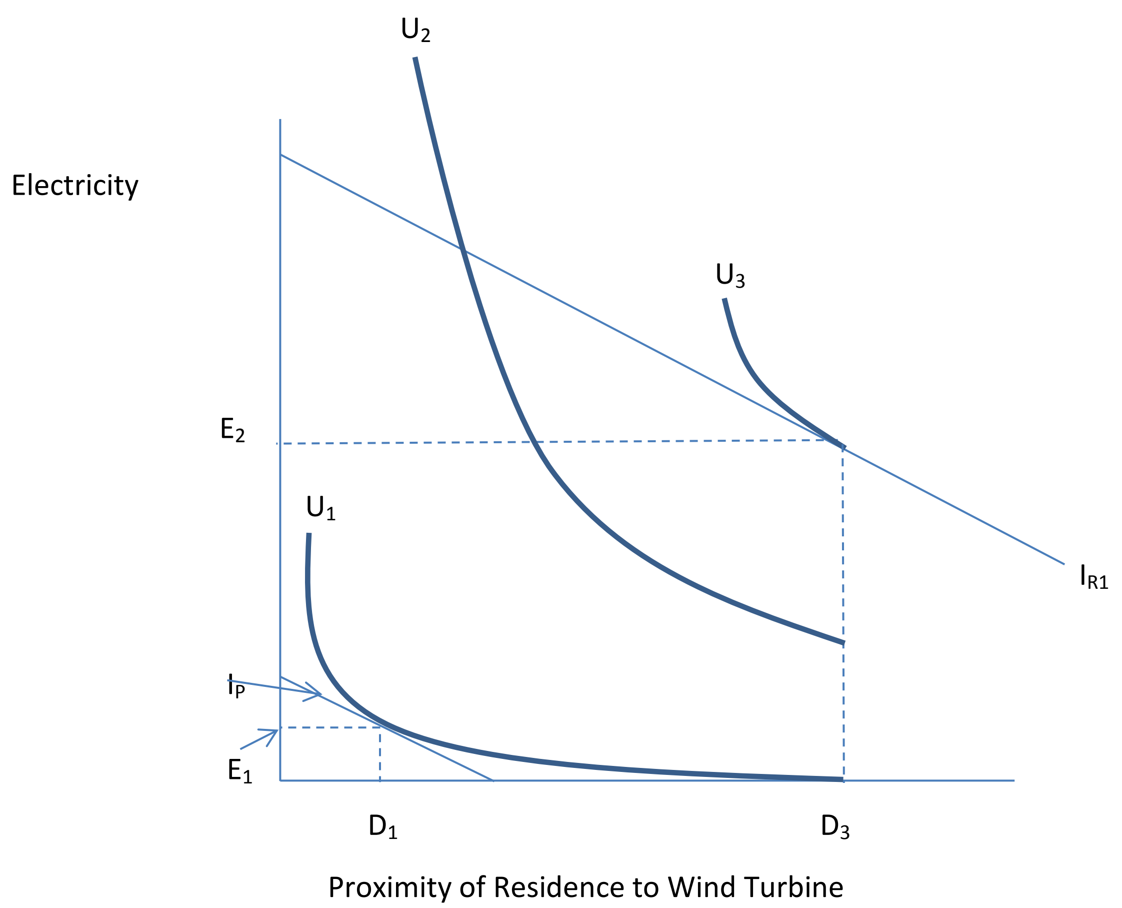

Figure 2.1 Choice of electricity and proximity in the absence of a wind farm development

In the model described in Figure 2.1 the poor resident has less income than the affluent resident to allocate between the electricity and proximity goods. As a result less of both goods is purchased, even though their preferences are the same.

The situation changes after the imposition of the wind farm D_2 distance from the relevant residents (see Figure 2.2). Immediately after the imposition of the wind farm on these residents (the first round impact), the affluent resident would find him or herself receiving a lesser proximity purchase than he or she would normally have chosen; D_3D_2 closer to the wind turbine than he or she would have chosen. The choice of the poor resident would not be affected by this imposition because his or her choice of D_1 is already less than D_2.

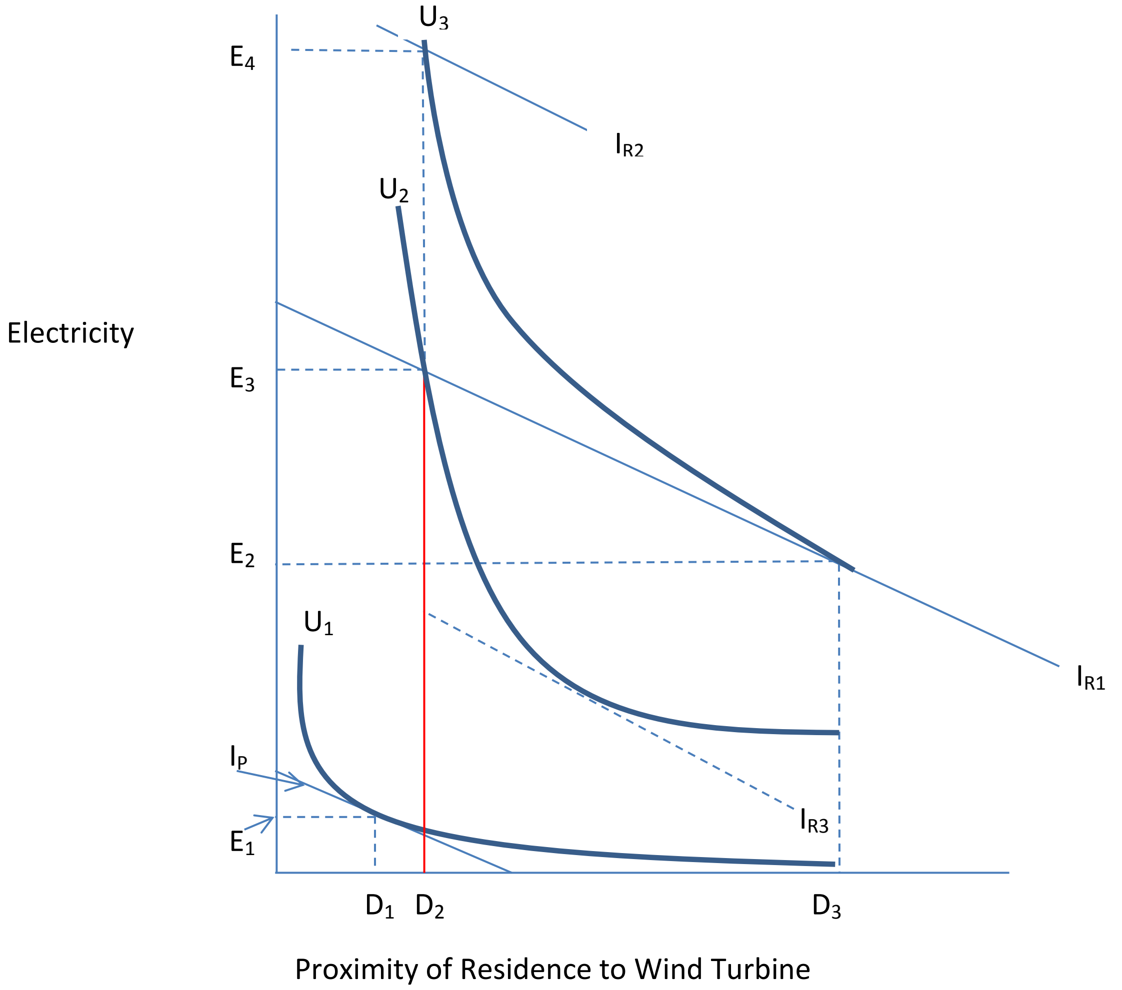

Figure 2.2 Choice of electricity and proximity after the imposition of a wind farm development

A second round impact would be the action pursued by the affluent resident to improve their proximity relative to the wind turbines by relocating their residence from D_2 to D_3 distance from them (Figure 2.2). If they owned the property they resided in this would mean selling the one D_2 distance from the wind turbine and buying another D_3 distance away. If they rented the property they resided, in it would mean terminating the rental agreement on the property close to the wind turbines and initiating a new one further away from the wind turbines; at a once off cost at least equivalent to E_2E_3 electricity (see Figure 2.2). In both the owners and renter cases this relocation will cause them to incur transaction costs, and in the owner's case it would also probably cause them capital losses.

The poor resident would not have any current incentive to relocate or trade for better proximity because their current choice would not actually be interfered with – even after the wind turbines were erected, they would still choose to locate themselves D_1 distance from the turbines and purchase E_1 electricity (see Figure 2.2). This prediction does not imply the location of the wind farm D_2 away from his or her residence would not give rise to dissatisfaction – their location after the wind turbine project is less favourable than it was before it, and should their income increase in the future, the wind farm development would impose future relocation costs similar in nature to those identified for the affluent residents.

The first and second round impacts on the choice of the affluent resident point us to three ways by which to estimate the compensation cost appropriate to a community on which a wind farm project is imposed.

(i) In order to increase distance of their property from the wind turbines to a preferred distance, the owner will need to sell their property that is close to the turbines and buy another further away. As a result the owner will incur property transaction costs and may also incur capital losses on the transactions. The owner will be subject to decreased demand for housing in the area where he or she owned property and wants to sell and increased demand in areas where they may seek to buy alternatively located property a greater distance from the wind turbines (because others also feel the same way). As a result of the changing demand pattern, the affected property owner is exposed to probable capital loss in the form of realising a lower property resale price than they would have obtained in the absence of the wind farm development. It follows that one way of calculating the cost of compensation required would be to estimate and sum the additional costs imposed on the land owner to restore their preferred combination of proximity to the wind turbines and electricity usage.

(ii) An alternative option for the residents who find themselves at undesirable residential locations is to seek compensation for their loss. One way of finding out how much would satisfy the affected resident would be to ask them what minimum compensatory income would be sufficient to return them to the same level of happiness they enjoyed before the imposition of the wind farm on their residential location, under the condition that they remained at their residence D_2 distance from the wind turbines. Their answer to this question would be the resident's estimate of the compensated variation in income of the reduced proximity (to the wind turbines) attractiveness, that is, their estimate of the difference in income between I_{R1} (the minimum expenditure required to achieve U_3 level of welfare), and I_{R2}, the level of income the affluent resident would be as happy as they were before the wind firm was imposed upon them and they were constrained to a location D_2 distance from the wind turbines (see Figure 2.2). The additional income would enable them to purchase E_2E_4 extra electricity, thereby compensating for their imposed inferior residential location D_2 distance from the wind turbines.

(iii) A potential weakness of approach (ii) above, is that the resident may not respond accurately because they do not have to take their budget constraint directly into account, only indirectly. A more direct way of forcing them to take their budget into account in their response would be to use a variant of approach (ii) above – to ask the negatively affected residents what maximum amount they would be willing to pay to avoid the wind turbine development being imposed on them. This approach hypothetically allocates the right to erect the wind turbines anywhere in the area to the developer. The affected residents are asked what income sacrifice would leave them at the same level of happiness as they would have enjoyed after the imposition of the wind farm on their residential location, under the condition that their income sacrifice would secure the cancellation of the wind farm project. Their answer to this question would be the resident's estimate of the equivalent variation in income of the reduced proximity to the wind turbines, that is, their estimate of the difference in income between I_{R1} and I_{R3}, these being respectively, the minimum expenditures required to achieve U_3 and U_2 levels of welfare (see Figure 2.2).

The relative merits of the willingness to accept (WTA) versus willingness to pay (WTP) bid elicitation vehicles is the subject of on-going economic debate. To the extent that low (conservative) estimates are considered preferred, the WTP bid elicitation format has the advantage. An analysis by Horowitz and McConnell (2002) of 45 independent studies found that WTA (for loss) was of the order of 4 to 7 time higher than WTP (for gain) for visibility and siting of public goods. The tendency for WTP estimates to be substantially lower led Arrow et al (1993) to recommend that WTP should be used instead of WTA when applying the *contingent valuation method*. The applicability of the Arrow et al (1993) rationale for preferring WTP has not been substantiated for the choice experiment format.

Others argue that low estimation is an unconvincing reason for supporting WTP over WTA and that this rationale for WTP may be being frequently used inappropriately (OECD 2006: 164-165). They point out that theoretical explanations for the difference between WTP and WTA have focused attention on the income, substitution, endowment and uncertainty effects (OECD 2006: 162). The difference is typically debated with respect to the change in expenditure required to compensate for a change in price, analysed in terms of the relevant Slutsky equations for goods x and y (Compensated Variation and Equivalent Variation below).

In the relevant Slutsky equations the first component on the right hand side is the substitution effect and the second component the income effect of an increase in price of good x that is an increase in Px where the price of good y remains unchanged (Py = Py0) (adapted from Snyder and Nicholson, 2012: 148-152; Mas-Colell, Whinston and Green, 1995: 80-83). In the Compensated Variation Slutsky equation the income effect is positive for normal goods because the minimum expenditure required is to cover an increase in welfare (+U), but in the Equivalent Variation Slutsky Equation the income effect is negative for normal goods because the minimum expenditure is required to cover a decrease in welfare (-U). In the Compensated Variation Slutsky equation the substitution effect relates to the original level of welfare (U0) while in the Equivalent Variation Slutsky Equation it relates to the new (after price, lower) level of welfare.

$$\frac{\partial X(Px,Py0,U)}{\partial Px} = \frac{\partial X(Px,\ Py0,\ U0)}{\partial Px} - [s_x\, e_{xI}/P_x]\frac{\partial E(Px,Py0,+U)}{\partial Px} \qquad \text{(Compensated Variation)}$$

$$\frac{\partial X(Px,Py0,U)}{\partial Px} = \frac{\partial X(Px,\ Py0,\ U1)}{\partial Px} + [s_x\, e_{xI}/P_x]\frac{\partial E(Px,Py0,-U)}{\partial Px} \qquad \text{(Equivalent Variation)}$$

Given that the change in expenditure required to compensate for the utility loss induced by the price increase (in the Compensated Variation Equation) is higher than the change in expenditure that would equivalently reduce the utility loss induced by the price increase (in the Equivalent Variation Equation), it follows that the higher the income elasticity of demand (e_{xI}) and the greater the share of total income spent on good x, that is s_x, the higher the WTA compensation for a loss is relative to WTP to pay for gain. The estimates of Willig (1976) suggest that the income effect is not a reason for the scale of difference typically found between elicitation formats using WTP and WTA.

Such analyses have led to there being greater focus of attention on the substitution effect to explain the disparity between WTP and WTA estimates of given welfare changes. Hannemann (1999) argues the less the substitution possibilities (and more convex the indifference curves), the greater the substitution effect relative to the income effect, and the greater is the compensation requirement (WTA) for a loss in welfare relative to the WTP for a gain in welfare.

The substitution effect arguments and explanations for the disparity found between WTP and WTA estimates of welfare changes are irrelevant to the wind farm development study as no change in relative pricing is being considered or proposed.

Much more relevant are the endowment and uncertainty explanations. Kahnermann and Tversky (2000) argue that, given any initial (start) endowment point and loss aversion, people will automatically value losses more highly than gains, and therefore set WTA higher than WTP. Their loss aversion theory is based on there being a diminishing marginal valuation of quality or quantity improvement. The hypothetical initial welfare position of the person (resident) after the imposition of the wind turbines and before compensation is worse than that of the person before the imposition and seeking to pay to avoid the imposition.

In addition to the different hypothetical endowment positions the person is placed in, there are information uncertainties the people face when being forced to make a bid decision about a future event. If a person must state their WTP before perfect information is achieved about the gain, *ceteris paribus*, it will be lower than after such information is acquired because the respondent will require to be compensated for having to take the bid decision before being able to utilize the (option) value of information that would become available by delaying making the bid decision. By similar reasoning, if forced to state WTA before full information about the loss is acquired, it will be higher because the respondent requires to be compensated for having to take the bid decision before the information on the loss is revealed and forego the option value of information derived from delaying making the bid decision. In this way uncertainty may serve to explain the difference between WTA and WTP.

None of these explanations for the difference between the magnitudes of WTP and WTA are arguments for WTP over WTA. At least one explanation is irrelevant to the wind turbine development situation being analysed (see Figure 2.2). The OECD (2006:165) guidelines on applying cost benefit analysis to the environment argue the conservative elicitation format argument may well be inappropriately applied in many circumstances to motivate using WTP instead of WTA. They observe that even for cases where a person's situation is going to improve, there is a case to use WTA rather than WTP. The reason is that people not only have a right to be compensated for loss of an attractive environment but also for failure to improve or rehabilitate the environment (OECD 2006:165), subject to this compensation be balanced against the property rights the persons or firms on whom the obligation is being imposed to pay the compensation. The payment of compensation for not rehabilitating should not infringe *too much* on the rights of others, for example tax payers (OECD 2006:165).

The main problem with applying the WTP format rather than the WTA one for the case described in Figure 2.2 is that the property right allocation basis for a WTP format is not credible. From a property right perspective, benefits are measured relative to the current state of a person's welfare (Mitchell and Carson, 1989) and the status quo is the primary reference and source of authority for these property rights. The property right assumption underlying the Mitchell and Carson (1989) position was that the person had a right to the initial (before quality reduction) situation (OECD, 2006: 158-9). From the perspective of the residents, those being surveyed, the initial situation is one without the wind farm development. In all but the most recent cases of properties purchased in the area the owners could not reasonably have expected wind turbines to be built in close proximity to them, because building and zoning regulations precluded this. Before the WTP format could be credibly applied to the residential population in the study area it would need to be shown that the developer and not the residents had the rights, and that would be almost impossible to demonstrate given the initial (and current) situation.

2.3 Valuation methods for non-market goods

There are a number of methods that can be used to derive economic values for non-market goods (See Figure 2.3). These methods can be categorised into revealed and stated preference techniques (Hanley & Spash, 1993). In revealed preference techniques, individuals reveal their WTP or WTA compensation for environmental goods through market prices. This technique is advantageous in that the price paid for the goods is real and not hypothetical. A limitation of this technique is that the link between the public and private goods needs to be adequately defined before prices can be determined for the public good (Adamowicz, Louviere & Williams, 1994; Adamowicz, 1995; Lee, 2012). Stated preference techniques involve asking the individuals to state their WTP or WTA compensation for an environmental good (Gundimeda, 2005).

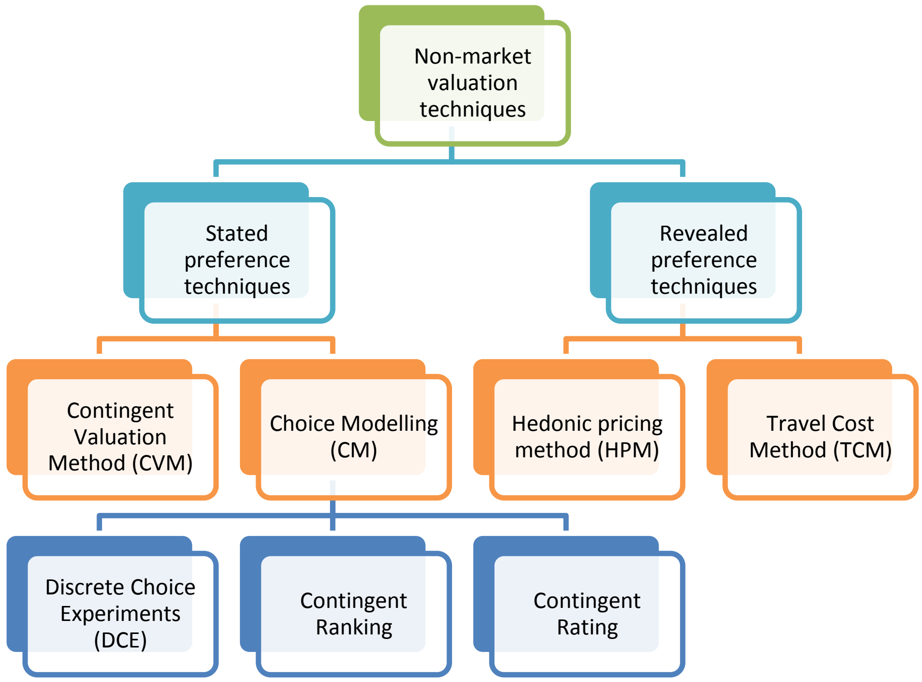

Figure 2.3: Valuation methods for preference-based outcome measurement of non-market goods

The hedonic pricing method (HPM) and the travel cost method (TCM) are two examples of market based revealed preference methods. Contingent valuation methodology (CVM) and discrete choice modelling (CM) methodology are examples of non-market based stated preference techniques. All of these methods allow for the estimation of economic values of environmental goods and disamenities. However, each method has its own advantages and draw backs.

2.3.1 Hedonic pricing method

The HPM is a method used to estimate economic values for environmental resources that have no direct market value by assessing the variation of market prices of goods that have differing quantities of the environmental resource. For example individuals may reveal their preference for clean air and quiet neighbourhoods by buying their property far away from the city centre.

The preference for clean air and quiet neighbourhoods would be revealed through the higher prices of properties in areas outside of the city centre. An HPM is a regression of market price against the characteristics that determine the economic value of the good. For the example described above, the hedonic regression can be represented as follows (Malpezzi, 2002):

$$R = f(S, N, L, C, T) \qquad (2.2)$$

Where R is the rent or market price of the house, S is the structural characteristics of the house, N is the neighbourhood characteristics, L is the location, C is the rental terms or conditions and T is the time the rent or market price is observed (Malpezzi, 2002). The above equation is often expressed in terms of its semi-logarithmic functional form (Malpezzi, 2002):

$$R = exp^{\boldsymbol{X\beta\varepsilon}} \qquad (2.3)$$

Where X is a matrix of the vectors *S, N, L, C* and *T*. Equation 2.3 can be rewritten such that:

$$lnR = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon} \qquad (2.4)$$

By estimating the unknown parameters $\boldsymbol{\beta}$ and $\boldsymbol{\varepsilon}$ in the above equations the price of the individual attributes can be estimated with given levels of the other attributes (Malpezzi, 2002). Differentiating the HPM with respect to one of the attributes yields the implicit price for that attribute (Gundimeda, 2005). Marginal WTP values can be calculated by regressing the implicit prices against the quantities/qualities of an environmental good and different socio-economic characteristic (Gundimeda, 2005).

2.3.2 Travel cost method

The TCM is a surrogate market-based valuation technique (Gundimeda, 2005). The TCM assumes that travel and activity costs to a recreational site or tourist destination can be used to determine estimates for WTP for a non-market good or service. The TCM is based on the hypothesis that the benefits of visitation to a site are at least equal to the travel costs incurred for the visit (Common, Bull & Stoeckl, 1999). It is therefore expected that as the price of access increases, the visit rate to an area will fall. Data relating to travel costs, the frequency of visits and the increasing cost of access over time can be used to estimate a demand curve for the site and therefore consumer surplus (Garrod & Willis, 1999; Kjaer, 2005). As an illustration, the simplest linear case where travel cost is the only determinant of visitation is shown (Common *et al.*, 1999):

$$V_i = \beta(p + \mu_i)D_i + \varepsilon_i \quad (2.5)$$

And

$$Consumer\ Surplus = -(\frac{1}{2\beta})\sum {V_i}^2 \quad (2.6)$$

where V_i is the visits from location i, D_i is the distance from location i, $p + \mu_i$ is the "subjective" price per unit distance from location i with $\mu_i \sim N(0, \sigma\mu^2)$. One of the main uses of applying the TCM is to determine how consumers' behaviour would change if particular levels of fees were set for the site. This method has multiple problems associated with the choice of dependent variables, holiday-makers versus residents, unreliable calculations of distance costs and the value of time (Kjaer, 2005).

Both the TCM and the HPM rely on consumption behaviour. This limits the amount of data available for analysis as only observable information relating to experience can be utilised. Hypothetical events or scenarios cannot be assessed because the preference cannot have been revealed. Furthermore, it is often difficult to quantify the relationship between real market goods and non-market goods. These limitations definitely exclude their applicability to the evaluation of preference for the wind farm in the Kouga local municipality. As consumption patterns have not yet been affected by the wind farm construction, and therefore no quantifiable relationship exists between real market goods and the non-market costs/ benefits of the wind farm.

2.3.3 Contingent valuation methodology

There are two main types of stated preference techniques, CVM and CM. These two techniques are unique in that they are able to capture use as well as non-use values[7] of environmental goods and services. CVM elicits individual's preferences for hypothetical goods or services by asking direct willing to pay (WTP)[8] or accept (WTA)[9] questions (Asafu-Adjaye & Dzator, 2003).

[7] Non-use values refer to the value that a good or service provides in the absence of its current use.
[8] Willingness to pay is the price an individual would be willing to pay to avoid the loss of or gain more of an environmental good or service.

Depending on the design, CVM can be categorised as either open-ended[10], bidding game[11], payment card[12] or dichotomous choice[13] (Bateman, Carson, Day, Hanemann, Hanley, Hett, Lee, Loomes, Mourato, Ozdemiroglu, Pearce, Sugden, & Swanson, 2002). Once the WTP or WTA values are determined for each individual, a limited dependent parametric model (usually the logit model) can be applied to estimate preference functions (du Preez, Menzies, Sale and Hosking, 2012). These functions can be used to find expected WTP or WTA estimates. For a simple dichotomous choice case, where the WTP or WTA questions are in the form of "yes"/ "no" to a Rand amount for an increase/decrease in an environmental good or service, the probability that the respondent will choose "yes" is given by the logit model (du Preez *et al*., 2012):

$$Prob(Yes) = 1/(1 + e^{-\boldsymbol{\beta X}}) \quad (2.7)$$

where $\boldsymbol{\beta X} = \beta_0 + \beta_i X_i$ where $i = 1, \dots, k$ and X_i contains both attitudinal and socio economic variables with at least one X_i as a monetary variable. The $\boldsymbol{\beta}$'s are the parameters to be estimated and the $X_i's$ are the Rand amounts willing to be paid/accepted by each household. Attitudinal and socio-economic variables can also be included in the estimation. A median WTA/WTP can be calculated with the following formula (Cameron, 1987; du Preez *et al*., 2012):

$$Median\, WTA/P \ = exp^{(\frac{\beta_0}{\beta_R})} \quad (2.8)$$

where β_0 is the sum of the estimated constant and the product of the explanatory variables multiplied by their respective medians and β_R is the coefficient of the monetary (Rand) value offered to the individuals.

Critics argue that CVM lacks validity because the WTA estimates differ from the WTP estimates for the same good under consideration (Asafu-Adjaye & Dzator, 2003). A further weakness of CVM is that it often includes an 'embedding' error (Venkatachalam, 2004). There is disparity in WTA/WTP values for the same good if the good is valued on its own or as a more inclusive package (Venkatachalam, 2004). Another problem often encountered with this method is that a

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[9] Willingness to accept in this instance is the price and individual would be willing to accept in compensation for the loss of or the gain of an environmental good or service.

[10] Individuals are required to state their maximum WTP/A amounts

[11] Individuals WTP/A amounts are elicited by increasing the amounts until unwillingness to pay/accept is reached.

[12] An individual is presented with different amounts. The individual identifies the preferred amount.

[13] Individuals are provided with an amount. The individual can either accept or reject the amount given.

large sample size is required because a limited amount of information is gathered from each respondent (Kjaer, 2005). It is also very difficult to design an elicitation bid question within a CVM framework that is not vulnerable to strategic bias and reflective of the budget constraint. It is for these reasons that CVM has lost favour with some researchers relative to CM, an approach which has less of these associated problems (Kjaer, 2005). As with CVM, CM can determine all forms of value including non-use values (Hanley *et al.*, 2001) but it is also vulnerable to strategic bias (but less so).

2.3.4 Choice modelling methodology

Choice modelling is a stated preference survey technique similar to that of CVM. CM differs from CVM in that an individual's preferences for a good or service are estimated by examining the trade-offs the respondents make between hypothetical levels of attributes making up a good or service, as opposed to direct WTP or WTA questions related to the good or service (Davies *et al.*, 2000).

Three methods are grouped under the term "choice modelling": DCEs, contingent ranking and contingent rating. All three techniques, under the right assumptions, are consistent with welfare economic theory and all share the same design of choice alternatives (Kjaer, 2005).

A DCE, known in marketing as conjoint-analysis, requires that the respondents choose one alternative out of a given set of alternatives (Kjaer, 2005). The data is said to be weakly ordered because only information on the chosen alternative is recorded (Kjaer, 2005).

Contingent ranking requires that the respondents rank the alternatives and therefore is preference ordered. This method results in more information than a DCE. However, it is more cognitively demanding[14] on the respondents, which can lead to poor quality results.

Contingent rating is similar to contingent ranking, with the exception that the respondents are able to indicate ties (rank two or more alternatives as equal). DCE methodology is the simplest method of the three and is the least cognitively burdensome for the respondents. From DCE analysis, four types of information can be inferred (Hanley, Wright & Adamowicz, 1998; Davies *et al.*, 2000):

[14] The complexity of the tasks and difficulty associated with indicating preferences.

- Which attributes significantly affect choice.
- The order of importance of the attributes to the individuals.
- The MWTP/A for the increase/decrease in a significant attribute.
- The WTP/A for a package that simultaneously changes the levels of significant attributes.

There are five stages required to perform a DCE exercise. The first stage involves the selection of the attributes of the good to be valued. A monetary measure is usually included as one of the attributes. The second stage is the assignment of levels to the selected attributes. These levels are required to be feasible, realistic and non-linearly spaced (Hanley *et al.*, 2001). The levels should also include all options relevant to the respondents' preferences. Literature reviews, focus groups and pilot studies are used to determine the attributes and the levels (stages 1 and 2). The third stage is the experimental design stage. This stage uses statistical design theory to combine the levels of the attributes into a number of choice options or profiles that will be presented to the respondents. The fourth stage involves the construction of the choice sets. These choice sets can be presented individually or in groups. The last stage is the estimation procedure. Ordinary least squares (OLS) regression or Maximum likelihood procedure can be used to determine WTP or WTA compensation figures. As the issue primarily being one of compensation, a WTA compensation for undermining the environmental status quo was selected in preference to a WTP to avoid the change in environmental attractiveness.

Due to its comparative advantages over the feasible alternatives, the DCE methodology was selected for application in this study.

2.4 Theoretical framework

Choice experiment methodology is based on two fundamental theories, random utility theory and Lancaster's theory of value. The basic assumption of random utility theory (RUT) is that all decision makers are utility maximisers that will choose the alternative that maximises their overall utility (Shen, 2005). Lancaster's theory of value proposes that all goods be broken up into attributes and that the utility that a decision maker derives from the consumption of the good is not determined by the consumption of the good as a whole, but the attributes that make up the good (Lancaster, 1966). Because the utility of any decision maker cannot be observed by an analyst, it is assumed that a decision maker k's utility for alternative i has an observable, deterministic component and an unobservable or random error component:

$$U_{ki} = V_{ki} + \varepsilon_{ki} \quad (2.9)$$

where U_{ki} represents the overall utility of decision maker k for a specific choice alternative i, V_{ki} represents the observable utility component and ε_{ki} represents the unobservable or stochastic utility component (Hensher, Rose & Greene, 2005).

The deterministic utility component is assumed to be linear:

$$V_{ki} = ASC_i + \beta_{1ki} f(X_{1ki}) + \beta_{2ki} f(X_{2ki}) + \beta_{3ki} f(X_{3ki}) + \cdots + \beta_{nki} f(X_{nki}) \quad (2.10)$$

where β_{1ki} is the parameter associated with X_1 and alternative i and ASC_i is the alternative specific constant[15] associated with the i^{th} alternative. The ASC is a constant that takes up the unobserved variation not explained by the attributes or the socio-economic variables (a vector of zero's with the value one each time alternative i is chosen) (Hensher *et al.*, 2005).

From Equation 2.9 and Equation 2.10 the utility associated with alternative i as evaluated by decision maker k can be written in matrix notation:

$$U_{ki} = \boldsymbol{ASC}_i + \sum_{n=1}^{N} \boldsymbol{\beta}_{nki} \boldsymbol{X}_{nki} + \boldsymbol{\varepsilon}_{ki} \quad (2.11)$$

In order to model individual choices with only the available or observed data, an analyst has to determine the probabilities associated with each alternative presented to the individual. If the individual faces a particular set of alternatives $i = 1, \dots, j, \dots, I$ then using the individual decision maker's rule, the individual will evaluate each alternative $U_1, U_2, \dots, U_I$ and select the option that yields the greatest utility. From RUT, the analyst would assume that the probability of the individual selecting alternative i is equal to the probability that the utility of alternative i is greater than or equal to the utility of alternative j (given $i \neq j$) after comparing all alternatives in the choice set of $i = 1, \dots, j, \dots, I$ alternatives (Hensher *et al.*, 2005)*:*

$$Prob_k(chooses\ i) = Prob\left(U_{ki} > U_{kj}\right) \forall\ i \neq j \quad (2.12)$$

which is the same as:

[15] Alternative specific constants (ASCs) are vectors of independent variables that take the value 1 for one alternative and zero for others (Tardiff, 1978). Including ASCs enables the analyst to control for correlations between observed and unobserved attributes (Klaiber & von Haefen, 2008). It is not necessary to include ASCs with models that have random coefficients, that is for unlabelled experiments (MacFadden & Train, 2000).

$$Prob_{ki} = Prob[(V_{ki} + \varepsilon_{ki}) \geq (V_{kj} + \varepsilon_{kj})] \ \forall \ i \neq j \qquad (2.13)$$

Equation 2.13 can be rearranged so that the unobserved components are separated from the observed components:

$$Prob_{ki} = Prob[(\varepsilon_{kj} - \varepsilon_{ki}) \leq (V_{ki} - V_{kj})] \ \forall \ i \neq j \qquad (2.14)$$

In order to estimate this probability with a conditional logit (CL) model[16] some assumptions are made about the distribution of the error component. The unobserved components are assumed to be independent and identically distributed (IID) with an extreme value (Gumbel) distribution. This assumption allows the analyst to estimate the probability of choosing alternative i over alternative j (McFadden, 1974; Hanley *et al.*, 2001; McFadden, 2001)*:*

$$Prob(U_{ki} > U_{kj}) = \frac{e^{(\mu V_{ki})}}{\sum_{j=1}^{J} e^{(\mu V_{kj})}} \ \forall \ i \neq j \qquad (2.15)$$

Equation 2.15 postulates that the probability of an individual selecting alternative i over alternative j is equal to the ratio of the exponent of the observed utility of i to the sum of the exponent of all the observed utilities of the other j alternatives (Bergmann *et al.*, 2006). As the deterministic component of utility is assumed to be linear in parameters, Equation 2.15 can be written as:

$$Prob(U_{ki} > U_{kj}) = \frac{e^{(\mu \boldsymbol{\beta}_n X_{ki})}}{\sum_{n=1}^{N} e^{(\mu \boldsymbol{\beta}_n X_{kj})}} \ \forall \ i \neq j \qquad (2.16)$$

From Equation 2.16 above X_{ki} are the explanatory variables of V_{ki}, which would include the ASCs, the attributes associated with alternative i and the socio-economic aspects of decision maker k. The log-likelihood function of Equation 2.16 is as follows:

$$LL = \sum_{n=1}^{N} \sum_{i=1}^{I} y_{ki} log \left[\frac{e^{(\mu \boldsymbol{\beta}_n X_{ki})}}{\sum_{n=1}^{N} e^{(\mu \boldsymbol{\beta}_n X_{kj})}} \right] \qquad (2.17)$$

where y_{ki} is an indicator variable that equals one if decision maker k chooses alternative i and zero otherwise (Hanley *et al.*, 2001). The estimates for the coefficients ($\boldsymbol{\beta}_n$) of the model can be calculated by maximising the log-likelihood function.

[16] The conditional logit (CL) is similar to the multinomial logit model (MNL) except that the CL model focuses on the set of alternatives as opposed to the individual and the explanatory variables are characteristics of those alternatives rather than characteristics of the individuals (Hoffman & Duncan, 1988).

The scale parameter μ in Equations 2.15 and 2.16 is inversely proportional to the standard deviation of the error distribution and confound the direct determination of the β_n parameters. It is typically normalised to 1 for the CL model (Hanley *et al.*, 2001; Shen, 2005). An implication of this specification is that the choice sets must conform to the restrictive assumption of independence from irrelevant alternatives (IIA) (Hanley *et al.*, 2001). This assumption requires that the ratio of choice probabilities must be independent of the introduction or the removal of other alternatives in the choice set (Hanley *et al.*, 2001). As a simple example, in a choice set containing three options for transportation: car, airplane and train, the IIA assumption postulates that the probability of choosing car over train is the same whether or not airplane is included in the choice set or not. One can test for the violation of this assumption using the test derived by Hausman and McFadden (1984)[17] - henceforth referred to as the Hausman test.

One of the problems often encountered with CL models is that the IIA assumption is often violated because these models do not account for heterogeneity in choice preference across respondents or correlation across observations (McFadden & Train, 2000; Glasgow, 2001; Hensher *et al.,* 2005). The nested logit (NL)[18] model was introduced to accommodate the violations of this assumption. The NL model allows the variation of the random components to differ across alternatives (relaxing the IID assumption[19]). This allows pairs of alternatives to be correlated. The NL model clusters the alternatives that are related into subgroups where the random components within the subgroup are correlated and the random components of alternatives that are not in the subgroup are uncorrelated. As an illustration of this concept, the choice making decision for a NL model of a respondent is shown in Figure 2.4.

[17] The test is conducted by comparing the unrestricted model, synonymous with the null hypothesis, where all alternatives are included, with the alternative hypothesis using the restricted number of alternatives (Hensher, Rose & Greene, 2005). The test statistic is defined in the equation below (Hensher *et al.*, 2005).

$Q = [p_u - p_r]'[VC_r - VC_u]^{-1}[p_u - p_r]$

Where p_u and p_r are the column vectors of parameter estimates for the unrestricted and restricted models and VC_u and VC_r are the variance-covariance matrix for the unrestricted and restricted models. The Q statistic is distributed Chi-squared with the number of parameters estimated in either model as the degrees of freedom (Hensher *et al.*, 2005).

[18] Also referred to as the hierarchical model or the tree extreme logit (Hensher *et al.*, 2005)

[19] The IID assumption has an equivalent behavioural association with the IIA assumption (Hensher *et al.*, 2005)

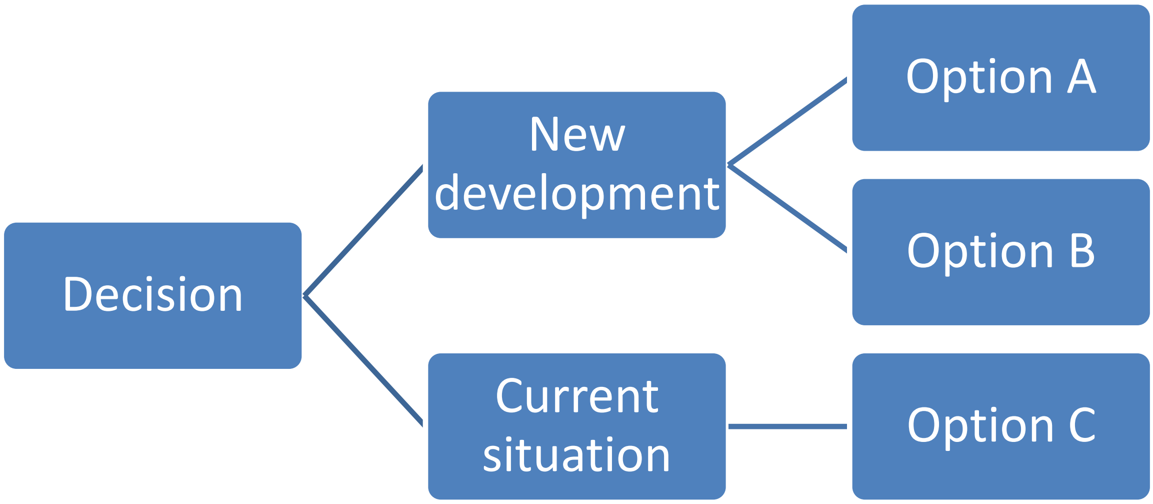

Figure 2.4: The choice scenario for a respondent for a NL model

Adapted from: Baskaran, Cullen & Wratten (2009)

In its simplest form, the ASC explains the utility associated with the first branch (the decision between a new development and the current situation). The choices for the second branch (alternatives A and B) are explained by the ASC_A (ASC for option A) and the levels of the attributes. The utility equations for the NL model illustrated in Figure 2.4 are as follows (Baskaran *et al.*, 2009):

First Branch:

$$V_{ij}(New\ Development) = ASC \quad (2.18)$$

Second branch:

$$V_{ki}(Option\ A) = ASC_A + \sum_k^N \boldsymbol{\beta}_j \mathbf{X}_{kij} \quad (2.19)$$

$$V_{ki}(Option\ B) = \sum_k^N \boldsymbol{\beta}_j \mathbf{X}_{kij} \quad (2.20)$$

$$V_{ki}(Option\ C) = \sum_k^N \boldsymbol{\beta}_j \mathbf{X}_{kij} \equiv 0 \quad (2.21)$$

In the two level NL model described above, the probability of a decision maker k choosing alternative i in the subgroup q $\left(Prob_{iq}\right)$, in the second branch,

$$Prob_{kiq} = Prob_k(i|q)Prob_k(q) \quad (2.22)$$

where $Prob_k(i|q)$ is the probability of decision maker k choosing the i^{th} alternative, conditional on the qth subgroup being chosen, and $Prob_k(q)$ is the probability that the decision maker will choose the q^{th} subgroup. These probabilities can be derived as follows (Kling & Thomson, 1996; Baskaran *et al.*, 2009):

$$Prob_k(i|q) = \frac{e^{\frac{V_{kiq}}{\gamma_q}}}{e^{I_q}} \quad (2.23)$$

$$Prob_k(q) = \frac{e^{\gamma_q I_q}}{\sum_{j=1}^{Q} e^{\gamma_j I_j}} \quad (2.24)$$

where $I_q = log\left[\sum_{r=1}^{R_q} e^{\frac{V_{krq}}{\gamma_q}}\right]$ is the inclusive value (*IV*) and γ_q is the coefficient of the *IV* parameter, which measures the degree of substitution between the various subgroups, Q is the number of subgroups and R is the number of alternatives in subgroup q (Baskaran *et al.,* 2009).

A possible reason for the violation of the IIA assumption is that the preferences of respondents are heterogeneous, that is respondents with similar socio-economic characteristics have specific preferences. In order to incorporate taste variation among the respondents, a random parameters logit model (RPL)[20] can be used for estimation. This model assumes that the preferences of the respondents are distributed by some known statistical distribution $\eta_k \sim f(\eta_k|\bar{\eta}, \sigma_\beta)$. The unobserved component of utility is $e_{ki} = \boldsymbol{\eta}_k \boldsymbol{z}_{ki} + \boldsymbol{\varepsilon}_{ki}$, where $\boldsymbol{\varepsilon}_{ki}$ is assumed to be IID Type I extreme value, $\boldsymbol{z}_{ki}$ is a vector of individual specific characteristics and $\boldsymbol{\eta}_k$ is a vector of random terms that varies across individuals k according to a known distribution $f(\eta_k|\bar{\eta}, \sigma_\eta)$ (Glasgow, 2001). Estimation of the variance σ_β provides an indication of heterogeneity in the model (Glasgow, 2001). With the new assumptions on the random component, the utility that individual k derives from choosing alternative i given in Equation 2.9 can be reformulated:

$$U_{ki} = \boldsymbol{\beta X}_{ki} + \boldsymbol{\eta}_k \boldsymbol{z}_{ki} + \boldsymbol{\varepsilon}_{ki} \quad (2.25)$$

If there is preference homogeneity $\boldsymbol{\eta}_k = 0$ and $\boldsymbol{\eta}_k \boldsymbol{z}_{ki} = 0$. The latter is a specific case – in fact, the CL model specification. The random component of utility is assumed to be IID extreme value Type 1. The unconditional choice probability that decision maker k will choose alternative i becomes:

[20] Also referred to as; a mixed logit model, a mixed multinomial logit model and a hybrid logit model.

$$Prob_{ki}(\eta) = \int L_{ki}(\eta) f(\eta|\bar{\eta}, \sigma_\eta) \partial(\eta) \quad (2.26)$$

and the unconditional probability of respondent k choosing alternative i (Equation 2.25) can be reformulated as*:*

$$Prob(U_{ki}) = \int \left[\frac{e^{\boldsymbol{\beta X}+\boldsymbol{\eta X}}}{\sum_{n=1}^{N} e^{(\boldsymbol{\beta X}+\boldsymbol{\eta X})}}\right] f(\eta_k|\bar{\eta}, \sigma_\eta)\partial\eta \quad (2.27)$$

where X contains all attributes and socio-economic characteristics of the individuals. Equation 2.27 cannot be estimated with standard maximum likelihood theory as the integral does not have a closed form. For this reason, a simulated maximum likelihood technique must be used (Glasgow, 1999). This technique involves drawing a value for η_k out of its distribution with given $\bar{\eta}$ and σ_η. The logit probability (the CL model in Equation 2.16) of each draw is calculated. This step is repeated several times, and the mean of the draws taken as the unbiased estimator of the unconditional choice probability of respondent k choosing alternative i. The simulated probability choice function is:

$$SimProb(U_{ki}) = \frac{1}{D}\sum_D log\left[\frac{e^{(\boldsymbol{\beta}_n \boldsymbol{X}_{ki}+\boldsymbol{\eta}_D \boldsymbol{X})}}{\sum_{n=1}^{N} e^{(\boldsymbol{\beta}_n \boldsymbol{X}_{kj}+\boldsymbol{\eta}_D \boldsymbol{X})}}\right] \quad (2.28)$$

where D is the number of draws of D and η_D is the D^{th} draw of η. The resulting choice probabilities are those that maximise Equation 2.28. The underlying utility function of respondent k is:

$$U_{ki} = V_{ki} + \varepsilon_{ki} = ASC_i + \sum_n \boldsymbol{\beta}_{nki}\boldsymbol{X}_{nki} + \sum_n \boldsymbol{\eta}_{nk}\boldsymbol{X}_{nki} + \boldsymbol{\varepsilon}_{ki} \quad (2.29)$$

where the k is the respondent $k(1, \dots, K)$ and i is the alternative option selected *(i = Option A, Option B, Option C…)*, n is the number of attributes $(1, \dots, N)$ and $\boldsymbol{X}_{nki}$ is the vector of explanatory variables including the attributes of the alternatives, socio-economic characteristics of the respondents, decision context and choice task in choice set (Hensher *et al.*, 2005). The non-random component of utility V is assumed to be a function of n choice-specific attributes $\boldsymbol{X}_{nki}$ with parameters $\boldsymbol{\beta}_{nki}$. The coefficient vector $\boldsymbol{\eta}_{nk}$ varies across the population with density $f(\eta_k|\bar{\eta}, \sigma_\eta)$, where $\bar{\eta}$ is the vector of actual parameters of taste variation (Baskaran *et al.*, 2009).

Using a RPL model is advantageous in that the model eliminates the bias due to heteroscedastic error terms (Glasgow, 1999). Additionally, the model allows for a statistical test of heterogeneity of respondent preferences for attributes by assessing the significance of the standard deviation of the η_{nk} estimates (Mazzanti, 2001). A significant standard deviation of the $\boldsymbol{\eta}_{nk}$ parameter would indicate heterogeneity in the preferences for an attribute (Mazzanti, 2001).

The RPL model estimates the amount of preference heterogeneity through the standard deviations of the parameters and the interaction between the mean parameter estimates and all other attributes of alternatives and socio-economic descriptors (Hensher *et al.*, 2005). A further advantage of using RPL models is that these models are accommodating of correlation of alternatives and across choice sets (Hensher *et al.*, 2005).

In applying an RPL it is necessary to determine the appropriate set of random parameters. This application can be achieved using the Lagrange Multiplier, or by assuming all parameters are random, and testing the significance of the standard deviations of the parameters using an asymptotic *t*-test or the log-likelihood ratio test (Hensher *et al.*, 2005).

One of the main problems with RPL models is the determination of the distributions of the parameters. There are four popular distributions that are typically used as approximations to the real parameters distribution: log-normal, normal, uniform and triangular (Hensher *et al.*, 2005). The choice of distribution is essentially arbitrary, but can be approximated if the "empirical truth" lies within the chosen distributions domain (Hensher *et al.*, 2005). The normal distribution is often selected because it is symmetrical about the mean and allows for a change in sign in its range (Hensher *et al.*, 2005).

2.5 The application of discrete choice experiment methodology

There are several steps to follow in order to apply choice experiment methodology (Louviere *et al.*, 2000; Hanley *et al.,* 2001 and Shen, 2005). These steps are summarised in Table 2.1.

Table 2.1: Summary of the choice experiment procedure

Steps			Components of each step
1.	Survey design	Choice set construction	Selection of attributes
			Assignment of levels
			Experimental Design
		Design considerations	Orthogonality
			Balanced and unbalanced designs
			Labelled and unlabelled experiments
			Dummy and effects coding
			Including a status quo option
		Survey development	Question framing
2.	Administration of surveys	Determination of sample size	Probabilistic sampling methods
			Non-probabilistic sampling methods
			Rule of thumb approaches
		Data collection	Survey mode
			Sampling strategy
			Survey technique
3.	Model Estimation		Choice model selection
			Interpretation of results
4.	Validity testing		Content Validity
			Construction and consistency

Source: Adapted from Hanley et al. (2001)

2.5.1 Choice set construction

The first step in applying a choice experiment is to construct the vehicle through which to obtain decision makers' preferences, a questionnaire to administer as part of a survey. The construction of this questionnaire is a critical part of the application of choice experiment methodology. The analytical results are dependent upon its relevance and accuracy. The design of the choice experiment questionnaire requires choice sets to be defined, which in turn involves the selection of appropriate attributes, the assignment of levels to each attribute and an experimental design to combine the attributes and levels into choice cards that will be presented to the respondents. The final phase of the survey construction is the presentation and decision on the choice of model to measure the preferences.

2.5.1.1 Selection of the choice attributes

The first step to creating choice sets involves the selection of the attributes to include in the choice experiment. These attributes must be important to the respondent group and should represent the characteristics of the relevant good appropriately (Shen, 2005). The number of attributes to include in the choice sets should be finite and as few as possible, without omitting important attributes that will affect the validity of the results. Literature reviews and focus groups are used to identify the attributes to include in the choice experiment (Hanley *et al.*, 2001).

There are two types of attributes, subjective and objective. Subjective attributes are usually qualitative attributes. These attributes can be assigned levels based on an ordinal scale. Proper descriptions of each level must be made to help the respondents understand. Subjective attributes are often difficult to define as the attributes do not have specified quantitative amounts. An example of a subjective attribute is conservation status. Objective attributes are objectively defined and are usually quantitative in nature. Distance and monetary measures are examples of objective attributes. A monetary attribute is usually incorporated into the choice experiment in order to allow for the estimation of WTP/A compensation.

2.5.1.2 Assignment of levels

Once the attributes are identified, levels expressing a range of potential variation in the attributes must be assigned (Louviere, Flynn & Carson, 2010). Literature reviews, focus groups and expert consultations are all processes that can be used to determine the levels for each attribute.

The range and the measurement of the attributes are important considerations when assigning the levels (Shen, 2005). The range of the levels can be determined by the range currently experienced by the respondents. One way in which the levels of the attributes can be assigned is by identifying the maximum and minimum values of the range. This way the respondents are more likely to agree on the magnitudes of the levels. The levels of the attributes must be realistic and acceptable to the respondents. Levels of qualitative attributes can be presented as an ordinal range (small, medium and large) or as levels representing realistic situations, such as whether or not there is a toll on the road (toll on the road, no toll on the road). These variables will need to be dummy or effects coded.

An important consideration for inclusion in the levels of the attributes is a status-quo or no-choice option. The inclusion of this level makes the choice scenarios realistic and improves the interpretation of the estimated welfare measures.

(a) Dummy and effects coding

If there are qualitative attributes to be included in the choice experiment, dummy or effects coding can be used to incorporate these attributes. For each qualitative attribute to be included in the choice set, a number of new variables are created, equivalent in number to one less than the number of levels of the qualitative attribute (Hensher *et al.*, 2005). For example, an attribute for colour with three levels, red, blue and green, would result in two new variables that could be dummy coded, as shown in Table 2.2 below.

Table 2.2: Example of dummy coding

New Variable / **Attribute level**	***Colour1***	***Colour2***
Red	1	0
Blue	0	1
Green	0	0

The attribute for colour is associated with the two new variables: *Colour1* and *Colour2* (See Table 2.2). The two new variables would be associated with $f(X_1)$ and $f(X_2)$, each having an associated coefficient (β). For alternative i, the utility associated with the colour red is given by (Hensher *et al.*, 2005):

$$V_i = \beta_{0i} + \beta_{1i} \times 1 + \beta_{2i} \times 0 = \beta_{0i} + \beta_{1i} \quad (2.30)$$

and the utility associated with the colour blue is:

$$V_i = \beta_{0i} + \beta_{1i} \times 0 + \beta_{2i} \times 1 = \beta_{0i} + \beta_{2i} \quad (2.31)$$

and for the colour green:

$$V_i = \beta_{0i} + \beta_{1i} \times 0 + \beta_{2i} \times 0 = \beta_{0i} \quad (2.32)$$

This specification yields different values of utility for each level of a qualitative variable. One problem with dummy coding qualitative variables, as shown above is that the utility of the base level (green) is confounded with alternative $i's$ *grand mean* (Hensher *et al.*, 2005). Effects coding qualitative attributes offer a promising solution to this problem as it provides the same non-linear effect estimation as dummy coding without confounding the base level with the *grand mean* (Hensher *et al.*, 2005).

The effects coding for the same example used above is shown in Table 2.3.

Table 2.3: Example of effects coding

New Variable / Attribute level	*Colour1*	*Colour2*
Red	1	0
Blue	0	1
Green	-1	-1

The effects coding in Table 2.3 is almost identical to the dummy coding in Table 2.2. The difference is in the coding for the base level. The estimate of utility for the base level (green) becomes:

$$V_i = \beta_{0i} + \beta_{1i} \times (-1) + \beta_{2i} \times (-1) = \beta_{0i} - \beta_{1i} - \beta_{2i} \quad (2.33)$$

The utility of the base level is no longer confounded with the *grand mean,* but may be estimated by $\beta_{0i} - \beta_{1i} - \beta_{2i}$. For this reason effects coding is a preferred measure of the non-linear effects in the attribute levels.

(b) Inclusion of a status quo option

The inclusion of a status quo option can have a predictable and significant effect on decision making (Samuelson & Zeckhauser, 1988). However, the status quo may introduce biases and can provide an easy option to avoid the choice task (Scarpa, Ferrini & Willis, 2005). The status quo bias may be accounted for by including an ASC (1 if the status quo is selected, 0 otherwise) into the model estimation procedure. Alternatively, a NL model specification can be used to account for the status quo bias.

2.5.1.3 Experimental design

Once the attributes and levels have been specified, the next step is to create combinations of the levels and attributes in such a way that a variety of different hypothetical scenarios arise. The most common statistical designs employed are complete factorial designs and fractional factorial designs. The experimental design is analysed as a matrix with the columns as the attributes and levels and the rows as the treatment combinations.

(a) Complete factorial designs

A complete factorial design is the combination of all attributes and levels. This design allows for the assessment of both the main effects and all interaction effects of the attributes on the choices. A main effect is a singular effect, such as the cost effect, or the effect of location (Kuhfeld, 2010). The interaction effects involve two or more factors, such as location by cost interaction (Kuhfeld, 2010). A main effects design only addresses the independent effects of each attribute on the response variable (choice) and does not include possible interaction effects between the attributes (Hensher *et al.*, 2005). A main effects only design explains 70-90% of the variation in choice (Louviere *et al.,* 2000). Interactions are included in the model when the preference for the level of one attribute in the model is dependent upon the level of another attribute (Hensher *et al.*, 2005).

Complete factorial designs are often infeasible, as they can result in a large number of choice cards. For example, a complete factorial design of 5 attributes at 3 levels results in 3^5 = 243 choice cards. This large number of choice cards would require a large sample of respondents, and/or a large number of choice sets to be presented to each respondent. The latter would be overly burdensome on the respondents and the former would increase the costs of the survey.

(b) Fractional factorial design

A fractional factorial design limits the number of scenario combinations by fractioning the design. By using a factorisation factor of 3 the number of alternative combinations in the example above, can be reduced from 243 to 3^{5-3} = 9 alternative combinations. Fractioning the design reduces the estimation power of the experiment because it removes some or all of the interactions between the attributes. If some higher order interaction effects are also included in the fractional factorial design, the number of choice sets has to increase, increasing the difficulty of the choice tasks. In deciding which design to use the analyst needs to consider the trade-off between the cognitive burden placed on the respondents and the analytical sophistication of the design (Shen, 2005).

A fractional factorial experimental design can be generated in statistical software packages like SPSS, R and SAS. The rows of the experimental design are combinations of attribute levels. Each row represents a unique alternative and is referred to as a choice card. The choice cards are grouped into choice sets and presented to the decision makers in pairs or groups. Presentation of choice sets may be in any format, as long as the choice sets relay the relevant information and provide the means for respondents to make a choice. The complexity of the choice task increases as the number of choice sets presented to each respondent increases (Bateman *et al.*, 2002). The complexity of the choice task directly influences the results through respondent fatigue or disinterest. For this reason, it is important not to include too many choice sets.

The experimental design must be randomised before the design can be used. Randomising the design involves ordering and assigning the attribute levels. Research on the randomisation of the choice sets is still underway (Hensher *et al.*, 2005). Researchers have tried to randomise the choice sets by presenting two or more respondents with the same block of choice sets and randomising the order of the attributes and levels. Randomisation of the choice sets serves to improve the compliance of the model with the assumptions defined.

2.5.2 Design considerations

Some considerations need to be made when designing a choice experiment, such as design orthogonality, whether the design is balanced and whether to use an unlabelled or a labelled experiment.

2.5.2.1 Balanced and unbalanced designs

An important, but not an essential aspect of the experimental design, is whether the design is balanced or not. For each attribute, if all the levels of that attribute within the experimental design are represented equally the design is said to be balanced (Hensher *et al.*, 2005). For example, if an attribute has two levels (0 and 1) and the level 0 appears two times more than level 1, the design is unbalanced. It is desirable to have a balanced orthogonal design because unbalanced designs create false significance of the unbalanced attributes (Wittink & Nutter, 1982; Wittink, Krishnamurti & Reibstein, 1990; Hensher *et al.*, 2005).

2.5.2.2 Orthogonality

Orthogonality is a mathematical constraint requiring all attributes be statistically independent of one another (Hensher *et al.*, 2005). It implies that the attributes are uncorrelated. Although the respondents may perceive the attributes as correlated, it is important that the defined attributes be statistically independent (Hensher *et al.*, 2005). The rows included in the experiment determine the column orthogonality of the experiment, so the removal of any of the rows will affect the orthogonality (Hensher *et al.*, 2005). Non-orthogonal designs confound the determination of the contribution of each attribute and can result in incorrect parameter estimations (Hensher *et al.*, 2005). If the orthogonality of the design is compromised, the attributes of the design will be correlated. Once multicollinearity is detected, there is very little the analyst can do. For this reason, the test for multicollinearity should be conducted prior to model estimation.

The data can be tested for multicollinearity by the method of auxiliary regressions (Hensher *et al.*, 2005) and Klein's Rule (Klein, 1962; Hensher *et al.*, 2005). The auxiliary regression test is carried out by regressing each attribute in the design against the remaining attributes (including a constant term). The R^2 for each auxiliary regression is calculated using Equation 2.34.

$$R_i{}^2 = \frac{R_{X_i}{}^2/(k-2)}{(1-R_{X_i}{}^2)/(n-k+1)} \qquad (2.34)$$

where $R_{X_i}{}^2$ is the R^2 of the regression of the attribute X_i on the remaining attributes, k is the number of parameters included in the regression and n is the sample size (Hensher *et al.,* 2005).

Each $R_i{}^2$ is compared to a critical F-statistic with degrees of freedom $k-2$ and $n-k+1$. If the $R_i{}^2$ value exceeds the critical value, the attribute under consideration is correlated with the remaining attributes (Hensher *et al.*, 2005).

Klein's rule compares the auxiliary $R_{X_i}{}^2$ values to the $R_X{}^2$ value of a regression of the dependent variable (choice) on the attributes of the model (Klein, 1962). If any of the auxiliary $R_X{}^2$ values exceeds the R^2 of the regression of choice, the design has significant multicollinearity (Hensher *et al.*, 2005).

Full factorial designs are inherently orthogonal, but only some fractional factorial designs are orthogonal. For this reason it is only necessary to test for orthogonality of the design if a fractional factorial design is utilised.

An array that is orthogonal but not balanced is not necessarily an efficient design and may not be optimal. The efficiency of a $(N \times p)$ design can be quantified based on the information matrix[21] $(\boldsymbol{X}'\boldsymbol{X})$ (Kuhfeld, 2010)**.** The diagonal elements of the inverse of the information matrix $(\boldsymbol{X}'\boldsymbol{X})^{-1}$ are the variances of the parameter estimates (Kuhfeld, 2010). The eigenvalues of $(\boldsymbol{X}'\boldsymbol{X})^{-1}$ determine the "size" of the efficiency of the design. Two methods are used to quantify the size of the efficiency: A-efficiency which determines the arithmetic mean of the eigenvalues $(trace(\boldsymbol{X}'\boldsymbol{X})^{-1})/p)$, and D-efficiency which determines the geometric mean $(det(\boldsymbol{X}'\boldsymbol{X})^{-1})^{1/p}$ of the eigenvalues[22] (Kuhfeld, 2010). These measures are scaled[23] to a range of 0 to 100. D-efficiency is preferred to A-efficiency because it is easier to compute and the ratio of two D-efficiencies is the same for different coding schemes (Kuhfeld, 2010). A D-efficiency value of 0 means that one or more parameters of the design are not estimable (Kuhfeld, 2010). A D-efficiency of 100 implies that the design is perfectly balanced and orthogonal and values between 0 and 100 mean that all parameters can be estimated but not with optimal precision (Kuhfeld, 2010).

2.5.2.3 Labelled and unlabelled experiment

The choice sets offered can be: labelled or unlabelled. An unlabelled experiment is an experiment where the alternatives presented are unlabelled and therefore uninformative to the decision maker (Hensher *et al.*, 2005). In an unlabelled experiment the choice sets are purely generic, in that the labels of the attributes do not provide any information beyond that which is provided by the attributes (Louviere *et al.*, 2000). With an unlabelled experiment the alternatives are differentiated purely by the attribute levels. A labelled experiment is alternative specific where a label conveys attribute level and other information about the alternatives to the decision maker (Louviere *et al.*, 2000). An example of an unlabelled experiment is given in Table 2.4 and an example of a labelled experiment in Table 2.5.

[21] In the context of DCEs, **X** represents the matrix of attributes and level combinations.
[22] The *trace* is the summation of the diagonal elements of a matrix and *det* is the determinant of the matrix.
[23] Scaling: $A - efficiency = 100 \times \frac{1}{N(trace(\boldsymbol{X}'\boldsymbol{X})^{-1})/p)}$ and $D - efficiency = 100 \times \frac{1}{N(det(\boldsymbol{X}'\boldsymbol{X})^{-1}))^{1/p}}$

Table 2.4: Unlabelled choice experiment for cell phone preferences

Attributes	Cell phone A	Cell phone B
Camera/ No camera Battery life Cost	Camera 48 hours R400	No Camera 72 hours R300

Table 2.5: Labelled choice experiment for cell phone preferences

Attributes	Smart phone	Ordinary cell phone
Camera/ No camera Battery life Cost	Camera 48 hours R400	No Camera 72 hours R300

Unlabelled experiments are more likely to produce attributes that satisfy the IID assumption because, in labelled experiments the label may be perceived as an attribute and/or be used to infer missing information and be correlated with the random component in the experiment (Louviere *et al.*, 2000). Labelled experiments also require an increase in the number of choice sets presented (Hensher *et al.,* 2005). Labelled experiments are best used when alternative specific parameters are required to be estimated.

It is possible to estimate utility functions for all alternatives with both labelled and unlabelled experiments. If the alternatives in the experiment are indefinable, the estimation of a utility function for each alternative is nonsensical.

2.5.3 Survey development

The design of the survey to assess respondent preferences typically includes an introductory section, a choice experiment section, a follow-up section to the choice experiment and a socio-demographic question section (Hasler, Lundhese, Martinsen, Neye & Schou, 2005; Lee, 2012).

The introductory question section includes information about the study and the environmental issue addressed by the study. The questions in this section should provide sufficient information to the respondents about the study and encourage the respondents to think critically about the topic (Lee, 2012). The introductory questions should be concise and to the point so as not to irritate or bore the respondents. The questions should be neutrally worded and clearly understandable to all respondents. Ambiguities result in confusion and misleading results.

The introductory questions precede the choice experiment so as to prepare the respondents for the choice scenarios and provide information and allow the respondents to consider the different aspects of the choice scenarios (Lee, 2012).

The choice experiment section of the survey should include an information section explaining the choice experiment and outlining the way in which to respond to the questions. The respondents should be informed about each attribute in the choice experiment and be made to understand that choices require trade-offs to be made in the levels of the attributes.

The follow-up questions are used to validate the respondents' comprehension of the survey and choice experiment and to assess possible biases in the choice responses (Lee, 2012). The validity of the survey is assessed through questions about ease of the survey, the preferences for a specific attribute in the choice sets and questions regarding the choice of the *status quo* option.

Socio-demographic questions are necessary inclusions in the survey as these questions provide information about the characteristics of the sample of respondents. These questions are personal and can make the respondents feel uncomfortable. For this reason these questions are typically placed at the end of the survey.

2.5.4 Administration of survey

The administration of the survey involves the determination of the sample size and the data collection process. Data collection includes the survey mode, sample frame and sample strategy to be employed.

2.5.4.1 Sample size and selection

There are two dominant sampling methods that can be employed to select a sample: probabilistic and non-probabilistic. A probabilistic method assumes all individuals in the population have the same probability of being selected to participate in the study. Non-probabilistic methods are subjective. The individuals included in the sample are selected at the discretion of the researcher (Bateman *et al.*, 2002). Both probabilistic and non-probabilistic approaches as well as rule of thumb approaches are commonly used to determine sample size in choice modelling applications (Hensher *et al.*, 2005).

(a) Probabilistic sampling methods

Simple random sampling, systematic and stratified random samples are all probabilistic sampling techniques (Louviere *et al.*, 2000; Hensher *et al.*, 2005). The simplest method to determine sample size is with simple random sampling. The sample size can be determined using the formula given by Equation 2.35 (Louviere *et al.*, 2000; Hensher *et al.*, 2005):

$$n \geq \left[\Phi^{-1}(1 - {}^{\alpha}/_{2})\right]^{2} \frac{1-p}{pa^{2}} \tag{2.35}$$

The sample size n is calculated by the level of accuracy of the estimated probabilities desired. The true percentage of the population is represented by p, α is the acceptable percentage of difference between the estimated probabilities and the true percentage of the population, q is the confidence interval of the estimation and Φ is the standard normal cumulative distribution function (CDF) (Shen, 2005). The formula for sample size is only applicable for simple random samples with independence between the choices (Shen, 2005).

(b) Non-Probabilistic sampling approaches

Convenience sampling, judgement sampling and quota sampling are all common non-probabilistic (and non-random) approaches to determine sample selection and size (Bateman *et al.*, 2002). These methods involve the researcher to select the number of respondents for inclusion in the study by convenience or by judgement as to how many respondents to include, or by ensuring that certain proportions (quotas) of each respondent group appear in the study (Bateman *et al.*, 2002).

(c) Rule of thumb approaches

Theoretical specifications of sample size are often disregarded in practice in favour of simpler approaches because budgetary constraints often take precedence over the theoretical specifications (Hensher *et al.*, 2005). Rule of thumb approaches have been developed for discrete choice analysis and are commonly determined by the minimum number of respondents required to estimate a “robust model” (Hensher *et al.*, 2005). For an unlabelled DCE, which only includes main effects, a sample size of at least 50 respondents with each respondent presented with 16 choice sets is acceptable (Hensher *et al.,* 2005; Lee, 2012). There are two other rule of thumb approaches that can be employed. The first ascertains that each alternative appears at least 30 times in the sample and the second involves presenting every choice set to a minimum of 50 respondents (Bennett & Adamowicz, 2001).

2.5.4.2 Data collection

The inclusion of specific respondent groups and the method of administering the surveys are decided before the survey is administered. These decisions depend on the survey mode, sample frame and sampling strategy used. The survey mode determines how the respondents will answer the survey question, the sample frame determines who the target population is and the sample strategy is the way in which the respondents are selected for inclusion in the survey.

(a) Survey mode

How the surveys are administered depends entirely on the type of respondents, the complexity of the survey, the objectives of the study and the budgetary constraints (Kragt & Bennett, 2008). In administering the survey the analyst should decide whether the surveys will be answered by the respondent (self-administration) or by an interviewer. Some self-administration survey modes include mail surveys, web-based surveys or computer-based surveys. Mail surveys and web-based surveys are easily administered, but suffer from low response rates and high error rates in the responses. Although web-based surveys have the advantage of being flexible, this type of survey is limited by targeting only a sub-group of the population (those who have access to computers and knowledge on how to use them). Two interviewer survey modes are telephonic and personal interviews. Choice experiment surveys are not ideally suited to telephonic survey methods as the choice sets are difficult to explain and can be confusing to the respondents. Personal interviews are the most advantageous form of response collection for a choice experiment survey. However, the costs of administering this type of survey are generally higher than for the other methods. Both methods of survey administration have benefits, but influence survey participation and reliability. For most choice experiment studies, personal interviews are recommended (Koponen, Maki-Opas & Tolonen, 2011).

(b) Sample Frame

The sample frame is defined as the target population from which a finite sample is selected and the survey tool administered (Louviere *et al.*, 2000; Oliver, 2010). The sample frame is determined principally from the objectives of a study. The objectives must be clearly defined so that a model may be developed from the sample. Incorrect specification of the sample frame can invalidate the data (Louviere *et al.*, 2000; Shen, 2005; Oliver, 2010).

(c) Sample strategy

The population from which the finite respondent sample will be drawn must be identified based on the objectives of the survey. Thereafter, a sampling strategy should be defined. There are many possible sampling strategies to employ, such as a simple random sampling, a stratified random sample or a choice-based sample (Shen, 2005). A specific sampling strategy may be more desirable if there is a sub-group that is of interest to the study or the accuracy of the estimates for a sub-group are to be improved (Shen, 2005). In practice, the sample size and sample strategy employed are determined mostly by the budgetary constraints (Alpizar, Carlsson & Martinsson, 2003; Shen, 2005).

2.5.5 Model estimation

The response data can be analysed using a number of different statistical choice models. The most popular model to estimate the choice probabilities is the CL model, but the RPL model has a number of benefits over the CL model (See Section 2.3). The model estimation involves the analysis of the choice models, the estimation of welfare measures and validity testing.

2.5.5.1 Analysis of the choice models

Statistical models may be estimated by using one of several statistical software packages, such as: SPSS, SAS, Limdep NLogit, R and STATA. Once the parameters of the models have been estimated it is possible to compare the model effects of attribute interactions and socio-economic characteristics on choice probabilities. At this stage the WTP or WTA compensation welfare measures may also be calculated.

2.5.5.2 Marginal WTP or accept compensation

Marginal WTP (MWTP) or marginal WTA (MWTA) compensation is the ratio of the price attribute with one of the other attributes in the choice experiment. The marginal values indicate the effect that a one unit change in the attribute levels will have on the price or subsidy accepted for a good or service. The formula to calculate MWTP or MWTA is given by Equation 2.36.

$$M = p^{-1} ln \left\{ \frac{\sum_i e^{V_i^1}}{\sum_i e^{V_i^0}} \right\} \qquad (2.36)$$

In this equation, M represents MWTP or MWTA, V^0 is the utility of the status quo, V^1 is the utility associated with the alternative and *p* is the coefficient of the cost attribute (Hanley *et al.*, 2001). Equation 2.36 can be simplified into the ratio of the coefficients and is often referred to as the implicit price of the attributes. The implicit price represents the money trade-off that a respondent makes for the other attribute.

$$implicit\ price = -\left(\frac{\beta\ attribute}{\beta\ monetary\ attribute} \right) \qquad (2.37)$$

The ratio of the two coefficients removes the confounding parameter in Equation 2.37 because the scale parameter μ is present in both the β coefficients of the attributes and the monetary attribute. A more complex matter is obtaining the standard errors for the implicit prices because the distribution of the maximum likelihood estimator for the welfare measure is a non-linear function parameter vector and unknown (Hanley *et al.*, 2001). The estimation of confidence intervals for the implicit prices can be derived by means of the delta method or the method proposed by Krinsky and Robb (1986).

The Krinsky and Robb (1986) method involves the simulation of an asymptotic distribution for the coefficient, by making repeated random draws for the multivariate normal distribution using the estimates of the coefficients and the associated covariance matrix (Hanley *et al.*, 2001). This method is also referred to as parametric bootstrapping (Hole, 2007). From the random draws, simulated values for WTA are calculated and these values used to determine the percentiles of the simulated distribution with the desired confidence level. The only assumption required is that the coefficients be joint normally distributed (Hole, 2007). Alternatively, the delta method can be used. This method involves estimating the asymptotic variance of the WTA or WTP measures, by taking the first order Taylor series expansion around the mean value of the variables, and calculating the variance for this expression.

$$var(W\hat{T}A_k) = [W\hat{T}A_{\beta_k} var(\hat{\beta}_k)] \times [W\hat{T}A_{\beta_c}\, var(\hat{\beta}_c)] = (\frac{-1}{\hat{\beta}_c})^2 W\hat{T}A_{\beta_k} W\hat{T}A_{\beta_c}\, covar(\hat{\beta}_k, \hat{\beta}_c) \tag{2.38}$$

$W\hat{T}A_{\beta_k}$ and $W\hat{T}A_{\beta_c}$are the partial derivatives of $W\hat{T}A_k$ with respect to β_k and β_c (Hole, 2007). The confidence interval can be created using the standard formula:

$$W\hat{T}A \pm \Phi^{-1}[1-\alpha/2]\Phi^{-1}\sqrt{var(\,W\hat{T}A_k)} \tag{2.39}$$

where $\Phi^{-1}[1-\alpha/2]\Phi^{-1}$ is the inverse of the cumulative standard normal distribution and the confidence level is 100(1 - α) % (Hole, 2007). This method assumes that the WTA/WTP welfare measures are normally distributed.

2.5.6 Validity testing

Validity testing can be divided into two sections, content validity and convergent validity. Content validity describes the extent to which the survey tool measures what it intends to and construct validity describes the compliance or consistency of the results of the survey with the assumptions defined and as would be expected from standard economic theory and other similar local/international studies. The model's validity can be assessed through statistical goodness of fit tests.

2.5.6.1 Content validity

The survey is considered to have content validity if the survey tool is appropriate in measuring that which the study sets out to achieve and satisfies all objectives. Content validity requires that the right questions be asked in a clear, unbiased and easily understandable way (Oliver, 2010). Content validity can be achieved by ensuring that the survey tool has undergone a thorough examination by several external sources and has been tested and assessed in a pilot study.

2.5.6.2 Convergent validity

(a)Compliance with assumptions defined

Assessing for compliance of the results with standard economic theory and the assumptions or expectations of the results can be done by assessing the sign and significance of the coefficients of the attributes. If the model is appropriately specified and estimated the model results should reflect expectations.

(b) Compliance with international studies

The validity of the results can be determined by comparison of the results with other similar international studies and other similar stated preference studies. This type of validity should be interpreted with care as without additional information, neither of the resulting estimations made by either study can be assumed to be superior.

(c) Compliance with survey findings

An important validity test for the choice experiment model estimations, is the analysis of the answers to additional questions included in the survey specifically for this purpose. The most important section to consider when assessing the results' validity is the follow-up questions to the choice experiment. Responses to the difficulty of the choice tasks, the understanding of the trade-offs, and the preference for a specific alternative or attribute in the choice task to each respondent, can be used to assess the validity of the choice experiment tool.

2.5.6.3 Model validity

Testing the significance and goodness of fit of the model to the data is a simple procedure requiring only ordinary least squares (OLS) regression. It can be done with reference to the value of the adjusted R-squared and F-statistic (Hensher *et al.*, 2005). The same procedure cannot be applied to results of the choice experiment because maximum likelihood estimation (MLE) is used to estimate the choice models. For choice model estimation, the goodness of fit of the model can be determined by the log likelihood at convergence (Hensher *et al.*, 2005).

(a) The Likelihood ratio (LR) test

The likelihood ratio test can be used to test the model significance and to compare two models to determine the superiority of one choice model over another for the same data set. The likelihood ratio test for model significance can be estimated by taking the difference in base model and the estimated model log-likelihoods and comparing the result to the chi-squared statistic with degrees of freedom equal to the difference in the degrees of freedom of the two models. The hypotheses tested are as follows:

Hypotheses:

H_0: $\beta_{Size} = \beta_{Cluster} = \beta_{Job} = \beta_{Distance} = \beta_{Income} = 0$

H_1: $At\ least\ one\ \beta_i \neq 0$

and the likelihood ratio statistic is defined as:

$$\chi^2_{LL} = -2(L_0 - L_M) \qquad (2.40)$$

where L_M is the maximum of the log-likelihood function and L_0 is the maximum of the log-likelihood function when all coefficients are zero (Koppelman & Bhat, 2006). The null hypothesis is rejected and the model is said to be significant if the test statistic is greater than the critical chi-squared value χ^2_{LL} at the 5% level of significance (Koppelman & Bhat, 2006).

The likelihood ratio index proposed by McFadden (1974) is used to test the goodness of fit of the model. The formula for this index is in Equation 2.41. The resulting pseudo-R^2 (namely R^2_{LL}) is similarly interpreted to an OLS regression model R^2.

$$R^2_{LL} = 1 - \left[\frac{lnL_M}{lnL_0}\right] \qquad (2.41)$$

In Equation 2.41 L_M is the maximum of the log-likelihood function and L_0 is the maximum of the log-likelihood function of all coefficients being equal to zero. The resulting pseudo-R^2 (R^2_{LL}) values of between 0.2 and 0.4 are considered to be equivalent to ordinary least squares (OLS) adjusted-R^2 of between 0.70 and 0.90 (McFadden, 1974; Louviere *et al.*, 2000). A value of 0.3 for the pseudo-R^2 represents a reasonable model fit (Hensher *et al.,* 2005).

(b) The likelihood ratio test to compare two models

The superiority of one choice model over another can be tested using the likelihood ratio test if more than one choice experiment model is applied to the same data. The likelihood ratio test to compare two choice models is:

$$LR = -2(LL_{M1} - LL_{M2}) \tag{2.42}$$

where LL_{M1} and LL_{M2} are the log likelihoods of the same data set for model 1 and model 2 at convergence. The LR is compared to the critical value from a chi-squared distribution table with a chosen level of significance and *n* being the difference between the degrees of freedom of the two models. The two models are said to be statistically different from each other if the null hypothesis is rejected, i.e. the value of LR is greater than the critical chi-squared value (Shen, 2005).

2.6 Review of international studies

There are some international choice experiments that have been administered with a view to providing guidance on wind farm location, e.g. whether the location of the wind farm should be offshore or onshore. For instance, Ek (2002) investigated how the Swedish public valued the environmental attributes of wind power with a focus on the location of the wind farm. The study attempted to maximise the net social benefits of wind power associated with the expansion of current wind energy projects in Sweden at a national level. Ek (2002) found that the public preferred the wind farms to be small and located offshore. Similarly, Krueger (2007) valued public preferences for different offshore wind farm developments in Delaware, USA. In this study, it was found that Delaware residents were WTP significant amounts for wind energy production to be moved further offshore.

Ladenburg and Dubgaard (2007) investigated the disamenities from off shore wind farms. The study considered the public preferences of Danish citizens for moving future wind farms further away from the coast line of Denmark. The study found that social benefits arose when the visual disamenities from future offshore wind farms were reduced, and that the marginal benefits of increasing the distance of the wind farm from the coast decreased with increasing distance.

A large volume of wind energy literature focuses attention specifically on the environmental and residential impacts of wind farms. Alvarez-Farizo and Hanley (2002) estimated the utility that Spanish people derived from the potential environmental impacts of wind farms, using two different stated preference techniques: a choice experiment and contingent rating. The study found that there the two techniques yielded a consistent finding and that were significant social costs in the form of environmental impacts associated with onshore wind farm developments, in the form of impacts on fauna and flora, impacts on the landscape and impacts on cliffs (Alvarez-Farizo & Hanley, 2002).

Following this study, Bergmann *et al.* (2006) applied the choice experiment technique to assess the benefits imposed by renewable energy developments in Scotland. They found that the public were particularly concerned with decreasing large landscape impacts, improving the impacts on wildlife and decreasing air pollution.

Dimitropoulos and Kontoleon (2008) studied the local acceptance of wind energy developments in the Greek Aegean islands. In contrast to other choice experiment studies, this study adopted a WTA compensation (for the negative social costs imposed by the wind farm) approach rather than a WTP approach. The study found that the conservation status of the location and community involvement were valued higher, by respondents, than the number of turbines or the turbine height. Two locations were considered in the study and significantly different results were found for the effects of height and turbine size at the two sites, indicating different degrees of local acceptance at the different sites.

An assessment of the landscape externalities from onshore wind power was conducted by Meyerhoff, Ohl & Hartje (2010). Using choice experiment methodology, the effects of height, size of the farm, mortality of birds and the distance between the residents and the wind farms were measured. The findings indicated that only a small minority of residents felt disturbed by the turbines. The residents were most concerned about the bird mortality rates and the distance from the turbines. It was concluded that externalities from wind farms did exist and that the extent of the externalities differed between subgroups due to preference heterogeneity (Meyerhoff *et al.*, 2010).

The public's preference for different energy options is addressed in a study by Borchers, Suke and Parsons (2007). This research considered whether Delaware residents' WTP for renewable energy projects differed by source. A comparison of farm methane, wind, solar and biomass energy projects was incorporated into a choice experiment. It was found that there was a positive WTP for renewable energy and that solar and wind energy was preferred to farm methane and biomass. In a similar study, Fimereli, Mourato & Pearson (2008) investigated UK electricity consumers' preferences for the use of low-carbon technologies in the production of electricity. The different technologies compared in a choice experiment were nuclear power, onshore wind power, offshore wind power and biomass. Unlike most other studies, Fimereli *et al.* (2008) found that most respondents preferred *onshore* wind power and the use of biomass. Similar findings to other studies were also obtained, such as the preference for lower carbon emissions and for a larger distance from residents to the different energy options.

Present applications of choice experiments reveal that negative externalities of wind power exist. In most studies the negative impacts on the environment were considered significant social costs. These costs are born largely by the residents and locals in the surrounding areas of the wind farms. All literature that evaluates distance from the renewable energy site indicates that the respondents are most concerned about the distance from the turbines - they prefer larger distances, irrespective of whether the wind farm is located onshore or offshore. The preference for wind farm size differs across studies and therefore a general consensus for this attribute is not discernible. The preference for renewable energy sources, when compared to each other, suggests that wind energy is favoured over alternative “green” energy sources. Table 2.6 lists some of the most relevant studies that apply DCE methodology to determine the public preferences of residents living in proximity to proposed wind farms for different wind power development options.

Table 2.6: Stated preference studies on the environmental impacts of wind farms

Study	Method	Model	Attributes	Significant WTP/WTA	WTP/WTA per year/household
Ek (2002)	Choice Experiment	Random effects binary probit model	<u>Location of turbines:</u>		
			-Mountainous	+	€0
			-On-shore	+	€12
			-Off-shore	+	€29
			Noise impacts	-	-
			Size of turbine	-	-
			<u>Grouping of turbines:</u>		
			-individual	+	€10
			-less than 10	+	€20
			-10 to 50	+	€0
Alvarez-Farizo & Hanley (2002)	Contingent Rating and Choice experiment	Conditional logit model	<u>Protection of:</u>		
			Cliffs	+	€22
			Habitat and Flora	+	€38
			Landscape	+	€37
Bergmann *et al.* (2006)	Choice Experiment	Multinomial logit model	Landscape impacts	-	€12
			Wildlife impacts	+	€6
			Air pollution	+	€20
			Employment benefits	- (+)	
Ladenberg & Dubgaard (2007)	Choice Experiment	Fixed effects logit model	<u>Distance from shore:</u>		
			-8km	+	€0
			-12km	+	€46
			-18km	+	€96
			-50km	+	€122
			<u>Number of turbines:</u>		
			-Small (5)	-	Heterogeneous preferences
			-Medium (7)	-	-
			-Large (14)	-	-
Krueger (2007)	Choice Experiment	Mixed logit model			Residents ($/month for 3 yrs.): Inland / Bay / Off-shore
			<u>Location of wind farm:</u>		
			-Inland		$45 / - / -
			-Bay		$45 / - / -
			-Off-shore		$50 / - / -
			<u>Distance from shore:</u>		
			- 0.9		$0 / $0 / $0
			- 3.6		$9.38 / $16.62 / $40.83
			- 6		$12.84 / $22.74 / $55.87
			- 9		$15.58 / $27.60 / $67.81
			- 12		$17.53 / $31.05 / $76.28
			- 15		$19.04 / $33.72 / $82.85
			- 20		$20.98 / $37.17 / $91.33
Fimereli *et al.* (2008)	Choice Experiment	Conditional logit model	<u>Energy Source:</u>		
			-Current energy mix	+	£0
			-On-shore wind	+	£88.80 – £111.69
			-Biomass	+	£52.84 – £58.47
			-Nuclear	-	(aversion to pay)
			Distance (per mile)		£3.49 –£4.28
			Local Biodiversity	+	£22.80 – £27.13
			Carbon emissions reduction	+	£1.16 – £1.34
Dimitropoulos & Kontoleon (2008)	Choice Experiment	Multinomial logit & Random parameter logit models			WTA (Subsidy/year/household)
			Size (WFS)	-	€202.23 - €1128
			NATURA	+	€719 - €2090
			Deliberation	+	€800 - €1056
			Height	+	Heterogeneous preference
Meyerhoff *et al.* (2010)	Choice Experiment	Latent class and conditional logit models	<u>Wind farm location:</u>		West Sachsen / Nordhessen
			Wind farm size		- / -
			Height	+	- / -
			<u>Red kite (reduction):</u>	- (+)	- /
			- 5%		/ €2.66
			- 15%	+	€2.22 / -€1.9
			<u>Distance:</u>	-	-€3.03 /
			- 1100		/ €3.84
			- 1500	+	€3.18 / €4.31
				+	€3.81 /

Adapted from Ladenberg and Dubgaard (2007)

Five of the eight studies reviewed used the CL and MNL models. Two of the studies applied the RPL model for estimation. Only one of the studies used a WTA compensation measure. All other studies used WTP measures. The attributes that were most significant in determining preference for wind farm developments were the location of the wind farm (distance away), the number of turbines (grouping), landscape impacts and the effects on fauna and flora.

2.7 A South African study of wind farm disamenities using CVM

Menzies (2011) carried out a contingent valuation study to address the compensation required by residents to accept the siting of the proposed 15 MW wind farm in the Jeffrey's Bay area of the Kouga local municipality. The proposed wind farm consisted of 6 - 10 turbines that were approximately 120 m tall and spanned an area of approximately 20 ha (Menzies, 2011).

As a result of the study an indirect cost associated with the proposed development was determined. Menzies (2011) addressed the social and private desirability of the development by conducting a social and private cost benefit analysis (CBA)[24]. The results of the study are summarised in Table 2.7.

Table 2.7: Summary of the results from Menzies (2011)

Annual WTA	Per person	Population
Rands	R146.52	R490, 695.48
CBA criteria	(Social – discount rate of 3%)	(Private – discount rate of 6%)
NPV	R-37,885,599	R153,751,632
IRR	0%	16%
BCR	0.477	1.813

The annual WTA per person amounted to R146.52 with the total Jeffrey's Bay population willing to accept R490,695.48 per annum (Table 2.7). The social CBA, the net present value (NPV) was negative and the internal rate of return was zero (Menzies, 2011). The discount benefit to cost ratio (BCR) was less than 1. For this reason the development was deduced to be socially undesirable because the capital investment required to initiate the development would be too large. The private CBA yielded a different result. The development was deduced to be desirable

[24] A social CBA addresses the impact that a project will have on society as opposed to a private CBA only incorporates the costs and benefits experienced by the firm owning the project (Beyer, 2012).

from the private perspective as the NPV was positive, the IRR was larger than the discount rate and the BCR is above 1 (Menzies, 2011). The revenues were calculated at prices that have since been lowered (the originally mooted REFIT[25] rates).

Menzies' (2011) study related to a smaller wind farm with different specifications to the Red Cap Investment Pty (Ltd) project (Beyer, 2012). One of the critiques of the study was that the energy yield was borrowed from international literature rather than estimated (Beyer, 2012). Additionally, the social cost of the wind farm as generated by the contingent valuation did not explain for which attributes of the wind farm the respondents were willing to accept compensation. The study also did not measure the social costs relevant to different income groups, particularly the poor.

2.8 Conclusion

The development of wind farms may negatively impact on nearby residents, especially ones who have invested in property with the intention of locating themselves far from industry. There are many ways of correcting for this negative impact. Chapter Two argues that a highly appropriate format for estimating the negative impact is one asking the affected residents their WTA compensation. It is a more credible bid elicitation vehicle than a WTP one and can be readily incorporated into discrete choice experiment analyses and welfare calculations.

The discrete choice experiment methodology is a stated preference technique that derives information on decision makers' preferences through the use of specifically designed hypothetical situations. It is the most appropriate of the stated preference techniques for this study because it does not have the associated "embedding" problems of CVM or as severe a potential to incorporate strategic bias, and it can be used to determine marginal values for attributes of the wind farm package. The CL model is the simplest model that is appropriate for the determination of expected WTA/P measures. The CL model has a major pitfall in that it is dependent on the restrictive IIA assumption. This assumption can be tested using the Hausman-test to determine whether the model is sufficient for estimation. If the model assumption is violated, the NL model or RPL model for discrete choice modelling estimation may be preferred. Both models relax the IIA assumption. There are benefits to both models. The NL model allows

[25] The REFIT rate is the renewable energy feed in tariff.

the analyst to test for alternative (status quo) bias and the RPL allows for heterogeneity in preferences and correlations in the alternatives of the choice sets.

A DCE is applied in four steps. The first step involves the survey design including the construction of the choice sets and design considerations. The second step is the administration of the surveys, including the determination of sample size and data collection. The third step is model estimation. The final step is validity testing.

A review of the international literature on the application of DCE methodology to determine the disamenities arising from renewable energy developments found that most studies used the CL and MNL models. Only one study used a WTA compensation measure. The remaining ones used WTP measures. The significant attributes included in these studies were the location of the wind farm (distance away), the number of turbines (grouping), landscape impacts and the effects on fauna and flora.

A CVM study on a smaller wind farm in the Kouga local municipality in South Africa determined residents WTA compensating measure for the disamenities arising from having a wind farm located in the vicinity. The annual WTA per person was determined to be R146.52. The study's main focus was on the viability of the wind farm project (using a CBA approach) and did not account for the aspects that determined the respondents WTA compensation measures, nor did it include information about different socio-economic groups.

The application of the methodology outlined in Chapter Two is presented in Chapters Three and Four. Chapter Three describes the survey design and administration while Chapter Four estimates the models and tests them for validity.

Chapter Three: Application of the choice experiment

3.1 Introduction

There are a number of key features of wind farms; one of which is location. Others are size of the wind farm and the amount of electricity it will generate. Assuming completeness in preferences, every individual has a preference pertaining to each feature (attribute) of the wind farm. Some attributes will be valued more highly than others and individuals will be willing to trade-off (substitute) reductions in some attributes for improvements in others. For example, if an individual prefers a reduction in the noise of the wind farm to an increase in the number of jobs created by the wind farm, it is expected that the individual would be willing to trade a reduction in the number of job prospects for a reduction in sound emissions from the turbines. DCE's can be used to estimate a value for such trade-offs and provide insight into the attributes of the wind farm that are most important to the individual (see Chapter Two).

In order to apply a DCE to elicit the preferences of individuals for the location of the wind farm a survey tool is required. The survey needs to be relevant, concise and informative. It should also be simple and not cognitively burdensome on the respondents. The survey tool should include attitudinal and knowledge based questions, choice options, follow-up questions to the choices and socio-economic questions (see Chapter Two).

The application of the DCE requires relevant attributes and levels to be defined. International choice experiment studies on wind farm disamenities and focus group studies are used to provide knowledge and insight into relevant attributes that affect residents surrounding potential wind power developments. After the attributes and levels are defined the design of experiment is created, thereafter a preference elicitation task based on the design is constructed.

Once the survey tool is ready for administration it should be tested by means of a pilot study. Thereafter, the sample size for the main experiment is to be determined, as well as the sample strategy and the survey technique to be employed. The main survey would then be administered and the data collected, processed and analysed.

3.2 Identifying the key attributes influencing choice

The St Francis Bay Residents Association (SFBRA) is a group of individuals that live in the St. Francis Bay area of the Kouga local municipality. This Association represents the interests of the residents of the affluent area of St. Francis Bay and the surrounding formal settlements. Its members provided insight into some of the potentially contentious issues that affect the residents near the proposed wind farms in the Kouga region (SFBRA, 2010).

The Association identified the following as significant negative impacts on the residents of St Francis Bay and Paradise Beach:

- A visual impact (the size and positioning of the wind turbines).
- An auditory impact (the noise produced from the magnetised generators and the movement of the blades passing the tower).
- The impact on fauna (the mortality of birds and bats by collision with turbine blades).

It also identified the following as potential benefits that may arise from the wind farm development: a small increase in permanent employment, a marginal increase (or decrease) in tourism and a reduction in power outages. Overall, the residents perceived the negative impacts likely to outweigh the economic benefits.

3.3 Environmental impact assessment (EIA) of the proposed Kouga wind farm

The planning for the development of the three proposed wind farms in the Kouga local municipality has warranted a need for an EIA. An EIA provides insight into the scope and detail of the project. It attempts to identify core environmental issues and the impact that the wind farms have on the surrounding areas, although it does not always fully account for the impacts on the residents and their feelings towards the developments. From the EIA it was ascertained that the construction and operation of the turbines could potentially cause the following significant impacts to the environment:

- Loss of vegetation, wetlands and habitat.
- Obstruction to natural water flows (hydrology impact).
- Impact on terrestrial fauna.

- Mortality of bat population.
- Mortality and migratory impact on the bird population.
- Impact on cultural heritage.
- Visual impact.
- Noise impact.
- Impact on the economy and tourism.

The impact on the vegetation and wetlands were in the form of direct loss of vegetation and habitat, changes to the species composition and ecological processes, loss of species of special concern and their habitat and changes in the fire regime and increased risk of alien infestations (Red Cap Investments, 2011). The construction and operation of the wind farm was expected to have a low impact on the natural flows of groundwater but the wetlands would be impacted by the wind farm construction (Red Cap Investments, 2011).

The potential impact on terrestrial fauna included the direct loss of habitat through site clearing and construction, road mortality from construction vehicles, entrapment, disruption of ecological corridors and poaching (Red Cap Investments, 2011).

The impact on bats were perceived to be through site specific mortality from turbine blades and mass mortality affecting bat recruitment on a regional scale (Red Cap Investments, 2011). Birds face similar impacts to those of bats, ranging from the mortality of birds from wind turbine blades, to the destruction of habitat from wind turbine construction. The collision of birds with the turbines was deemed as highly negatively significant. The impact on birds and bats was expected to be the most substantial of the environmental impacts, but of a low level of significance, not sufficient a reason not to recommend the project (Red Cap Investments, 2011). The specialists proposed that with correct phasing and monitoring procedures these impacts could be mitigated (Red Cap Investments, 2011). The perceived effects of the different mitigation measures included in the EIA were not elaborated on, and little to no validation was provided for each of the mitigation proposals.

Cultural heritage was not perceived to be adversely impacted by the wind farm construction and operation (Red Cap Investments, 2011). The mitigation measures for this impact were site conservation and restoration - these sites were perceived to be poorly maintained and unregulated (Red Cap Investments, 2011).

The landscape, largely composed of agricultural land, with few man-made structures, will be dramatically changed by the erection of the wind towers (at maximum height of 150m to 160m) (Red Cap Investments, 2011). The intrusion of the wind turbines on the existing views of sensitive viewers, the presence of night lights on the nightscape and the shadow flicker on residents in proximity to the wind farms were all highlighted concerns. However, the EIA argued that as the nature of visual perception is subjective, there was only a medium level of significance that should be placed on the visual impacts of the wind farms (Red Cap Investments, 2011).

The noise levels were not considered to be of high negative significance[26], providing suitable mitigation measures were put in place. The operational phase of development is when the most significant impacts would arise (Red Cap Investments, 2011). Micro-siting[27] in areas where noise levels were expected to exceed 45dB (A)[28] and ambient noise monitoring[29] were potential mitigation measures identified in the EIA for noise reduction (Red Cap Investments, 2011).

The EIA forecast the impact on tourism and the local economy to be positive once the wind turbines were constructed. Most benefits were expected to be gained by the landowners, historically underprivileged South Africans residing within the Kouga local municipality and the general community through Corporate Social Investment (CSI).

The EIA noted that less than 1% of the area where the wind turbines will be constructed will be permanently altered and that the high negative biophysical impact may be effectively mitigated (Red Cap Investments, 2011).

[26] It was found that the recommended day/night limit of 45 dB(A) would possibly be exceeded in 6 of the 32 Noise Sensitive Areas (NSA).

[27] Micro-siting involves the positioning of the wind turbines so as to reduce potential negative impacts such as noise pollution.

[28] 45 dB(A) is the recommended day/night noise criteria.

[29] Ambient noise monitoring can be used to determine the power mode settings required in order to ensure that the 45dB (A) noise limit is not exceeded (Red Cap Investments, 2011).

3.4 Choice set construction

3.4.1 Attribute selection and assignment of levels

3.4.1.1 The impact of wind turbines identified by international literature

Wind turbines are known to impact the surrounding area and environment in which they are located. These impacts affect the residents surrounding the wind farm more so than residents in other areas. Table 3.1 below summarises the important attributes identified in several international studies.

Table 3.1: Attributes highlighted in international studies for consideration

Attribute Group	Attributes
Physical attributes of wind farms	Height, size of wind farm, grouping of turbines
Landscape, fauna and flora protection	Landscape protection, wildlife protection, fauna and flora protection
Economics	Employment and community involvement
Site	Distance away from residential areas, location: offshore, onshore, in a conservation area.
Monetary measures	WTP or WTA welfare measure

(a) Physical attributes of wind farms

Ek (2002), Dimitropoulos and Kontoleon (2008) and Meyerhof *et al.* (2010) all incorporated an attribute for wind turbine height. Ek's (2002) study included: noise, height and the grouping of wind farms. According to Ek's (2002) results, reduction in noise levels and small or separately placed wind turbines were preferred by respondents. The height attribute was not statistically significant.

In the study by Dimitropoulos and Kontoleon (2008) the height attribute had two levels; 50 meters and 90 meters. These measures were chosen in accordance with the typical wind turbine installations of mainland Greece. An attribute for wind farm size was also included in the study. This attribute was described as the number of wind turbines comprising the wind farm and was separated into four levels; small, medium, large and larger. Neither attribute was statistically significant. This result was explained by heterogeneous preferences among respondents for wind farm height and size.

Meyerhof *et al.* (2010) included attributes for height and wind farm size. The physical attributes of the wind farms were not found to be significantly important to respondents. Exceptions were evident only in one subgroup, where the respondents (advocates in West Sachsen) preferred not to limit the maximum height to 150 meters.

Ladenberg and Dubgaard (2007) included an attribute for the number of turbines. The larger the size of wind farms the greater the negative utility.

(b) Landscape, fauna and flora protection

An attribute for fauna and flora protection, as well as an attribute for landscape protection was used in the study by Alvarez-Farizo and Hanley (2002). The study had two levels for these attributes: 1 if protected, and 0 if lost. All the attributes were significant. Protection was valued more than loss in all cases.

Bergmann *et al.* (2006) also included attributes for the impact on wildlife and the impact on the landscape in their choice experiment study. Main effects were only considered (no interactions between the attributes were included in the choice experiment). The three levels of the wildlife impact attribute were: slight improvement, no impact and slight harm. The four levels of the landscape impact attribute were; none, low, moderate and high. The respondents were only WTP to reduce high landscape impact, but not low or moderate impacts. The respondents also indicated a preference for reducing the wildlife impact. Fimereli *et al.* (2008) found similarly – a preference for energy options that did not decrease local biodiversity.

(c) Economics

Bergmann *et al.* (2006) used employment creation as an additional attribute in their choice experiment. The attribute had three levels of possible long-term employment opportunities corresponding to three different wind farm investments. Employment creation was not found to be a significant attribute suggesting that the respondents did not attach importance (or credibility) to net employment creation claims.

(d) Site

Siting is considered by most studies as an important determinant of preference for wind farm developments. Siting includes the location and distance away from residential areas. Ek (2002) assigned three levels to the attribute for location: on-shore, off-shore and mountains. The conclusions drawn were that the external costs of wind farms could be reduced by moving the wind farms off-shore and wind farms in mountainous locations were environmentally spoiling more than other locations.

Ladenburg and Dubgaard (2007) extended the Ek (2002) study, by incorporating an attribute for the distance (in kilometres) from the shore. The number of turbines and the number of off-shore wind farms in Denmark was also included as an attribute. They found that respondents were WTP increasingly large sums of money to reduce the visual disamenities of off-shore wind farms. The respondents that were within sight of the wind farms were WTP increased amounts to increase the distance between their residence and the wind turbines, but the marginal benefit decreased as distance increased between the wind farm and the residents. Krueger (2007) followed the same reasoning as Ladenberg and Dubgaard (2007), including as an attribute, wind farm location and the distance from the shore in miles. Krueger (2007) found similarly to Ladenberg and Dubgaard (2007) that the residents on the coast were WTP higher prices to move the wind farms further off-shore and that the marginal social benefits decreased the further away the wind farms were from the shore.

Fimereli *et al.* (2008) included a distance attribute into their choice experiment study. The distance attribute was defined by how close/far the energy option would be located from residential areas. A fixed attribute for the amount of land each energy option would occupy was also included. In the results, respondents valued energy options that were situated further from residential areas and preferred on-shore wind energy and biomass to nuclear energy.

Dimitropoulos and Kontoleon (2008) included an attribute indicating whether the wind farm would be located in a NATURA 2000 network protected site. The attribute captured the respondents' preferences for the conservation status of the area. This attribute was highly significant, indicating that the respondents valued the conservation status of the area. It was concluded that siting was more important than the physical attributes of wind farms.

The majority of the wind energy projects considered for development in South Africa are onshore. For this reason, offshore locations were not (yet) considered a relevant level option with respect to distance attribute.

Distance from residential areas is a significant attribute in all the international studies covered in this literature review. The inclusion of this crucial attribute allows for the determination of the disamenity cost of wind farm proximity to the residents.

(e) Monetary attribute

The inclusion in a choice experiment of a cost or subsidy attribute permits estimation trade-off (substitution) between the changes in attribute levels and costs, and thereby the equivalent surplus (Bateman *et al.*, 2002). A WTP approach is common and used in the studies of Ek (2002), Alvarez-Farizo and Hanley (2002), Ladenburg and Dubgaard (2007), Krueger (2007), Fimereli *et al.* (2008), Borchers *et al.* (2007), Meyerhoff *et al.* (2010) and other similar studies. A common cost attribute selected is an annual or monthly increase in the household electricity bill. Dimitropoulos and Kontoleon (2008) advocated a different approach, the inclusion of a WTA welfare measure. Their motivation was that the respondent should not be 'paying' but rather be compensated - wind farms impose negative externalities on the local communities. Local communities have existing property rights or expectations that may be infringed upon and having to 'pay' to avoid the externalities imposed by the wind farms is unfair. This dissertation agrees with the argument of Dimitropoulos and Kontoleon (2008). A WTA welfare measure is appropriate – one that compensates for the negative externalities imposed. Further justification for this topic is provided in Chapter Two, Section 2.3.4.

3.4.1.2 Preliminary attributes selected

Against the background of international literature, four groups of attributes relevant to wind farm developments were identified. The first group of attributes was the physical aspects of the wind farms. These attributes were included in the studies as: height, noise of the wind turbine blades, grouping of the wind farms and size of wind farm. The second group related to landscape, fauna and flora protection. There were several different attributes in this group: landscape protection, fauna and flora protection and effects on local biodiversity. The third group of attributes were of an economic nature, i.e. employment creation and community involvement. The fourth (and most important group) of attributes was the siting of the wind farm: distance from residential areas, location onshore/offshore and location in nature conservation areas.

The most common monetary attributes included in international studies were WTP ones, but WTA attributes may be more appropriate. Focus group studies were used to fine tune the attributes and levels to the local circumstances.

3.4.1.3 Focus group meetings

Two focus group meetings were held. One meeting was held with the Kromme Trust committee from the St. Francis Bay community, forming the affluent focus group, and the second was held with informed members of the underprivileged areas of the Kouga local municipality. Obtaining adequate representation in the focus group is always a challenge in these studies.

(a) St Francis Bay residents focus group

The St. Francis Bay community comprises approximately 1400 residents (SFBRA, 2010). During the peak holiday seasons the population of St. Francis Bay increases to approximately 20 000 (SFBRA, 2010). The Kromme Trust committee are a group of volunteers that meet regularly to discuss issues that are deemed of interest to this community. Its members are mainly drawn from the more affluent sections of the community.

At one of their meetings, the researcher made a small presentation of the project and relevance of the study, and a copy of the draft survey questionnaire was handed out to all individuals present. They completed the questionnaire and returned it, together with a discussion and comment about whether it captured the main issues about the development from the residents' perspective. The results of this focus group analysis are summarised in Appendix A.

(b) Kruisfontein, Kwanomzamo and Sea Vista residents focus group

A second focus group session of poorer individuals from the informal settlements of Kruisfontein, Kwanomzamo and Sea Vista was also conducted. A meeting with the housing manager at the Kouga local municipality Housing Department was arranged to assist with some background information on the underprivileged residents' electricity situation and the sentiments toward the proposed wind farm. The housing manager indicated that the majority of residents in the informal settlements pay for electricity through a prepaid system. The housing manager also indicated that most households connected to electricity are subsidised with 50kWh per month, and the majority of residents are aware that they receive subsidised electricity.

In the meeting, the housing manager suggested that job creation was of great importance to these individuals. The housing manager indicated that the residents of the informal settlements were able to attend information sessions pertaining to the wind farm development, but many of the residents had not attended, and were not well informed about the wind farm and its various impacts. Given this information, it was decided that a standard focus group session would not be sufficient for this population group, and that the survey of randomly selected individuals from each of the informal settlements should be used to supplement the focus group session (See Appendix B). Seven questionnaires were completed.

Most responses confirmed the points made by the housing manager. All respondents stated that they paid for electricity and were aware that they received subsidised electricity.

(c) Summary of the focus group findings

From the focus group sessions it was determined that the affluent community were most concerned about the visual appearance and the environmental impact of the wind farm. The group was also concerned about the effect on bird and bat mortality due to collision with the turbine blades. The main cause for concern over the negative visual appearance of the wind farm was due to the number of turbines making up the wind farm, the clustering (grouping) of the turbines and how far the wind farm was to be away from residential areas. This finding was similar to that of Krueger (2007). Of the three aspects highlighted, the visual appeal of the landscape, clustering of the turbines and number of turbines also affect bird and bat mortality.

The results from the underprivileged focus group survey indicated that the poorer communities were mostly concerned about the environmental impact that the wind turbines would have on the fauna and flora and possible job creation opportunities that would arise from the development.

3.4.1.4 The final attributes and levels selected

In light of the focus group session information, the attributes included in the survey for the affluent population group were determined to be:

- Number of turbines that make up the wind farm.
- Clustering of the turbines.
- Distance away from residential areas.
- A monthly subsidy allocated to each household (in Rands).

The subsidy attribute is a necessary inclusion to derive marginal costs for the disamenities imposed by each attribute.

The attributes selected for inclusion in the underprivileged survey were:

- Number of turbines that make up the wind farm.
- Number of jobs created.
- Distance away from residential areas.
- A monthly increase in the electricity subsidy allocated to each household (in Rands).

A summary of the attributes and the levels included in the choice experiment is shown in Table 3.2.

Table 3.2: Summary of the attributes and levels incorporated into the choice experiment

Survey Group	Attribute	Levels
Affluent	Size of wind farm	10, 20, 53 turbines
	Clustering of turbines	Close together, moderately close together & widely spaced apart
	Proximity to residential areas	0.5km , 2km , 6km
	Subsidy per household	R100 , R250, R550
Underprivileged	Size of wind farm	10, 20, 53 turbines
	Job Creation	5 , 20, 40
	Proximity to residential areas	0.5km , 2km , 6km
	Subsidy per household (per month)	R3.25 , R13, R19.5

The attributes selected for inclusion in the study are discussed in more detail below.

(a) Size of the wind farm

The number of turbines making up the wind farm is synonymous with the wind farm size. The maximum number of wind turbines proposed for construction in one location in the Kouga local municipality is 53 turbines (Red Cap Investments, 2011). This number was set as the upper bound for the attribute of wind farm size. Two other levels of wind farm size were also included. These levels were determined from the study by Dimitropoulos and Kontoleon (2008), namely: small (10 turbines) and medium (20 turbines).

(b) Clustering of the turbines

The clustering of the turbines is defined as the spacing of each turbine in proximity to another turbine. The levels of the attribute for the clustering of turbines are qualitative values in accordance with Dimitropoulos and Kontoleon (2008). The three levels for this attribute were labelled, “close together”, “moderately close together” and “widely spaced apart”. These labels represented the distance between the turbines of 50 meters, 250 meters and over 1 km respectively. As this attribute was qualitative, it required effects coding for inclusion in the choice experiment. Two new variables (*Cluster 1* and *Cluster 2)* were created for this attribute to represent the three levels (Hensher *et al.,* 2005). The effects coding for the attribute is shown in Table 3.3.

Table 3.3: Effects coding for the cluster attribute

Level / Attribute	*Cluster 1*	*Cluster 2*
Close together	1	0
Moderately close together	0	1
Widely spaced apart	-1	-1

The level of the status quo was coded as zeros for both *Cluster 1* and *Cluster 2* (Birol, Das & Bhattacharya, 2009).

(c) Distance away from residential areas

The distance between the residential areas and the wind farm is one of the most important factors contributing to the acceptability of the wind farm, because the further away the wind farm is from the residential areas the less of a visual impact it has on the residents and the surrounding landscape. From the focus group discussions it was determined that at a distance greater than 6km away from residential areas the wind farm will not have an effect on the residents. With this feedback in mind, the minimum and maximum distances away from residential areas were chosen to be 0.5km and 6km respectively and an intermediary level of 2km away was also included.

(d) Number of jobs created

The probable number of long-term employment positions created by the wind farm development is relatively small in comparison to the probable number of temporary jobs created in the construction phase of the development. The majority of the long-term jobs potentially created by the industry would be for skilled or specialised labourers, e.g. engineers, and the majority of the temporary employment will be for unskilled labourers. The levels assigned to the hoped for, net new job creation were 5, 20 and 40. These potentials may well be on the optimistic side because they do not take into consideration any job losses linked to the potential migration of the affluent away from the area, in search of preferred proximity away from industry.

(e) Subsidy

The monetary attribute is a necessary inclusion in choice experiment methodology in order to derive marginal values for the attributes and levels. A WTA welfare measure was adopted for this project because it was assumed that the development of the wind farm would impose negative externalities on the residents living in proximity to the development (see also Chapter Two, Section 2.2). The construction of the wind farm may infringe on the property rights of the residents in the form of changes in the residential environment and depreciating property prices.

The subsidy values for the affluent group were based on electricity consumption. The levels of the attribute were R100, R250 and R550 per household per month. These levels needed to be as high as they could realistically be, as they were to form the basis for the compensation trade-off to be later calculated. The subsidy for the underprivileged group was based on the free basic electricity prices (South African Government Information, 2011). The subsidy was in the form of an increase in the electricity subsidy allocated each month. The levels for this attribute were in the form of an increase in electricity subsidy of R3.25, R13 and R19.50 per household per month.

(f) Status quo option

A status quo alternative was included to reflect a realistic market situation, where the option to opt-out, or select the current or base situation, is possible. In this study the option of no wind farm is a realistic possibility and the alternative to the “no wind farm option” would be in the form of a nuclear energy facility or expansion of coal power stations. In this sense the status quo was potentially definable. Its inclusion in the study would improve the reliability and the model estimation of the results.

3.4.2 Design considerations

The orthogonality, the balance of the design, the coding of qualitative variables and the choice of whether to use an unlabelled as opposed to a labelled experiment are all considerations that were made before constructing the choice sets for the choice experiment.

3.4.2.1 Orthogonality

Orthogonality in design is important. An orthogonal fractional factorial design of 27 attribute level combinations was created in SPSS version 12.0.1. Some interaction effects were provided for.

3.5.2.2 Balanced design

The design was checked for balance. Each attribute level was counted and an equal number of each attribute and each level were included in the design. Every effort was taken to include an equal number of each choice card in the final design of the choice sets.

The D-efficiency of the design was 68%; adequate for the purposes of parameter estimation but not completely optimal in terms of precision.

3.5.2.3 Unlabelled experiment

A generic (unlabelled) experiment was designed. The choice to apply an unlabelled as opposed to a labelled experiment was because the wind farm alternatives were not distinct from one another and could not be labelled. A benefit from using an unlabelled experiment is that the IID assumption is less likely to be violated.

3.4.3 Experimental design

All attributes had 3 levels. For this reason a 3^{k-p} design was used, where k denotes the number of attributes and p denotes the factorisation level. Four attributes, each with three levels were included in the experiment. The full factorial design is $3^4 = 81$ attribute level combinations. As a multiple of this number of questionnaires would be required to provide accurate estimates for the representative population, it was not feasible to use the full factorial design as it would be too costly. Orthogonality and balance were important in the design of the experiment. The fractional factorial design combination of four attributes at three levels is orthogonal for a design of 9 or 27 cards. A factorisation factor of $p = 1$ was used with the final fractional factorial design being $3^{4-1} = 27$ attribute level combinations.

This design was a 4×27 matrix of attribute level combinations (choice sets). The combinations were randomly paired together to create 108 choice sets of two choice cards (Hensher *et al.*, 2005). This randomisation of the choice cards was done by sampling from the design without replacement. The final design was adequately balanced and orthogonal, indicating that there were approximately equal numbers of the attribute level and choice cards included in the design.

A maximum of six choice sets is recommended by most choice experiment literature in order to make the choice task more manageable and less cognitively burdensome (Bateman *et al.*, 2002). In this study, four choice sets for each respondent were deemed sufficient to provide a suitable sample without burdening the respondents excessively. The 108 choice sets were blocked to create 27 surveys, each with four choice sets of two choice cards. The 27 surveys were to be completed by 27 different respondents. Each respondent was required to complete four choice tasks in order to maintain the orthogonality of the design. The project budget allowed for each of the 27 surveys to be administered 10 times.

3.5 Survey development

The survey included four sections: an introductory section, the choice experiment section, a follow up section to the choice experiment and a demographic and socio-economic section. The survey was assessed by several informed individuals. Statements and/or questions were rephrased and tested before the survey was administered.

3.5.1 Introductory questions

The same information was presented and available to each respondent before answering the choice experiment. This information was used to aid the decision making process. The information was reduced to a concise level, so as not to overly burden the respondents and to reduce the survey length. The introductory questions included questions on the respondents' attitude and knowledge toward wind energy, the issues of energy shortages and environmental concerns and potential solutions to the problem.

3.5.1.1 Statement of issue

The need to invest in renewable energy solutions, the potential threat of future energy supply shortages and the increasing cost of electricity was discussed with each respondent prior to the survey being conducted. Questions 1.6, 2.1 and 2.2 in the affluent surveys and questions 1.3, 1.4, 1.7, 2.1 and 2.2 in the underprivileged survey dealt specifically with these issues (see Appendices D and E).

Most of the other subsections in question one and question two of both surveys addressed the respondents' general knowledge and perceptions toward wind energy and the impact this type of renewable energy would have on the environment and society.

3.5.1.2 Statement of potential solution

The solutions to the problem of increasing clean energy generation in South Africa, presented to the respondents by the survey administrators, were in the form of the proposed wind farm development by Red Cap Investments Pty (Ltd) in the Kouga local municipality or alternatively the introduction of a nuclear power facility in the Kouga local municipality. Questions 1.3 and 1.8 for the affluent survey and questions 1.5, 1.7 and 1.8 for the underprivileged survey dealt with the knowledge and perceptions (acceptance or rejection) of the residents towards these potential developments.

3.5.2 The discrete choice experiment

3.5.2.1 The choice sets

Four choice sets, on four separate pages, were presented to each respondent. Each choice set contained three alternatives, two alternative wind farm options and a status quo option. Photo examples were provided for each attribute in the choice sets, in order to help the respondents visualise the alternative wind farm scenarios.

The choice experiment was preceded by an explanation section. This section detailed how the choice experiment was to be answered and presented an example choice set.

Each survey administrator was given strict instructions on how to administer this part of the survey. The survey administrators were required to explain that "Option A" and "Option B" were two different wind farm scenarios that would be developed in the Kouga local municipality. The two alternatives proposed the development of a wind farm including the four attributes presented in each respective column of the table. The respondents could only choose one of the options. The respondents were encouraged to consider all attributes of each alternative in order to make a decision. A status quo option was included in each choice set.

An example of the choice set used is shown in Figure 3.1.

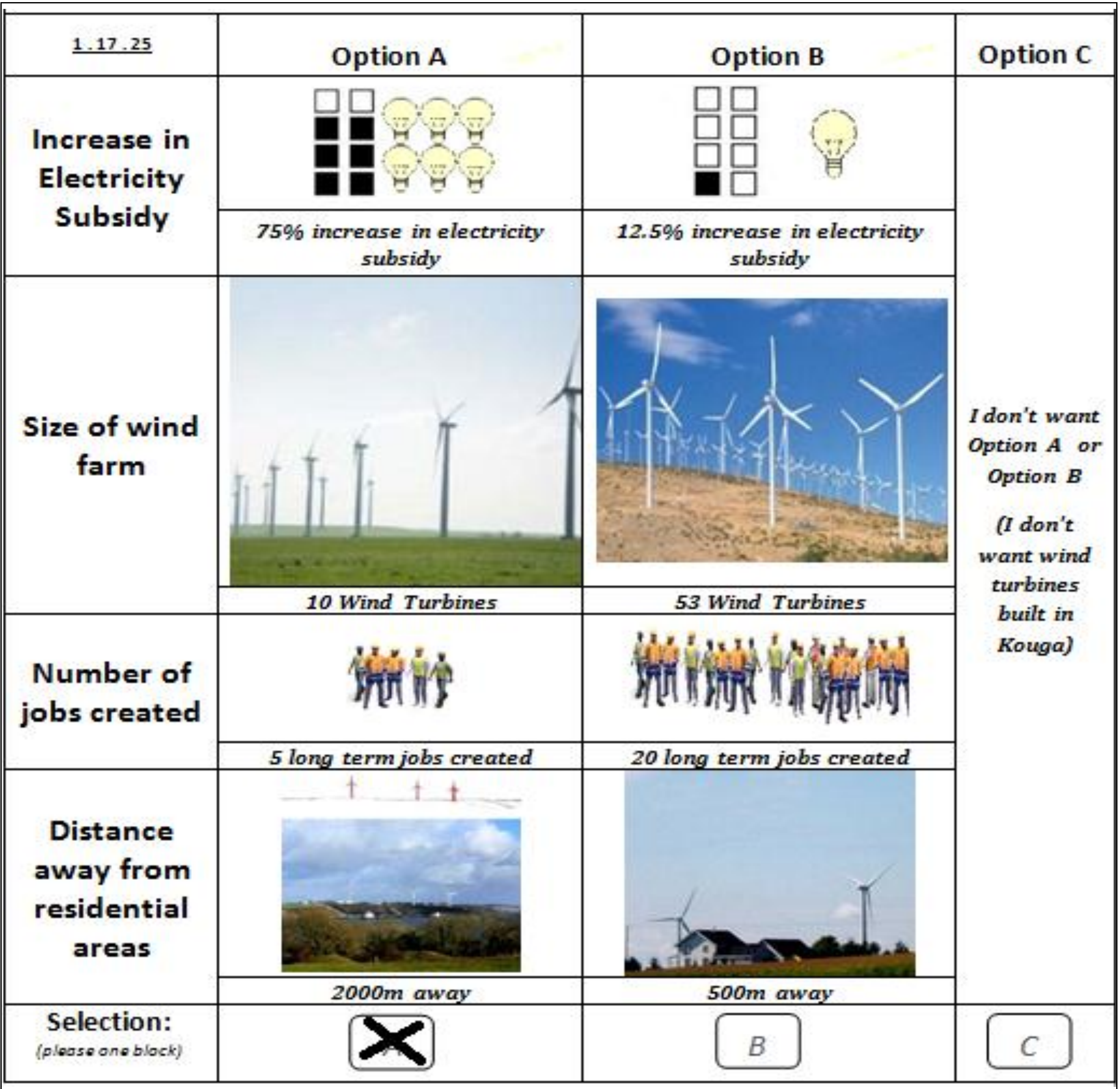

Figure 3.1: Example of a choice set

Option C was the status quo option, stated as "Neither option A nor option B". This statement indicated that the respondent should select option C (the status quo) if neither wind farm option was preferred. The four attributes included in each wind farm option were presented in the left column. Pictures were used to illustrate the different attribute levels. The respondents were asked to consider all attributes presented on each choice card and select only one option. The following example was given to explain how to make the choice selection:

Example: This person chose option A because he/she likes *fewer wind turbines,* at a *greater distance away* from areas where people live, with a larger *amount of electricity subsidy* even though the *number of jobs created by the wind farm project is less*.

In the above example, the respondent considered all of the attributes and chose option A. In this example the respondent traded-off the number of jobs created by the wind farm project with the electricity subsidy amount, distance away from residential areas and number of turbines. This choice indicates that the respondent is willing to forgo larger potential employment opportunities for improvements in the other attribute levels.

3.5.2.2 Follow-up questions

Question four contained the follow-up questions for the choice experiment. The question inquired about the respondents' experience with the choice tasks and the preference for particular attribute levels.

The first question in this section asked whether the respondent found the choices easy or difficult to make. The second question was conditional upon the answer to the first question, indicating that the respondent found the choices "difficult" to make. The respondent was asked why the choices were difficult to make and several possible answers were suggested. These two questions were included to determine the reliability of the respondents' choices.

The third question asked the respondents to indicate which attribute (if there was one) was most important in the decision making process. This question gave the respondents the opportunity to indicate whether they considered each attribute and decided based on the combination of attributes or on one attribute alone. If the respondents considered all attributes in the choice set, no assumptions would be violated. If the respondents' choices depended on the level of one specific attribute, the IIA assumption would be violated. The Hausman-test can be used to determine whether this assumption has been violated in the choice experiment. From the follow-up questions, if one attribute was most important to the respondents for decision making, the results should reflect this.

The final question was only required to be answered by respondents who selected the status quo option. This question elicited the reason why the respondents had chosen this option and not one of the wind farm alternatives. The responses to this question were intended to assist with explaining the reasons for opposition to wind energy in the Kouga local municipality.

3.5.3 Socio-economic questions

The final section of the survey was concerned with the respondents demographic information and socio-economic status such as age, gender, occupation, household income and education. The household income distributions presented to the respondents were different for the affluent and underprivileged survey.

3.5.4 Survey framing

Every effort was taken to phrase the survey questions in a manner that would be simple for the respondents to understand and to ensure that a response was not suggested. Additionally, the language used needed to be concise and simple to understand. Dillman *et al.* (2009) was used to develop the draft survey. Before the survey questionnaire was finalised, it went through rephrasing in the light of on-going criticism and comment.

Before the survey was administered, each survey administrator was required to attend an information session and was briefed about each aspect of the survey to ensure that they could both inform the respondents and help the respondents understand the questions before answering.

3.6 Administering the survey

On completion of the choice experiment design and survey construction, the survey was administered in several phases. Firstly, a pilot study was conducted. The results of the pilot study were analysed and some elements of the questionnaire rephrased. The sample size, sample strategy and survey technique were determined. The main survey was then administered.

3.6.1 The pilot study

Due to time and funding constraints, a total of 53 surveys were conducted as part of a pilot study. All questionnaires were completed through personal interviews. A total of 26 questionnaires were completed for the underprivileged group and 27 questionnaires were completed for the affluent group. The respondents to the surveys were selected randomly from St. Francis Bay and Sea Vista in the Kouga local municipality. The results of the pilot study are shown in Appendix C.

The results from the pilot study data were consistent with the findings from the focus group discussions. The affluent respondent group were most concerned about the distance between the residential areas and the wind farm developments. In the results this respondent group did not indicate that wind farm size was an important attribute influencing their preference for wind energy developments. The results indicated that this group preferred that the wind farm was developed in the Kouga municipality over the status quo (that no wind farm would be built). The results of the underprivileged respondent group indicated that utility was only derived from increases in job creation. This respondent group differed from the affluent respondent group in that they associated higher utility from reducing the distance between the wind farm and residential areas. In the results for both respondent groups, the monetary attribute was not significant. This result renders the estimation of WTA compensation measures irrelevant for the changes in attribute levels. This result called into question why the respondents would not trade-off monetary gains over attributes such as job creation or distance, especially in the underprivileged respondent group. The insignificance of the monetary attribute could be attributed to the limitations of the sample size and the respondents perceiving the compensation packages offered to differ by too small a scale. For this reason, conclusions could not be made based on this data set.

Several notes were made in respect of the survey structure, design and question wording after the pilot study was carried out.

3.6.2 Determination of the sample size

The appropriate sample size for each alternative in the choice experiment can be calculated using the simple random sample equation (2.35). Calculating the sample size based on the smaller choice proportion would result in a higher minimum sample size (Hensher *et al.*, 2005).

The smallest choice proportion is for the status quo. Calculating the sample size based on the status quo choice is beneficial in that the allowable error for the other alternatives is smaller than the alternative used to calculate the sample size (Hensher *et al.*, 2005). Although this strategy is best, the most common determination of sample size is based on the choice proportions[30] of the alternative that is of most interest in the study (Hensher *et al.*, 2005). One of the choice proportions for the wind alternatives was used to calculate the sample size. The simple random equation for sample size can be computed for one wind alternative and one choice set as follows:

Choice proportion of the population is $p = 0.41$

The allowable deviation is $a = 0.08$

The inverse cumulative normal distribution function is $\Phi^{-1}\left(1 - {}^{\alpha}/_{2}\right) = 1.96$

$$n \geq [1.8808]^2 \left(\frac{1 - 0.41}{0.41 \times 0.08^2}\right) = 685.341$$

As each respondent would be presented with four choice sets, the minimum number of respondents required is equal to the sample size calculated for one choice set (n) divided by the number of choice sets in each survey (Hensher *et al.*, 2005). The minimum number of respondents required for the study is: (685.341/4 = 171). The minimum number of respondents required for each socio-economic group in the study was dually set at 171.

One hundred more surveys for each socio-economic group were added to the computed sample size, to improve the statistical accuracy of the results and allow for some leniency with data collection. A total of 270 surveys for each socio-economic group were prepared, resulting in a total of 540 surveys being administered.

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[30] The choice proportions for each wind alternative were determined from the results of the pilot study. These proportions were determined from the number of individuals that chose a wind farm alternative over the status quo. The choice proportions for the two wind farm alternatives, A and B, were assumed to be the same because the choice experiment was unlabelled and therefore the two alternatives were indistinguishable from each other. The choice proportion for each wind alternative was $p = 0.435$; this was determined from the pilot study results (see Appendix C). A third alternative in the form of a status quo would have a choice proportion equal to one minus the sum of the choice proportions of the other alternatives, $p = 1 - (2 \times 0.435) = 0.13$.

3.6.3 Data collection

3.6.3.1 Survey mode

The way in which the survey is conducted and the data collected is an important aspect of DCEs. The respondents in choice experiments require an understanding of the task and information on the choice sets before any answers are elicited, which was why personal interviews were selected as the preferred survey technique.

A broad range of individuals were surveyed, from the uneducated and poor to the wealthy and informed. The survey administrators were informed about the project and handed a project overview and example survey to familiarise themselves with the study. The survey administrators were taught how to conduct the surveys and were instructed not to use their own perceptions to influence the respondents' answers in any way. The survey administrators were informed of the Rand values of the monetary options for the underprivileged survey, the instructions were to disclose these values to the respondents during the interview process. The Rand values were not indicated in the survey for fear that the respondents would fixate on the monetary amounts and either expect compensation or not consider the other options. The survey administrators were paired up and tasked with conducting a mock survey. The information session was concluded with additional pointers and a question and answer session. Each survey administrator was allocated a small gift to accompany each survey. These gifts were offered to compensate the respondents for the time spent answering the survey and were intended to ease the survey administrator's problem in persuading participants to answer the survey questions.

3.6.3.2 The sample frame

The sample frame was taken as the residential population of the Kouga local municipality that would be affected by the proposed wind farm development of Red Cap Investment Pty (Ltd). Some residents in the Kouga local municipality would not be directly affected by the wind farm development because they will not be located near the wind farms. To determine which residents will and will not be affected by the wind farm is difficult, because a person's perception of wind energy is subjective. The wind farm could have a greater impact on a concerned resident that will live far away from the wind turbines than an unconcerned resident that will live very close to the wind turbines. For simplicity, it is assumed that the residents that reside in the vicinity of the West, East and Central clusters would be the only people affected by the Kouga wind farm development. Table 3.4 below shows the population statistics of the towns around each cluster.

Table 3.4: The Population Statistics of the Kouga local municipality

Cluster	Town	Population	Percentage affected
Eastern	Jeffreys Bay, Paradise Beach and Aston Bay	40,203	40% (16,081)
Western	Oyster Bay	1,016	100%
Central	Cape & St Francis Bay	2,800	100%
	Humansdorp	23,991	50% (11,996)
Total affected population (estimated)		31,893	
Proportion of pilot study respondents that selected a wind farm option (A & B) or the status quo option (C) respectively		(A & B) = 0.822 (C) = 0.177	

Jeffreys Bay and Humansdorp are the largest towns. These two towns are not affected by the wind farm development as much as the other smaller towns of St. Francis Bay, Paradise Beach and Oyster Bay as they will be located further from the wind turbines (Table 3.4). It was roughly estimated that only 40% and 50% respectively of the populations of Jeffreys Bay and Humansdorp will be affected by the wind farm development. Within this sample frame, two groups of residents were identified, distinguished by residence (Table 4.1).

3.6.3.3 Sample strategy

A stratified sampling method was used to identify respondents for the survey from different locations in the Kouga Municipality. The population was divided into two mutually exclusive groups, each group representing a proportion of the population (Hensher *et al.*, 2005). An intercept sampling method was used to select respondents within these strata to participate in the study. This sampling method requires every n^{th} resident to the Kouga local municipality encountered within a defined area be asked to participate in the survey. As personal interviews were conducted, non-response was minimal and reduced to respondents that did not complete the survey.

It was impractical to pre-select individuals from the study site to partake in the survey because the majority of the population of the Kouga local municipality are holiday makers that do not hold permanent residence in the area. There is very little information pertaining to the underprivileged residents in the area due to the informal nature of this group's residence in the area.

Similar studies have reported that many respondents that were included in the "random" sample were either unwilling to complete the survey or were unavailable to be surveyed (Menzies, 2011). Randomisation of the sample was achieved by following an intercept selection strategy in randomly pre-selected locations.

3.6.4 The main study

The survey was administered in July 2011. A total of 270 personal interviews were conducted with underprivileged residents from the townships of Kwanomzamo, Sea Vista, Tokyo Sexwale, Kruisfontein, Umzamowethu and Ocean View and 270 affluent residents were interviewed from Paradise Beach, Aston Bay, St Francis Bay, Port St Francis, Cape St Francis, Humansdorp, Oyster Bay and Jeffreys Bay.

3.6.5 Data capturing and cleaning process

Once the data had been collected, it was captured into Microsoft Excel by a trained data processor. A total of 244 useable or partially useable surveys for the affluent population were collected and entered. There were 26 surveys from the affluent group that were unusable and were removed from the data set. All 270 surveys collected and captured for the underprivileged respondent group were usable. The data was sorted according to survey number and screened for missing observations and potential erroneous data entries. The existence of correlations between the attributes was assessed through the method of auxiliary regressions and Klein's Rule (Klein, 1962; Hensher *et al.*, 2005).

The results of the test for multicollinearity for the attributes of the design for the underprivileged respondent group are shown in Table 3.5.

Table 3.5: Auxiliary regression method and Klein's rule for the test for multicollinearity for disadvantaged respondents

Dependent variable in the auxiliary regression	Auxiliary regression R^2	R_i^2	F-statistic	Klein's rule R^2
Subsidy	0.0051	2.7517	3.00	0.1023
Size	0.0006	0.3455		
Jobs	0.0005	0.2441		
Distance	0.0054	2.9109		

The comparison of the R_i^2 values for each of the auxiliary regressions and the F-statistic indicates that the attributes of the design are uncorrelated at the 5% level of significance. The application of Klein's rule yielded the same result - the R^2 for the regression of choice was larger than the R_i^2 values of any of the auxiliary regressions.

The utility derived from the *cluster* level of "close together" was negative, indicating that this level was not an appealing option for the respondents. The utility derived from the levels of "moderately close together" and "widely spaced apart" were positive and almost identical, indicating that the difference between these levels was not distinguished by the respondents.

The tests for multicollinearity in the attributes of the design for the affluent respondent group are shown in Table 3.6 below.

Table 3.6: Auxiliary regressions and Klein's rule for the test for multicollinearity for affluent respondents

Dependent variable in the auxiliary regression	Auxiliary regression R^2	R_i^2	F-statistic	Klein's rule R^2
Subsidy	0.006	1.8453	2.61	0.096
Size	0.003	0.9678		
C1	0.001	0.2258		
C2	0.003	1.0664		
Distance	0.007	2.1269		

The R_i^2 are all less than the critical F-statistic and therefore there is significant evidence at the 5% level of significance to reject the null hypothesis that there is a correlation in the design attributes. Klein's rule confirms this finding, as none of the auxiliary R^2 values are larger than the R^2 of the regression on choice.

3.7 Conclusion

The survey tool compiled for the Kouga local municipality comprised five parts. The first two parts of the survey pertained to the respondents' knowledge and attitude toward wind energy and greenhouse gas emissions.

The third part contained the choice experiment task. In order to create the choice experiment, attributes and levels were determined from international literature and focus group meetings. The final attributes selected for inclusion in the choice experiment for the affluent survey were: size of the wind farm, clustering of the wind turbines, distance away from residential areas and a subsidy per household per month. The underprivileged survey choice experiment included the same attributes as the affluent survey with the exception of the clustering of the turbines and the subsidy per household. An attribute for the number of jobs created by the wind farm development was incorporated instead of the clustering of turbines, as this respondent group indicated the importance of the employment prospects of the wind farm development in the focus group survey. The monetary vehicle differed slightly from that of the affluent survey in that an increase in the allocated electricity subsidy per household per month was used instead of a general subsidy per household per month as presented to the affluent respondents.

Three levels were assigned to each attribute. All attribute levels were quantitative and non-linearly spaced, except for the attribute for clustering of the turbines in the affluent survey.

An orthogonal and balanced, fractional factorial experimental design was created based on these attributes and levels. A status quo option was also included in each choice set. The design chosen to be unlabelled as the two wind farm options differed in the combination of the attribute levels and for this reason could not be labelled.

The fourth part of the questionnaire was the follow-up question section to the choice experiment. This part was important to validate whether the experiment was understood and answered correctly. The last section of the questionnaire asked demographic and socio-economic questions.

After the questionnaire was constructed, it was tested by means of a pilot study, where a total of 53 questionnaires were administered: 26 questionnaires for the underprivileged group and 27 questionnaires for the affluent group. The pilot study found that the changes in the levels of the attribute for distance away from residential area significantly influenced the choices of the affluent respondent group and similar to the focus group survey, the underprivileged group showed preference for the attribute for job creation. The monetary measure was not significant in both socio-economic groups, due to the limited sample size.

The main study was administered by an intercept stratified sampling method. A total of 540 questionnaires were administered, 270 questionnaires for each socio-economic group. The data was collected and captured under supervision of the lead researcher. There was no multicollinearity present between the design attributes. The analysis of the responses to the main survey is presented in the following chapter.

Chapter Four: Analysis and modelling of responses

4.1 Introduction

A total of 514 of the administered questionnaires were usable (See Chapter Three). The two groups were distinguished by residence. Residents in informal (townships) were deemed underprivileged and those in formal (suburban) areas were deemed affluent (although they may not have classed themselves this way). The underprivileged residents (those that reside in informal areas) were presented a different questionnaire to that of the affluent residents (residing in formal areas). Focus group assessment indicated that the two groups had different education levels and preferences for wind farm location.

Chapter Four analyses responses of each sampled population group and by doing this, aims four and five of the expanded primary objectives of this dissertation (outlined in Chapter Two). Responses are described and choices modelled to determine WTA and MWTA welfare measures. Three models are estimated: the CL model, NL model and RPL model (see Chapter Two for the model derivations). The best-fit model is used for calculation of the welfare measures.

4.2 Population statistics and survey responses

Descriptive statistics for the responses to demographic and socio-economic questions reflect the survey sample characteristics (Table 4.1).

Table 4.1: Population statistics of the Kouga local municipality

Area	Number of households	Population	Sample affluent	Sample underprivileged	Total sample
St. Francis Bay	3 032	11 721	90	64	154
Humansdorp	5 617	23 991	40	151	191
Jeffreys Bay	11 356	40 203	108	43	151
Oyster Bay	533	1 016	2	3	5
Other	5 200	20 244	4	9	13
Total	25 738	97 175	244	270	514

Source: Kouga local municipality (2011)

The majority of the affluent respondents reside in five areas within the Kouga municipality: Jeffrey's Bay, Humansdorp, St. Francis Bay, Paradise Beach and Aston Bay, but respondents from Port St Francis, Cape St Francis and Oyster Bay were also included in the survey. There were 151 respondents from the Humansdorp area and a total of 64 respondents were from the St. Francis Bay area (Table 4.1).

The underprivileged questionnaire was administered in three main areas within the municipality: Jeffrey's Bay (Tokyo Sexwale and Ocean View), Humansdorp (Arcardia, Kruisfontein and Kwanomzamo) and St. Francis (Sea Vista).

The total sample was approximately 0.5% of the total population of the Kouga local municipality. Of the residents of the Kouga local municipality, only a small percentage was expected to be affected by the wind farm development. The respondents included in the experiment were concentrated in the areas that were expected to experience the highest impact of the wind farm development. The survey response rate was high (95%), because personal interviews were conducted for each respondent. The 5% negative response rate occurred in the affluent respondent group, who were typically less willing to participate in the survey.

4.3 Respondent demographics

The sample respondent demographics for the two socio-economic groups are shown in Table 4.2.

Table 4.2: Summary of the respondent demographics for each socio-economic group

Characteristic		Affluent Sample	Underprivileged Sample	Population
Education	No education	1%	17%	11%
	Some education	99%	83%	89%
Gender	Male	53%	52%	49%
	Female	47%	48%	51%
Employment	Not employed	1%	9%	25%
	Employed	86%	89%	66%
	Retired	13%	2%	7%
Mean Age		47	36	30
Mean Income		R 281 676.24	R 30 800.89	Not available

The respondents from the affluent sample population group were better educated, held more full-time employment positions and earned larger incomes than the respondents from the underprivileged sample respondent group. Males and females were equally represented in the sampled population, in line with the population distribution in the Kouga local municipality for gender. The mean age of the respondents was higher than the population's in both respondent groups, because only heads of households were included in the survey (see also Table 4.3). The respondents from the affluent group were older on average (Table 4.3). Many were retired. The mean income for the population could not be determined.

Table 4.3: Age distribution of respondents

Age	Number of affluent respondents	Number of underprivileged respondents
18-19	2	2
20-24	14	36
25-29	27	66
30-34	25	44
35-39	25	34
40-44	18	28
45-49	26	25
50-80	105	35
>80	2	0

4.3.1 Annual household income distribution of respondents

Figure 4.1 below displays the distribution of annual household income (in Rands) for the affluent respondents.

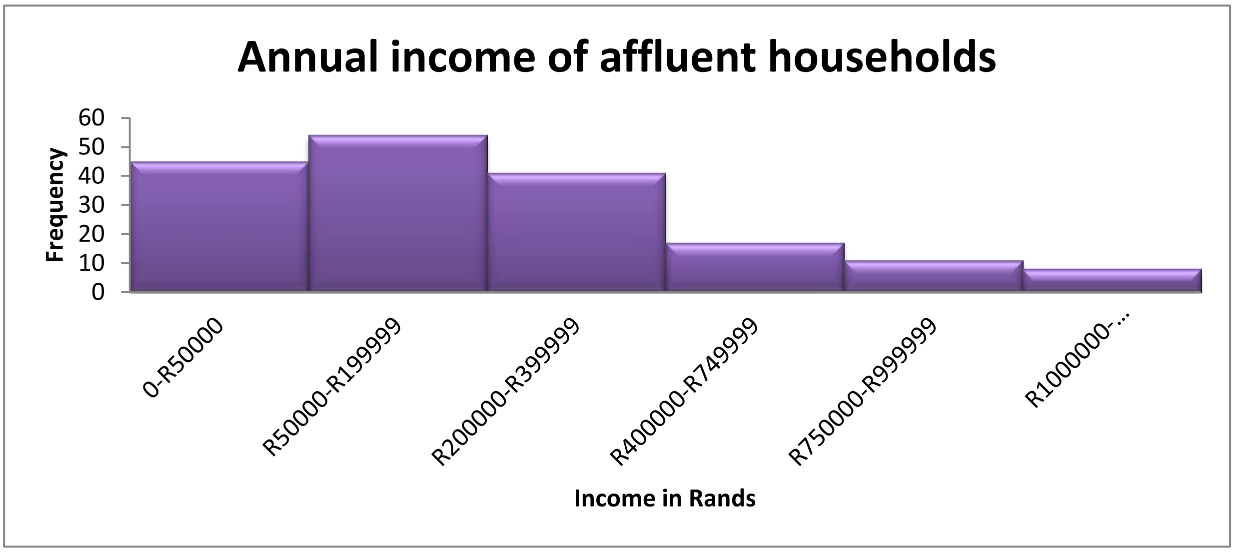

Figure 4.1: The gross annual household income for the affluent respondents

The average gross household income for the affluent sample was approximately R 281 676.24 and the average monthly income approximately R23 500. A small percentage of the respondents indicated that they earned higher sums of money. There were 68 respondents who refused to state their household’s gross annual income.

The distribution of income shown in Figure 4.1 is skewed to the right, indicating that the majority of the respondents in the affluent sample were receiving annual incomes in the lower income categories. Most respondents had an annual household income of between R0 to R399 999.

Figure 4.2 shows the distribution of annual income of the underprivileged respondent group.

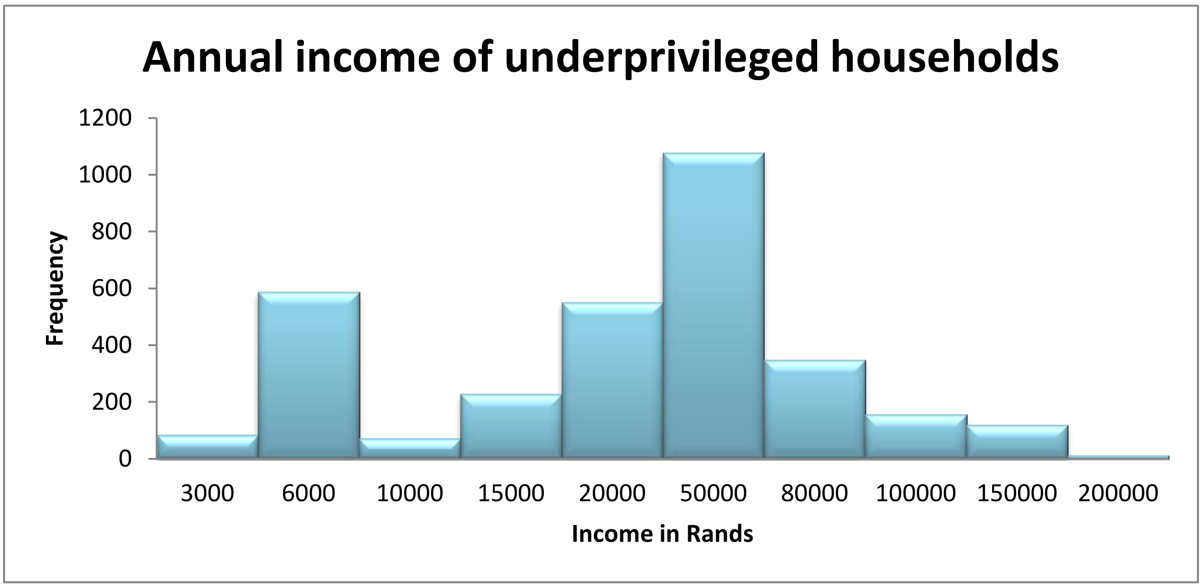

Figure 4.2: Gross annual income of underprivileged households

The average annual income from the underprivileged group was approximately R 30 800.89. Households in the underprivileged areas in Kouga receive approximately R 2 600 in income each month. Most households received between R15 000 and R100 000 per year (Figure 4.2). The spike in the curve at annual incomes between R3 000 and R6 000 reflects reliance on government subsidies/grants of R500 a month[31].

4.3.2 Respondent employment statistics

The percentages of the employment categories for the affluent respondent sample are shown in Table 4.4.

[31] These subsidies were mostly in the form of pensions or child support grants.

Table 4.4: Employment percentages for the affluent respondents

Employment	Percentage
Salary Employment	62%
Retired	13%
Self-employed	21%
Unemployed	1%
Farmer	3%

Most of the affluent respondents held salaried employment positions or were self-employed. A total of 13% of the respondents were retired. A further 21% of the respondents were self-employed entrepreneurs. Only 1% were unemployed and 3% were farmers.

Table 4.5 shows the employment percentages for the underprivileged respondent group.

Table 4.5: Employment percentages for the underprivileged respondents

Employment	Percentage
Owner/Entrepreneur	3%
Wage/Salary Earners	77%
Unemployed	9%
Retired	2%
Part-time worker	9%

The majority of respondents received wages or salaries. These respondents held full-time jobs such as farm workers, supermarket employees and construction workers. Of the respondents, 9% were unemployed, 3% receiving grants or government subsidies and 2% of the respondents were retired. A further 9% indicated that they were casual labourers, only working part-time. A part-time worker was defined as one that did not hold full-time jobs and was only working on a contract (short term) basis.

4.3.3 Education attainments of respondents

The distribution of education levels of both the affluent and underprivileged respondents is shown in Figure 4.3.

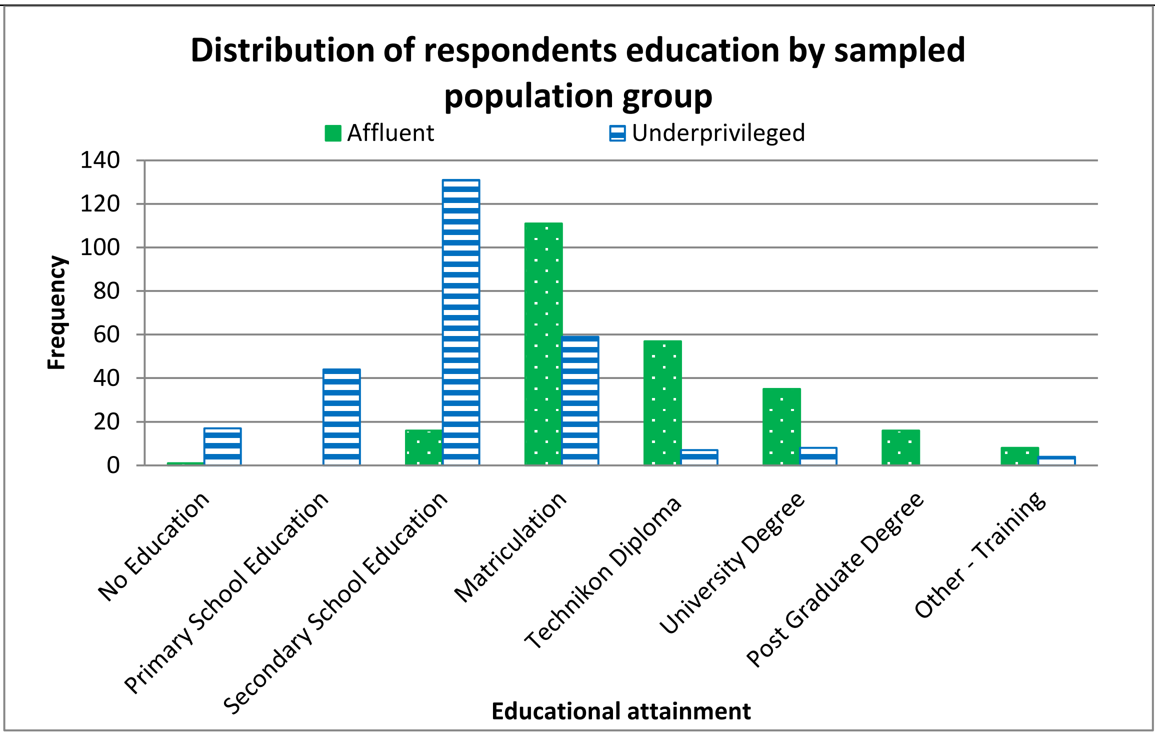

Figure 4.3: Distribution of respondents' education

The distribution of education levels is skewed to the left for the underprivileged respondents and skewed to the right for the affluent respondents. The majority of the underprivileged respondents were poorly educated, with 71% having not completed high school. Only 6% of the respondents indicated that they had some tertiary education, in the form of Technikon diplomas or University degrees.

The affluent respondents were better educated with several having obtained tertiary qualifications. The majority of the affluent respondents matriculated from high school and a large number of the respondents had tertiary degrees or diplomas (Figure 4.3). The number of respondents with little or no education was minimal.

4.4 Choice experiment model estimation

Three different choice models were estimated for each socio-economic group, a CL, NL and a RPL model. The software used to estimate these models was NLogit 4.0. All models estimated the respondents' preferences for the attributes presented in the choice sets. All models provided estimates for the effect that a change in the attribute levels would have on the probability that one of the three alternatives would be chosen (Lee, 2012).

4.5 Model estimation

4.5.1 Analysis of preferences for the underprivileged respondent group

The underprivileged respondent group were presented with several choice cards containing attributes for *size*, *job*, *distance* and a *subsidy*. The *distance* attribute was linearly transformed by taking the natural logarithm, because this variable had very large discrepancies in its values and linearization could be achieved through a natural logarithm transformation.

4.5.1.1 The basic CL model for the underprivileged respondents

A CL model was estimated to determine the preferences of the underprivileged respondents for the location of the proposed wind farm. Four attributes were included in the model. An attribute for wind farm size, distance away from residential areas, number of jobs created and a subsidy. A dummy coded ASC for the status quo option was included in the utility function of the status quo alternative and was coded 0 for each status quo option and 1 for each of the choice options. The following equations were fitted:

$$V_{(Wind\ farm\ Option\ A\ )} = \beta_{subsidy}\ (X_1) + \beta_{size}\ (X_2) + \beta_{distance}\ (X_3) + \beta_{jobs}\ (X_4) \quad (4.1)$$

$$V_{(Wind\ farm\ Option\ B\ )} = \beta_{subsidy}\ (X_1) + \beta_{size}\ (X_2) + \beta_{distance}\ (X_3) + \beta_{jobs}\ (X_4) \quad (4.2)$$

$$V_{(Status\ Quo)} = ASC + \beta_{subsidy}\ (X_1) + \beta_{size}\ (X_2) + \beta_{distance}\ (X_3) + \beta_{jobs}\ (X_4) \quad (4.3)$$

The $X_i's$ are the vectors of quantitative data pertaining to each attribute in the choice card presented to the respondents. The V represents the vector of observed choices made by the respondents. The results of the CL model estimation of Equations 4.1, 4.2 and 4.3 are shown in Table 4.6.

Table 4.6: CL model estimation for underprivileged respondents

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Subsidy (X_1)	0.0288***	0.0068	4.2400	0.0000
Size(X_2)	0.0035	0.0026	1.3650	0.1721
lnDistance(X_3)	0.1815***	0.0469	3.8660	0.0001
Jobs(X_4)	0.0410***	0.0033	12.4670	0.0000
ASC(status quo)	-1.3382***	0.2564	-5.2200	0.0000
Maximum Likelihood estimates				
No. of observations	1080	Base LL function	-965.487	
No. of parameters	5	Pseudo R^2	0.12	
Estimated LL function	-863.4402	AIC	1.608	

* 10% level of significance; ** 5% level of significance; ***1% level of significance

The signs of the coefficients of all the attributes are positive indicating that the respondents derive positive utility from the defined changes. The sign of the coefficient of the ASC is negative and significant. Implying that there is some degree of status quo bias, *ceteris paribus* (Hanley *et al.*, 2001). In other words, respondents prefer to receive a subsidy and have a wind farm option than have the status quo situation of no wind farm. The positive coefficient *size* indicates that a greater utility is derived from larger wind farms. The coefficient for *size* is insignificant at the 5% level, indicating that this attribute may not be important in determining respondent preference for wind farm alternatives. The positive coefficient of *job* attribute implies a preference for improved employment prospects. The positive coefficient on the *ln (distance)* attribute indicates that positive utility is derived from having the wind farm located further away from residential areas, confirming the hypothesis that the respondents were concerned about the negative effect that the wind farm would have on their immediate environment.

To determine the model's performance the log-likelihood ratio-test was performed. The test compares the log-likelihood function of the estimated model against the log-likelihood of its base model (Hensher *et al.*, 2005). The log-likelihood of the estimated model is -863.4402 and the log-likelihood for its base model is -965.4870. To perform the log-likelihood ratio-test the test statistic is calculated and its value is compared to the Chi-square critical value at a significance level of $= 0.05$. The test statistic was calculated as -2(-965.487+863.44) = 204.094. The test statistic exceeded the critical Chi-square value at the 5% level of significance ${\chi^2}_{(2)d.f.} = 5.991$, and it was accordingly deduced that the null hypothesis could be rejected - that the estimated model was not an improvement on the base model is rejected (Hensher *et al.*, 2005). The pseudo R^2 is 0.12, indicating a poor model fit, as would be expected, because this model only includes the attributes as parameter estimates and does not account for individual characteristics or external determinants of choice.

The poor performance of the CL model could also be due to the violation of the IIA assumption (See section 2.5.6.2 Convergent validity). In order to determine whether this assumption had been violated the Hausman test was conducted. The status quo was omitted from the data and the restricted model estimated. The resulting test statistic was 16.0924 and the p-value for this test was 0.0003, enough evidence to reject the null hypothesis that the IIA assumption had been violated.

4.5.1.2 The NL model specification for status quo bias

The NL model relaxes the IIA assumption and allows for testing of the status quo effect by defining a tree specification for the choices. The tree specification is illustrated in Figure 4.4.

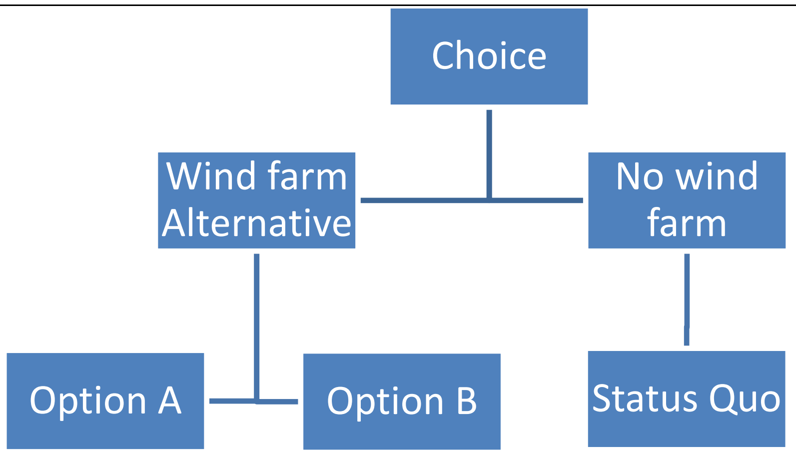

Figure 4.4: Tree specification for the NL model

Four attributes were included in the NL model estimation. The attributes were for *size*, *subsidy*, *distance* and *jobs*. Two *IV* parameters were specified. These parameters were for the branches of the tree specified in Figure 4.4. The RU1 specification was used[32]. The "no-wind farm alternative" was normalised to one. A significant *IV* parameter in this model specification would determine whether there is status quo bias in the model. If there is status quo bias, the specification of an NL model or an RPL model is more appropriate than the CL model for estimation. The utility functions fitted for the NL model were:

$$V_{(Wind\ farm\ Option\ )} = \frac{\gamma_{Option}}{\mu_{(Option|i,1)}} \times IV_{Option} = \gamma_{Option} \times IV_{Option} =$$
$$\gamma_{Option} \times ln(e^{\gamma_{(Option\ A|2,1)} \times V_{Option\ A}} + e^{\gamma_{(Option\ B|3,1)} \times V_{Option\ B}}) \quad (4.4)$$

$$V_{(Status\ Quo)} = \frac{\gamma_{Status\ Quo}}{\mu_{(Status\ Quo|1,1)}} \times IV_{Status\ Quo} = 1 \times IV_{Status\ Quo} = 1 \times ln(e^{ASC+\beta X}) \quad (4.5)$$

where γ is the scale factor for the branches of the tree, IV is the index of expected maximum utility and μ is the scale parameter.

The results of the analysis of the NL model for the underprivileged respondent group are shown in Table 4.7.

[32] The RU1 probability choice structure normalises $\mu_{(j|i,l)} = 1$, the scale parameters of the elemental alternatives. The scale parameter for the status quo was normalised to one: $\mu_{status\ quo} = 1$.

Table 4.7: The NL model estimation for the underprivileged respondents

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Subsidy	0.0299	0.0072	4.1850	0.0000
Size	0.0037	0.0027	1.3670	0.1717
Distance	0.1920	0.0499	3.8460	0.0001
Jobs	0.0442	0.0036	12.3820	0.0000
ASC(status quo)	-2.9819	0.6209	-4.8030	0.0000
IV Parameters				
	***IV* parameter**	**Standard error**	**Wald Statistic**	**p-value**
Wind farm alternative	0.5920	0.2061	2.873	0.0041
Status quo alternative	1	......(Fixed Parameter).......		1
Maximum Likelihood estimates				
No. of observations	1080	Base LL function	-1445.905	
No. of parameters	6	Pseudo R^2	0.4057	
Log-Likelihood function	-859.2813	AIC	1.6024	

* 10% level of significance; ** 5% level of significance; ***1% level of significance

The NL model has a LL of -859.2813. The log-likelihood ratio test statistic comparing the NL model to the CL model is 8.3174. The NL is a dramatic improvement on the CL model. It is significant and has a pseudo R^2 of 0.40571. The estimated model coefficients are consistent in sign and significance with the CL model. The Wald–test[33] was conducted to determine whether the *IV* parameter for a wind farm alternative is significantly different to 1. The test statistic was -3.041, which may be compared to the critical value of $\pm$1.96 (at a 5% level of significance). It follows that one can reject the null hypothesis and conclude that the *IV* parameter for the wind farm alternative was statistically different from 1 and therefore was distinct from the status quo alternative. In summary, the NL model specification yielded a substantially improved statistical fit.

[33] If the *IV* parameter is between the bound 0-1 and the p-value is greater than the level of significance then the parameter is not statistically different from zero. To determine whether an IV parameter is statistically equal to one the same Wald-test can be applied with a slight modification. The Wald test statistic is calculated as: $ld - test = \frac{IV-1}{standard\ error}$, this test statistic is compared to a critical value of ± 1.96 $(\alpha = 0.05)$.

The NL model is an improvement on the CL model as it allows for the relaxation of the IIA assumption, but the NL model assumes homogenous preferences across all respondents and can bias the estimates of individual preferences. By accounting for heterogeneity in preferences the accuracy and reliability of estimates of demand, participation, marginal and total welfare can be improved (Greene, 1997). Taking preference heterogeneity into consideration also has policy implications in that it may reveal information about those affected most by policy changes and allows estimates to be made of the aggregate economic impact associated with the changes. The RPL model was applied to account for the unobserved heterogeneity in preferences.

4.5.1.3 The RPL model for the underprivileged respondent group

An RPL model was estimated that assumed all attributes, aside from the *subsidy* attribute, were normally distributed[34] random parameters. Non-random parameters are interpreted the same as the CL and NL models. The utility equations estimated by the model were as follows:

$$V_{(Wind\ farm\ Option\ A)} = \beta_{subsidy}(X_1) + (\beta_{mean(size)} + \sigma_{sd(size)} \times \mathrm{N}) \times (X_2) + (\beta_{mean(distance)} + \sigma_{sd(distance)} \times \mathrm{N}) \times (X_3) + (\beta_{mean(jobs)} + \sigma_{sd(jobs)} \times \mathrm{N}) \times (X_4) \quad (4.6)$$

$$V_{(Wind\ farm\ Option\ B)} = \beta_{subsidy}(X_1) + (\beta_{mean(size)} + \sigma_{sd(size)} \times \mathrm{N}) \times (X_2) + (\beta_{mean(distance)} + \sigma_{sd(distance)} \times \mathrm{N}) \times (X_3) + (\beta_{mean(jobs)} + \sigma_{sd(jobs)} \times \mathrm{N}) \times (X_4) \quad (4.7)$$

$$V_{(Status\ Quo)} = ASC + \beta_{subsidy}(X_1) + (\beta_{mean(size)} + \sigma_{sd(size)} \times \mathrm{N}) \times (X_2) + (\beta_{mean(distance)} + \sigma_{sd(distance)} \times \mathrm{N}) \times (X_3) + (\beta_{mean(jobs)} + \sigma_{sd(jobs)} \times \mathrm{N}) \times (X_4) \quad (4.8)$$

where N has the standard normal distribution and $\beta_{mean(attribute)}$ is the mean and $\sigma_{sd(attribute)}$ is the standard deviation based on the logit formula applied to the random draws of the coefficient for the attribute. If a parameter is specified to be non-random, the standard deviations are not estimated for that parameter (Dimitropoulos & Kontoleon, 2009). The results of the RPL estimation are shown in Table 4.8.

[34] The normal distribution is convenient as the parameter estimate for the *subsidy* attribute was assumed to be normally distributed.

Table 4.8: RPL model with all non-monetary attributes as random parameters for the underprivileged respondents

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Jobs	0.0775***	0.0147	5.2610	0.0000
ln(Distance)	0.2366***	0.0653	3.6250	0.0003
Size	0.0050	0.0032	1.5870	0.1126
Non-random parameters in utility functions				
Subsidy	0.0369***	0.0091	4.0730	0.0000
ASC(status quo)	-2.0607***	0.6264	-3.2900	0.0010
Derived standard deviations of parameter distributions				
Jobs	0.0887	0.0233	3.8130	0.0001
ln(Distance)	0.2365	0.1979	1.1950	0.2320
Size	0.0033	0.0149	0.2190	0.8265
Maximum Likelihood estimates				
No. of observations	1080	Chi-squared	666.8575	
No. of parameters	10	Degrees of freedom	8	
Log-Likelihood function	-853.0725	AIC	1.5945	
Pseudo R^2	0.2810			

* 10% level of significance; ** 5% level of significance; ***1% level of significance

The LL function was -853.0725 and therefore the LR test statistic comparing the RPL model to the CL model is 20.74 (Table 4.8). The RPL is a significant improvement from the CL model ($\alpha = 0.05$). The pseudo R^2 is 0.28 is a reasonable model fit, but is not as good as the NL model fit. The significance and sign of the parameter estimates are consistent with the NL and the CL models. Significant parameter estimates of the derived standard deviations of the RPL model indicate that there is heterogeneity in the parameter estimates for the sampled population around the mean parameter estimate (Hensher *et al.*, 2005). The dispersion of the *job* attribute, represented by the derived standard deviation of 0.089, is statistically significant with a Wald statistic of 3.81 and a *p*-value of 0.0001. Different distributions forms were assigned to the *job* attribute to determine the best model fit

(Hensher *et al.*, 2005). The normal distribution provided the best model fit. All other attributes do not have a significant dispersion around the mean.

Interaction terms were included in the RPL model to explain the heterogeneity in the *job* attribute (the explanatory variables were interacted with the *job* attribute). Interaction terms for gender of the respondent (dummy coded, 0 for males, 1 for females), age of the respondent, and knowledge of wind energy (two different measures) were included in the model. The results of this RPL model, together with interaction terms, are shown in Table 4.9.

Table 4.9: The RPL model for the underprivileged respondents with explanatory variables as determinants of heterogeneity

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Jobs	0.121	0.027	4.527	0.000
Non-random parameters in utility functions				
Subsidy	0.036	0.008	4.258	0.000
Size	0.005	0.003	1.634	0.102
Distance	0.223	0.059	3.791	0.000
ASC(status quo)	-1.723	0.328	-5.258	0.000
Heterogeneity in mean, Parameter: Variable				
Jobs: Gender	-0.036	0.011	-3.165	0.002
Jobs: Know1	-0.014	0.011	-1.251	0.211
Jobs: Know2	0.002	0.006	0.356	0.722
Jobs: Age	-0.001	0.000	-1.413	0.158
Derived standard deviations of parameter distributions				
Jobs	0.082	0.018	4.509	0.000

Maximum Likelihood estimates			
No. of observations	1080	Pseudo R^2	0.2890
No. of parameters	10	Chi-squared	685.9032
Log-Likelihood function	-843.5497	Degrees of freedom	10
Base LL function	-1186.501	AIC	1.5807

* 10% level of significance; ** 5% level of significance; ***1% level of significance

The LR statistic, comparing the first specification of the RPL model and the second RPL specification with interaction terms included, is 19.05, indicating that the second model is a significant improvement on the first model, and is significant. The overall model is statistically significant, as can be seen by the Chi-squared value of 685.9 with 10 degrees of freedom. The pseudo R^2 value improved to 0.289, an acceptable fit for this class of model (Hensher *et al.*, 2005).

The differences in the marginal utilities held for the *job* attribute are in part explained by differences in respondent gender. The negative and statistically significant '$job \times gender$'

parameter indicates that the sampled male respondents are more sensitive to an increases in job prospects than female respondents.

4.5.1.4 Welfare estimates

Willingness to accept compensation measures can be calculated for each of the significant attributes in the RPL model with interaction terms in order to generate scale (intensity) of preferences of the Kouga local municipality residents for the wind farm alternatives.

The WTA measure for the *distance* attribute was calculated differently to the *job* attribute. It was calculated for moving the wind farm from the baseline of 0.5km to 2km, 6km and the status quo of 120km away. The WTA measures were determined by Equation 4.9 (Krueger, 2007).

$$WTA = \frac{\beta_{ln(distance)}(lnX_i - \ln(0.5))}{-\beta_{subsidy}} \qquad (4.9)$$

In Equation 4.9 the X_i represents the distance i from the residential areas (2km, 6km and the status quo of 120km away) and $\beta_{subsidy}$ represents the coefficient for the *subsidy* attribute. The Delta method was used to determine the implicit price and the standard errors of the *job* attribute. Confidence intervals were created for each of the WTA measures. Possible preference heterogeneity was accounted for by simulating 5 000 random draws from a normal distribution with a mean and standard deviation value corresponding to the coefficient ($\beta_{ln(distance)}$ for *distance* and the coefficient of the implicit price for *job*) and the associated standard deviation values[35] (Krueger, 2007).

The draws created a distribution of WTA figures. The mean of the distribution is reported as the WTA compensation measure for each attribute level. The WTA compensation estimated for the *job* and *distance* attributes are shown in Table 4.10.

[35] The standard deviation was calculated by multiplying the standard error by $\sqrt{n}$

Table 4.10: WTA a reduction in compensation for increases in distance and jobs for the underprivileged respondents

Attribute	Different levels	Willingness to accept compensation measure	95% Confidence interval	
			Upper limit	Lower limit
Distance (kilometres)	2	-R 21.38***	-R 17.83	-R 24.88
	6	-R 38.31***	-R 31.96	-R 44.61
	120	-R 84.51***	-R 70.48	-R 98.38
Jobs (number of new jobs)	10	-R 34.15***	-R 16.97	-R 51.22
	20	-R 68.69***	-R 34.73	-R 102.89
	40	-R 136.70***	-R 66.54	-R 206.74

* 10% level of significance; ** 5% level of significance; ***1% level of significance

The negative WTA compensation measures pertaining to the *distance* attribute indicate that the sampled respondents were willing to accept a reduction in subsidy the further away the wind farm was located from their residential areas. The sampled respondents were willing to accept a reduction in subsidy of R 21.38 per month if the wind farm was moved from the base level of 0.5km away to 2kms away from the residential areas. Similarly, the negative WTA measure for the *jobs* attribute indicates that the sampled respondents were willing to accept a reduction in compensation for increases in the number of jobs created by the wind farm.

Moving the wind turbines far away from residential areas, so that the wind turbines are no longer visible, is not always the best practice and may not be in line with policy objectives. It may be a better alternative to compensate. For this purpose it is useful to assess the marginal willingness to accept (MWTA) measures. MWTA compensation measures were calculated for the significant attributes by taking the difference of the two WTA measures and dividing it by the difference in the corresponding change in distance (Krueger, 2007; Ladenburg and Dubgaard, 2007). The MWTA measures for the *distance* and *job* attribute are shown in Table 4.11.

Table 4.11: MWTA a reduction in compensation for unit changes in jobs and distance for the underprivileged respondents

Attribute	Levels	MWTA	Upper Limit	Lower Limit
Distance (kilometres)	0.5 to 2	-R 14.25	-R 11.89	-R 16.59
	2 to 6	-R 4.23	-R 3.53	-R 4.93
	6 to 120	-R 0.41	-R 0.34	-R 0.47
Jobs (number of new jobs)	0 to 10	-R 3.41	-R 1.70	-R 5.12
	10 to 20	-R 3.45	-R 1.78	-R 5.17
	20 to 40	-R 3.40	-R 1.59	-R 5.19

* 10% level of significance; ** 5% level of significance; ***1% level of significance

A negative sign of the MWTA compensation would imply a reduction in the level of subsidy the representative household would accept if marginal beneficial change in the attribute were to occur. The reduction in MWTA compensation measures is higher for distances closer to the residential areas, indicating that the majority of the sampled respondents would derive social benefit from moving the wind turbines more than 0.5 kilometres away from residential areas. The MWTA compensation measures are consistent indicating that the sampled respondents derive the same amount of utility for each increase in the job prospects created by the wind farm, indicating that the respondents do not prefer a particular improvement in job prospects but rather, derive consistent benefits for each improved job prospect that is created.

The results indicate that underprivileged were willing to trade-off financial gain for greater job prospects, but the fact that the underprivileged did not differentiate benefits between small increases in the number of jobs and large increases in the number of jobs is an inconsistency.

As the parameter estimates for the distance attribute was also significant, WTA measures measure could also be calculated with respect to distance (See Table 4.10). The resulting MWTA measures for the distance attribute for the underprivileged sample population are shown in Figure 4.5.

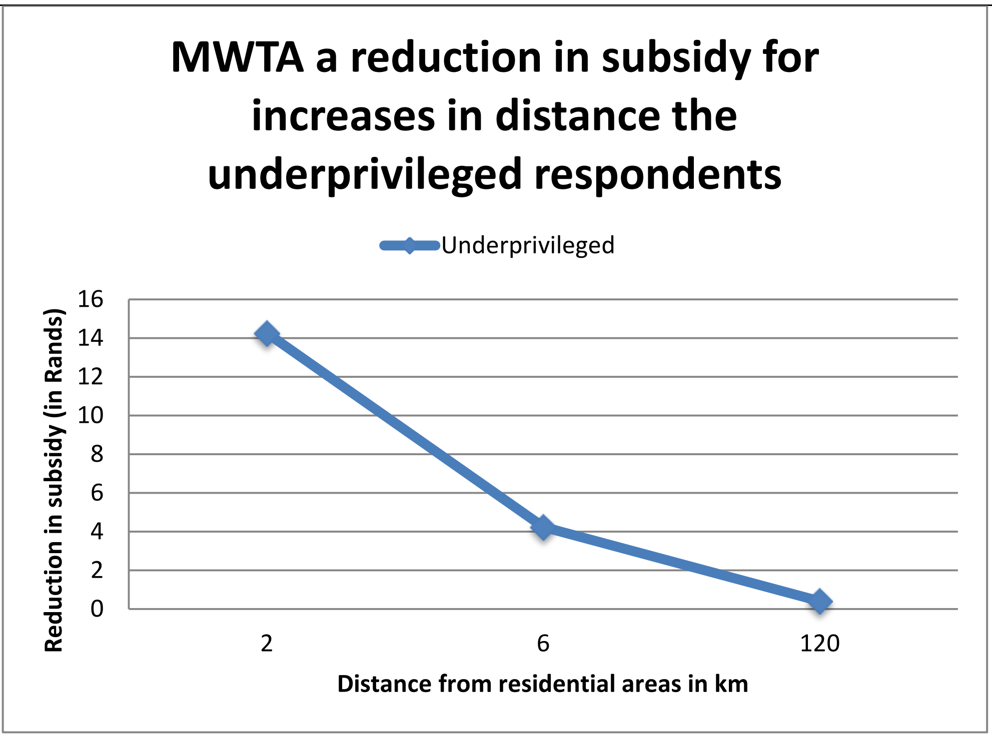

Figure 4.5: Marginal WTA compensation for changes in the distance attribute

The underprivileged respondents are WTA a reduction in the subsidy each month of R14.25 per kilometre distance from the base-line distance of 0.5 km to 2 km away from the residential areas (Figure 4.5). The MWTA a reduction in subsidy each month drops to R4.23 per kilometre between 2 km and 6 km away from residential areas.

As the distance between the residential areas and the wind turbines increases, the sampled population is prepared to accept less and less of a reduction in compensation until the full subsidy value is accepted. The MWTA a reduction in subsidy is below one at a distance of 120 km away from residential areas. This rate of change indicates that for the underprivileged respondent group the benefits are minimal for locating the wind turbines at a distance greater than 120 km away. The greatest social benefit is derived for the initial movement of the turbines further than 0.5 km from residential areas.

4.5.2 Modelling of affluent respondent preferences

The affluent respondent group were presented choice sets containing the attributes of cluster, size, distance and a subsidy. For all models, the cluster variable was effects coded into two levels. Additionally, the distance attribute was transformed using the natural logarithm.

4.5.2.1 Basic CL model analysis for the affluent respondent group

The CL model for the affluent respondent group was estimated with attributes for size of the wind turbine farm, distance from residential areas, clustering of the wind turbines and a subsidy per household per month included in the model[36]. Explanatory variables were also included in the model. The CL model results for the affluent respondents are shown in Table 4.12.

[36] The utility functions fitted were similar to those presented in the underprivileged respondent group model results except that the *cluster* attribute replaced the *jobs* attribute: $V_{(Wind\ farm\ Option)} = \beta_{subsidy}\ (X_1) + \beta_{size}\ (X_2) + \beta_{distance}\ (X_3) + \beta_{Cluster\ 1}\ (X_4) + \beta_{Cluster\ 2}\ (X_5) + \beta_{socio-economic\ characteristics}\ (\boldsymbol{X})$

Table 4.12: Basic CL results for the affluent respondents

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Subsidy	0.0006**	0.0003	2.2380	0.0252
Size	-0.0035	0.0027	-1.2820	0.1999
Distance	0.6815***	0.0541	12.5950	0.0000
Cluster 1	-0.2646***	0.0688	-3.8440	0.0001
Cluster 2	0.1198	0.0785	1.5260	0.1269
Gender	-0.6304***	0.2426	-2.5980	0.0094
Age	-0.0126*	0.0076	-1.6650	0.0959
Knowledge	0.0868	0.1330	0.6530	0.5139
University	1.7302***	0.5222	3.3130	0.0009
ASC(status quo)	-1.7320***	0.5116	-3.3860	0.0007

Maximum Likelihood estimates			
No. of observations	976	Base LL function	-1293.41
No. of parameters	6	Pseudo R^2	0.3868
Estimated LL function	-793.1074	AIC	1.6457

* 10% level of significance; ** 5% level of significance; ***1% level of significance

The *subsidy* and *distance* attribute both have positive signs indicating that increasing changes in the attribute levels were preferred to decreases (Table 4.12), implying that residents were expected to choose higher subsidies and larger distances between the wind turbines and the residential areas. The coefficient of the attribute for size of the wind farm is negative, implying that the residents derived greater utility from smaller wind farms than larger ones. The wind farm *size* was not a significant attribute in the determination of choice, as can be seen by the insignificant *p*-value at the 5% level of significance for the Wald statistic. The two coefficients, *Cluster 1* and *Cluster 2* respectively, represent the two levels for the *cluster* attribute; “close together” and “moderately close together”. These two levels were compared to the base level Cluster 3 of “widely spaced apart”[37]. The coefficient of the level “close together” is negative and significant, indicating that the respondents derived disutility from a change in the spacing of the turbines of “widely spaced apart” to “close together”. The respondents did not distinguish a difference between the levels

[37] The coding of the clustering of the turbines attribute is discussed in detail in Chapter Three.

"moderately close together" to "widely spaced apart", as can be seen by the significance of the coefficient. The ASC for the status quo was negative and significant, indicating that the respondents held a preference for the wind farm alternative over the status quo of no wind farm. The LL for the base model is -1293.413 and the LL for the estimated model is -807.36. The LL ratio-test statistic was 972.106. The test statistic exceeds the critical Chi-square value at the 5% level of significance $\chi^2_{(3)d.f.} = 0.216$, excluding the null hypothesis. The pseudo R^2 is 0.387, a good fit, approximately equivalent to an OLS R^2 of between 60% and 80%. The Hausman test statistic is 2.43 and the *p*-value for the test is 0.3, indicating that the IIA assumption was not violated - the specification of a more complex model which relaxes the IIA assumption is unnecessary.

4.5.2.2 The NL model analysis for the affluent respondent group

The NL model was estimated for the affluent respondents with the same attributes included in the model as the CL model. Additionally explanatory individual specific variables were added to the NL model, namely, gender, age, knowledge of the wind farm, and whether or not the respondent went to university. Income was not incorporated into the model as it was not a significant determinant of choice, due to the stratification of the sample. Two branches were incorporated in the decision tree specification. The branches were specified for a wind farm alternative and one for the status quo or non-wind farm option (as shown in Figure 4.4). *IV* parameters were estimated for each branch of the tree. The *IV* parameter for the non-wind farm option (the scale parameter) was standardised to a value of one as is recommended by Hensher *et al.* (2005). The results of the NL model are shown in Table 4.13.

Table 4.13: The NL model estimates for the affluent respondents

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Subsidy	0.0006**	0.0003	2.2400	0.0251
Size	-0.0035	0.0027	-1.2840	0.1993
Distance	0.6765***	0.0536	12.6120	0.0000
Cluster 1	-0.2621***	0.0684	-3.8310	0.0001
Cluster 2	0.1180	0.0779	1.5160	0.1296
Gender	-15.2774	10.8624	-1.4060	0.1596
Age	-0.3025	0.2633	-1.1490	0.2506
Knowledge	1.8160	3.2591	0.5570	0.5774
University	41.4381	24.5531	1.6880	0.0915
ASC (Status quo)	-1.7146**	0.5222	-3.2830	0.0010
IV Parameters				
	***IV* parameter**	**Standard error**	**Wald Statistic**	**p-value**
Wind farm alternative	1.0413***	0.0244	42.7090	0.0000
Status quo alternative	1	......(Fixed Parameter).......		1
Maximum Likelihood estimates				
No. of observations	976	Base LL function	-1293.413	
No. of parameters	11	Pseudo R^2	0.3867	
Estimated LL function	-793.1866	AIC	1.6476	

* 10% level of significance; ** 5% level of significance; ***1% level of significance

The sign and significance of the coefficients of the attributes and the ASC for the wind farm alternative are consistent with the results of the CL model. The *IV* parameter for the wind farm alternative is positive and significant, but not highly so. At the 5% level of significance the *IV* parameter for a wind farm alternative is not statistically equal to one or zero, based on the Wald-test (the test statistic being -1.692). The parameter value is not statistically different from one at the 5% level of significance. For this reason, partitioning the 'wind farm alternative branch' from the 'non-wind farm alternative branch' was not necessary and there is no loss of significance by collapsing the branches into one to form the CL model (Hensher *et al.*, 2005). The LL ratio-test statistic for the comparison of the CL model and the NL model is 3.53, implying that the model is not significant ($\alpha = 0.05$) and that the NL model yields no better fit than the CL model. The goodness of fit given by the pseudo R^2 was as high as the CL model, at 0.38.

4.5.2.3 The RPL model for the affluent respondent group

The RPL model was also estimated for comparison with the CL and NL models. All attributes except the subsidy attribute were included in the model as normally distributed random parameters. The results of the analysis are shown in Table 4.14

Table 4.14: The RPL model estimates for the affluent respondents

Variable	Coefficient	Standard Error	Wald Statistic	*p*-value
Random parameters in utility functions				
Cluster 1	-0.2699***	0.0764	-3.532	0.0004
Cluster 2	0.1212	0.0846	1.433	0.1518
Distance	0.7076***	0.1065	6.644	0.0000
Size	-0.0032	0.0028	-1.138	0.2550
Non-random parameters in utility functions				
Subsidy	0.0006**	0.0003	2.206	0.0274
ASC(status quo)	-1.1391***	0.1787	-6.375	0.0000
Derived standard deviations of parameter distributions				
Cluster 1	0.1488	0.7317	0.203	0.8388
Cluster 2	0.6580	0.6010	1.095	0.2736
Distance	0.1237	0.6744	0.183	0.8544
Size	0.0048	0.0249	0.193	0.8473
Maximum Likelihood estimates				
No. of observations	976	Pseudo R^2	0.2473	
No. of parameters	6	Chi-squared	530.3825	
Log-Likelihood function	-807.0543	*Degrees of freedom*	10	
Base LL function	-1072.246	AIC	1.674	

* 10% level of significance; ** 5% level of significance; ***1% level of significance

The sign and significance of the parameters are consistent with both the CL and NL models. The derived standard deviations were all insignificant at the 5% level of significance, implying that the preference of the sample population for wind farms was homogeneous. The model was significant (the Chi-squared value of 530.38) and had an adequate model fit for this model specification (Pseudo R^2 =0.247).

4.5.2.4 Welfare estimates

The WTA compensation measures shown in Table 4.15 reflect the preferences of the affluent sampled population of the Kouga local municipality for the location of the wind turbines in the municipality. The WTA measure is defined as a compensation variation measure of the income required to return the respondents back to their baseline utility after the specified change (Krueger, 2007). The specified change was the relocation of the wind turbines further away from residential areas.

Due to the absence of preference heterogeneity, the simpler CL model specification was the best model fit in this case - better than the RPL and NL models. The delta method was used to determine the confidence interval for the WTA measures (see Table 4.15).

Table 4.15: The WTA compensation measures for change in location for the affluent respondents

Attribute	Different levels	Willingness to accept compensation measure	95% Confidence Interval	
			Upper limit	Lower limit
Distance (kilometres)	2	-R 1 088.28***	-R 838.76	-R 1 340.14
	6	-R 1 950.71***	-R 1 503.45	-R 2 402.18
	120	-R 4 302.44***	-R 3 315.97	-R 5 298.18

* 10% level of significance; ** 5% level of significance; ***1% level of significance

The sampled population had a strong preference for moving the wind turbines away from the residential areas. The respondents were WTA large reductions in compensation, implying that the respondents would be willing to pay to have the wind farms located greater distances from the residential areas. The respondents were WTA a reduction in compensation of R1088.28 to have the wind farm located 1.5km away from the base level of 0.5km and R4302.44 to have the wind farm located 119.5km away from the base level.

Some would argue WTA overestimates relative to WTP (Dimitropoulos & Kontoleon, 2008), but in this case WTA is the more appropriate welfare measure.

The MWTA statistics measure the monetary compensation required for a movement of the wind turbines toward residential areas (shown in Table 4.16).

Table 4.16: MWTA compensation for unit changes in distance for the affluent respondents

Attribute	Levels	MWTA	95% Confidence Interval	
			Upper Limit	Lower Limit
Distance (kilometres)	0.5 to 2	-R 304.10	-R 11.66	-R 111.91
	2 to 6	-R 228.08	-R 34.99	-R 335.74
	6 to 120	-R 216.67	-R 699.89	-R 6 714.89

* 10% level of significance; ** 5% level of significance; ***1% level of significance

The MWTA for a change in distance from the closest wind turbine of 0.5km away to 2km away was negative R304.10, a large reduction in subsidy. The MWTA a reduction in compensation was negative R216.68 for a change in the distance from the closest turbine distance of 6km away to 120km away. Figure 4.6 shows the effect on MWTA of increases in distance from the closest turbine for the affluent respondents.

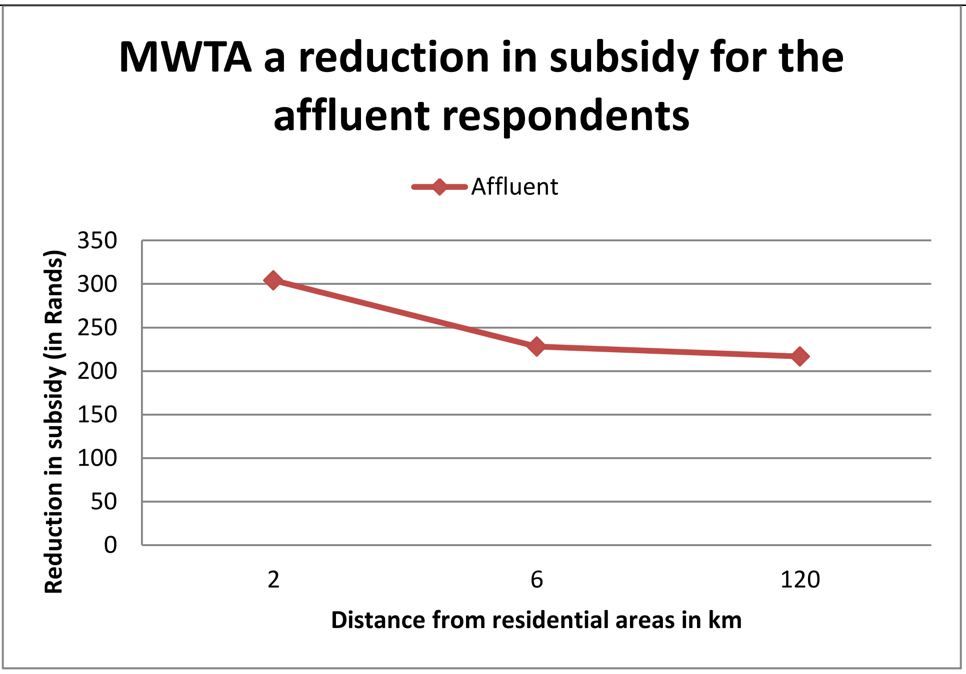

Figure 4.6: Marginal WTA compensation for changes in distance

The marginal returns diminish the further away from residential areas the wind turbines are placed. The MWTA a reduction in compensation are highest the closer the wind turbines are located to the residential areas.

4.5.2.5 Interpretation of the effects coded Cluster attribute levels

The attribute for *cluster* was qualitative and for this reason this variable was effects coded in the model. The interpretation of this attribute is not as straight forward as the other quantitative variables, because extrapolating meaningful interpretations beyond sign and significance of the coefficients is not possible without performing a log-transformation (Hensher *et al.*, 2005). The utility functions for each of the alternatives in the model may be derived without transforming the data. The utility functions for each of the alternatives are shown below:

$$V_{(Wind\ farm\ Alt)} = -0.262\ (Cluster1) + \ 0.118\ (Cluster2)$$

Various (dis)utilities from the cluster levels:

$$Close\ Together: V_{(Wind\ farm\ Alt)} = \ -0.262(1) + \ 0.118(0) = \ -0.262$$

$$Moderately\ Close\ Together: V_{(Wind\ farm\ Alt)} = \ -0.262\ (0) + \ 0.118\ (1) = 0.118$$

$$Widely\ spaced\ apart: V_{(Wind\ farm\ Alt)} = \ -0.262\ (-1) + \ 0.118\ (-1) = \ 0.114$$

The utility derived from the *cluster* level of “close together” was negative, indicating that this level was not an appealing option for the respondents. The utility derived from the levels of “moderately close together” and “widely spaced apart” were positive and almost identical, indicating that the difference between these levels was not distinguished by the respondents. The respondents preferred that the distribution of the turbines be any arrangement other than that of the “close together” level (50m apart).

4.6 Validity testing

The validity of the responses to the choice experiment could only be assessed by the consistency of the results with economic theory and by the respondents’ own answers to the validity of their responses (given by the responses to the additional questions). As there has been no other choice experiment study on wind energy in the Kouga local municipality (or any other municipality in South Africa) it is not possible to validate the study based on comparison with similar studies.

4.6.1 Consistency of the results with economic theory

Economic theory suggests that the WTA compensation would increase as the negative environmental effect increased. For the affluent respondents, the closer the turbines the greater the compensation required, and the closer the clustering arrangement, the greater the compensation required. The poor would be expected to prioritise job prospects higher than the rich. These expectations are consistent with the results of the DCE.

4.6.2 Assessment of the responses to the introductory and follow-up questions

4.6.2.1 Respondents attitude toward wind farms

The majority of the respondents had seen a wind turbine in operation (Table 4.17). In the affluent group, 77% indicated that they had seen an operational wind turbine.

Table 4.17: Responses to question 1.1: Have you ever seen a wind turbine in operation?

Response	**Affluent respondents**	**Underprivileged respondents**
Yes	77%	52%
No	23%	47%

The respondents were positive toward Red Cap Investment's proposed wind farm. Of the respondents 84% indicated that they support the development of the wind turbine farms in the Kouga local municipality (Table 4.18).

Table 4.18: Percentage responses for each respondent group to the acceptance of Red Cap Investments Pty (Ltd) wind turbine farm in the Kouga local municipality

Response	Affluent respondents	Underprivileged respondents
Acceptance	84%	84%
Rejection	10%	13%
Indifferent / Not sure	6%	3%

The underprivileged respondents ranking of aspects that could be impacted by the development of a wind farm in the area is shown in Table 4.19.

Table 4.19: Underprivileged respondents' perceptions of the impacts of wind energy

Aspects affected by wind farm	Positive	Neutral	Negative	Not Sure	Result
Tourists	195	17	20	38	72% Positive
Job Creation	225	12	7	26	83% Positive
The price of electricity	176	11	36	47	65% Positive
Aesthetics of Landscape	187	23	36	24	69% Positive
Animals	40	139	50	41	51% Neutral
Birds	28	126	78	38	47% Neutral
Noise	19	142	61	47	53% Neutral

The underprivileged respondents perceived that the development of the wind farm would have a positive effect on tourism, job creation, electricity prices and the aesthetics of the landscape (Table 4.19). More than 83% of the respondents believed that the wind farm would have a significantly positive effect on job creation in the area. The perception of the respondents toward the effects of wind turbines on the prevalence of animals, birds and noise was not clearly evident. The majority of the respondents were neutral with regard to the potential impact on animals and the creation of noise.

The affluent respondents' perceptions of the impacts that the wind turbines would have on the environment and economy are shown in Table 4.20.

Table 4.20: Affluent respondents' perceptions on the impacts of wind energy

Aspects affected by wind farm	Positive	Neutral	Negative	Not Sure	Result
Tourism	79	88	48	29	36% Neutral
Job Creation	182	37	12	12	75% Positive
Electricity rates	163	40	20	21	67% Positive
Aesthetics of landscape views	41	63	116	22	48% Negative
Property values	56	65	94	29	39% Negative
Bird life	15	68	136	24	56% Negative
Noise	11	101	93	39	41% Neutral
Global environment and climate	123	79	15	27	50% Positive

About 75% of the respondents believed that there would be a positive improvement in employment brought about by the wind farm development, while 67% of the respondents believed that the presence of the wind farm in the Kouga local municipality would reduce electricity prices. The majority view held by the respondents was that the wind farm would negatively affect the landscape aesthetics, property prices and bird life. The impact on tourism and noise were seen as less significant. The respondents did not hold a consistent opinion about the impact of wind energy on the global environment and climate change. About half of the respondents were of the view that a wind energy development would contribute to slowing up global climate change and environmental degradation.

There are many reasons as to why the respondents would not support Red Cap Investments Pty (Ltd)'s wind farm in the Kouga local municipality. One of the reasons was expected to be because nuclear energy was preferred. The responses to the preference of a nuclear energy facility over a wind farm are shown in Table 4.21.

Table 4.21: Respondents' likelihood to support the nuclear project rather than the wind project

Knowledge	Affluent respondents	Underprivileged respondents
More Likely to support	11%	10%
Less likely to support	80%	78%
Not Sure	7%	12%
No effect on my decision	2%	0%

The general consensus for both respondent groups was negativity toward a nuclear energy development in the Kouga local municipality - only about 10% of both respondent groups supported the nuclear energy development (Table 4.21).

4.6.2.2 Respondent knowledge of wind farms

Three questions of the survey assessed the respondents' knowledge by means of a test. A score was assigned to each respondent based on each correct answer given in the test. The frequency of each of the scores was calculated and the percentage of respondents that were knowledgeable was determined. The results are shown in Table 4.22.

Table 4.22: The percentage respondents in each group that had knowledge of wind energy and wind turbines

Knowledge base	Affluent respondents	Underprivileged respondents
No knowledge	5%	30%
Limited knowledge	27%	40%
Fairly knowledgeable	40%	24%
Knowledgeable	28%	6%

The majority of the respondents had some knowledge about wind energy, but the underprivileged respondents were poorly informed about wind energy and the impact of wind turbines – 57% were unaware of the function that a wind turbine performs.

The majority of the affluent respondents were of the opinion that the wind farm would be net-beneficial to the environment, especially if it was located far away from the residential areas (Table 4.23). The majority of the underprivileged respondents felt that the wind farm would save the environment, livelihoods and attractiveness of the landscape. A number of the underprivileged saw no problem in building the wind farm close to the residential areas (Table 4.23).

Table 4.23: Responses to question 2: Respondents' perceptions on the impacts that wind farm developments may have on the environment and the resident population.

Environmental aspects	Affluent Respondents		Underprivileged respondents	
	Agree	Disagree	Agree	Disagree
Reduce South Africa's carbon footprint	85%	6%	70%	12%
Larger wind farms are better for the environment	65%	16%	73%	13%
The presence of wind turbines will reduce the happiness of residents	39%	38%	10%	80%
Wind farms have a negative effect on the landscape	66%	19%	22%	64%
Wind turbines should be built far away from residential areas	76%	10%	45%	32%

4.6.3 Analysis of the responses to the choice experiment section

The descriptive statistics of the choice experiment are shown in Figure 4.7 and Figure 4.8, in the form of response frequencies for each choice card presented to the respondents, the percentage selection of the higher attribute level and the mean number of respondents selecting the status quo option.

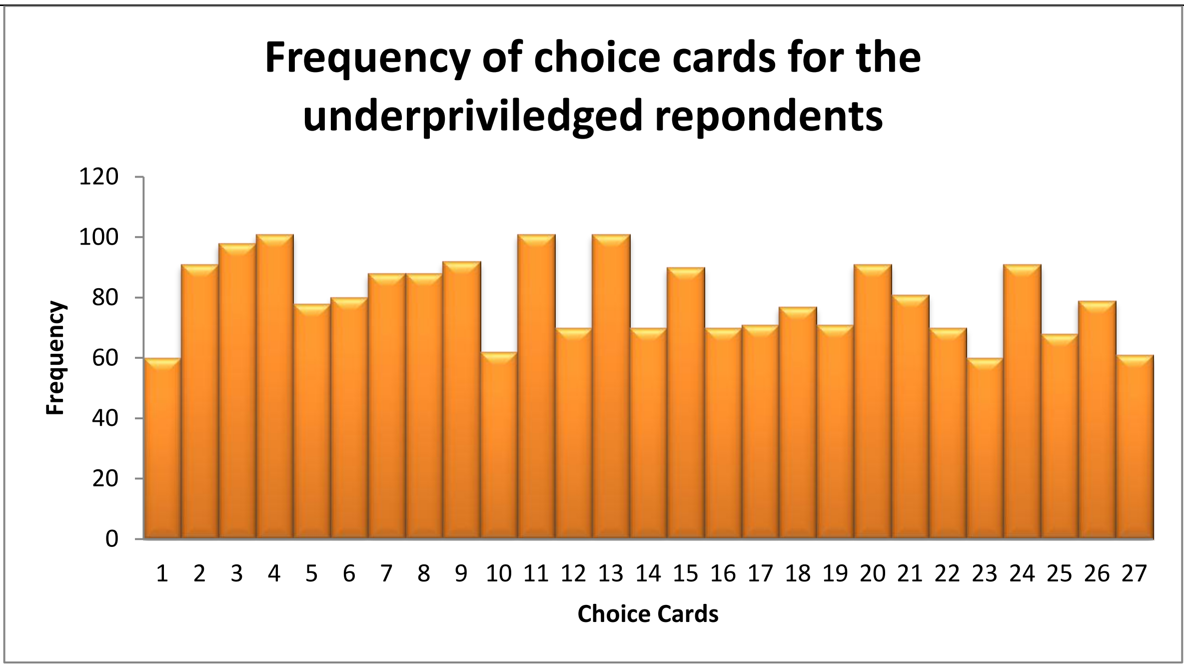

Figure 4.7: Frequency of choice cards for the underprivileged respondents

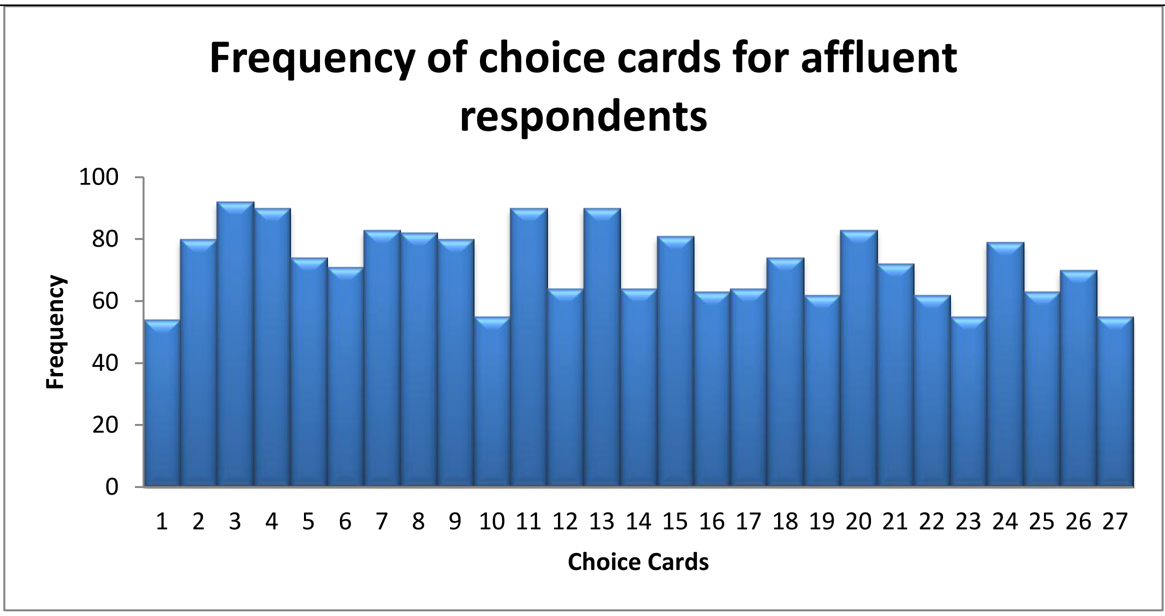

Figure 4.8: Frequency of choice cards for affluent respondents

Each choice card was compared at least 60 times in the underprivileged survey and at least 50 times in the affluent survey. As the same experimental design was used for both surveys the frequency distributions are similar. The choice cards that appeared most frequently in both surveys were cards 3, 4, 11 and 13, while the choice cards that appeared less frequently were 1, 10, 23 and 27.

The percentage of respondents that chose the higher value attribute level in each alternative, can be compared to the results of the models of choice to validate the signs and significance of the resulting coefficients. The percentage of the underprivileged respondents' preferences over attribute levels are shown in Table 4.24.

Table 4.24: The percentage of underprivileged respondents that chose higher and lower value levels of each attribute

Attribute	Percentage higher attribute level chosen	Percentage lower attribute level chosen	Status quo chosen
Size	46.2%	44.3%	9.5%
Jobs	69.2%	21.0%	9.8%
Distance	49.4%	41.0%	9.6%
Subsidy	52.9%	37.9%	9.2%

The percentage of underprivileged respondents that chose the higher attribute level for size was 46.2%, slightly larger than the percentage that chose the lower level for this attribute (44.3%), showing why this attribute was not a significant determinant of choice.

Greater employment prospects, further distances away and larger subsidies were preferred by the underprivileged respondents to the lesser attribute level alternatives. The percentage of affluent respondents that chose the higher value attribute levels for each alternative, excluding ties, is shown in Table 4.25.

Table 4.25: The percentage of affluent respondents that chose higher and lower value levels of each attribute

Attribute	Percentage higher attribute level chosen	Percentage lower attribute level chosen	Status quo chosen
Size	43.9%	44.0%	12.1%
Distance	65.5%	22.2%	12.3%
Subsidy	48.7%	39.5%	11.8%

The affluent respondents had similar preferences as the underprivileged respondents for the levels of the attribute for size of the wind farm, distance away from residential areas and subsidy. Higher values of the levels were preferred to lower values. The percentage of respondents that chose each level of the effects coded cluster attribute was determined separately, as shown in Table 4.26.

Table 4.26: The percentage of affluent respondents that chose the different levels of the cluster attribute

Attribute/Level	Close together	Moderately close together	Widely spaced apart	Status quo chosen
Cluster	23.6%	29.8%	34.0%	12.6%

The *cluster* attribute was qualitative and had three levels denoting the positioning of the turbines in relation to each other. The majority of affluent respondents preferred the *cluster* attribute level of "widely spaced apart", in line with the results of the models for choice.

The descriptive statistics relating to the selection of the status-quo option and the follow-up questions respectively to the choice experiment are shown in Table 4.27 and Table 4.28.

Table 4.27: Descriptive statistics for the choice experiment for the underprivileged sample population

Percentage of respondents that thought the choices were easy to make	71% easy or somewhat easy	29% difficult as many things were important in making the choices
Number of respondents that selected the status quo option	32 respondents chose the status quo on at least one occasion	11 respondents chose the status quo for every choice set question

Answers to questions relating to the choice experiment for the underprivileged respondent group show that most respondents found the choice experiment easy to interpret. Of the respondents, 53% felt that the most important attribute for determination of choice was job creation. Only 32 respondents selected the status quo option at least once in the choice experiment and 11 of these respondents chose the status quo for all four choice sets. The most common reason for choosing the status quo was because a better option was not given.

Table 4.28: Descriptive statistics for the choice experiment for the affluent sample population

Percentage of respondents that thought the choices were easy to make	65% easy or somewhat easy	35% difficult as many things were important in making the choices
Number of respondents that selected the status quo option	32 respondents chose the status quo on at least one occasion	15 respondents chose the status quo for every choice set question

The affluent respondents also felt that the choice experiment was easy to complete - only 35% felt that the choice experiment choices were difficult. The main reason provided for the difficulty in completing the choice experiment questions was that there were many things considered important by these individuals and it was difficult to decide which choice was best. The most important attribute for decision makers was the distance away from residential areas - 50% of the respondents based their decision on this attribute. The status quo was selected at least once by 32 respondents. The individuals that selected the status quo were not in favour of wind energy.

4.7 Conclusion

As anticipated, the demographics and socio-economic characteristics of the two sampled population groups were distinct. The affluent respondents were on average more knowledgeable, better educated, earned higher annual household incomes and were older than the underprivileged respondents.

The majority of the respondents in each socio-economic group were supportive of Red Cap Investment Pty (Ltd)'s proposed wind farm development in the Kouga local municipality.

A simple CL model yielded the best predictive model for the affluent survey and the RPL one for the underprivileged survey. This enabled reliable compensation values to be calculated that would leave the negatively affected respondents no worse off. The compensation calculated was with respect to distance (proximity) to the turbines erected. Should the developer locate the wind turbine farm within 0.5km of a residential area, instead of at least 2km away, it (or the government that approves and subsidises the project) should compensate the affluent residents R1088 per household per month, and the underprivileged residents should be compensated R21 per household per month. Should the developer locate the wind turbine farm within 2km of a residential area, instead of at least 6km away, it (or the government that approves and subsidises the project) should compensate the affluent residents R228 per household per month.

There also is a strong case for some of the affluent residents to be compensated even greater amounts. As there is currently no wind farm located there, one could argue that the maximum compensation calculated is appropriate in some cases. The maximum compensation calculated was R4 302 per household per month to locate the wind farm within 0.5 km of the residences, as against 120 km away from the area.

The underprivileged respondent group were concerned about the location of the turbines and attracted by the number of jobs created by the wind farm development. The preferences for the job attribute were heterogeneous in terms of gender - males chose differently with regard to the number of jobs preferred than woman in the same sample respondent group.

Two internal forms of validity assessment were carried out. It was found that the results were consistent with economic theory and found that attitudes and knowledge about the wind farm were mostly adequate, but less so for the underprivileged group. For this reason, the results of the choice experiment conducted among the latter group may be less reliable. The underprivileged group may be more prone to 'superficial advertising' influence. The choice experiment was not found to be overly difficult or burdensome by respondents themselves. The opt-out option (status quo) was not selected by so many respondents as to raise doubts about the validity of the alternative choices generated through the experimental design.

Chapter Five: Conclusions and Recommendations

5.1 Conclusion

South Africa has committed itself to reducing its carbon footprint (Chapter One). Several policies have been created in South Africa to address the twin problems of reducing greenhouse gas emissions in order to reduce its contribution to global climate change, and upscale electricity power to meet demand growth. Eskom, South Africa's leading energy supplier has relied heavily on its diminishing supplies of coal and outdated power plants to produce energy (Calldo, 2008).

Wind power is one of the solutions proposed to address this twin challenge. From a climate change perspective, wind is preferred to fossil fuel based energy production because wind turbines do not significantly contribute to greenhouse gas emissions. However, wind turbines do cause other disamenities. They detract from the naturalness of the area, create noise pollution, affect the bird and bat population in the area (causing increased mortality due to collision with the turbine blades) and negatively affect property values.

In the Kouga local municipality in the Eastern Cape of South Africa, a company called Red Cap Investments Pty (Ltd) has proposed the development of a wind turbine farm consisting of 121 wind turbines. These wind turbines will be spread over three locations in the Kouga local municipality, Paradise Beach, St Francis and Oyster Bay. The reception of its development by the residents in these areas has been mixed. There were both positive and negative sentiments toward the wind farm proposal. The St Francis Bay residents association have expressed strong negative feelings toward the proposal.

The design decision on which payment elicitation vehicle to use, willingness to pay (WTP) or willingness to accept (WTA), was considered with the conservative estimation perspective in mind. It was concluded that the argument supporting the conservative estimate perspective (see Chapter Two, Section 2.2) is not convincing enough to warrant abandoning the conventional property right perspective, or even warranting qualifying the compensation values calculated as potentially inflated. There are substantial negative effects expected to be experienced disproportionally by the residents located in the vicinity of the wind farm.

Chapter Two argues that the property owner's rights to the status quo with respect to the environment will be infringed, and for this reason they should be compensated. It also concludes that the relevant research question is how much they would be willing to accept in compensation (Chapter Two and Three).

This study has assessed the resident's preferences toward the Kouga wind farm development through the application of a choice experiment. Welfare estimates were generated for the attributes that affect the acceptance of the wind farm.

The choice experiment methodology has been used extensively in marketing (conjoint analysis) and in valuing environmental resources that do not exhibit real market values. In the survey, the residents of the Kouga local municipality were required to make choices between several hypothetical wind energy scenarios defined by a selection of attributes at different levels. The selection of attributes and levels was based on similar international studies and through conducting focus groups. Two socio-economic groups of respondents were surveyed: an affluent group and an underprivileged group, identified by location of residence (Chapter Three).

A stratified sampling method combined with the intercept method was employed to select respondents to be interviewed. Three different choice models were estimated: a CL model, NL model and a RPL model (Chapter Four).

The results for the CL, NL and RPL models for the affluent respondent group were similar in magnitude, sign and significance. The simple CL model yielded the best fit statistically as the data did not violate the IIA assumption. The size attribute was not a significant determinant of choice and considered irrelevant in respondents' acceptance toward the wind farm development. The negative sign for the cluster and distance attributes showed that the respondents were WTA a *reduction* in subsidy, i.e. large reductions implied that the respondents were willing to pay for improvements in the levels of these attributes. Two effects coded attributes were created and estimated for the qualitative cluster attribute levels. The parameter estimates could not be interpreted as easily as the quantitative variables. The respondents preferred the cluster level of "widely spaced apart" as opposed to "close together" and were WTA compensation for a wind turbine clustering arrangement that was closer together rather than one spaced wider apart. There was no heteroscedasticity in the respondents' choices for the attributes.

For the underprivileged respondent group, the magnitude, sign and significance of all the estimated coefficients of the attributes were similar for each of the models. The negative signs for the attributes of *distance*, *jobs* and *size* indicate that the respondents were WTP for increases in the attribute levels. The respondents preferred to have the wind farm located further away from residential areas, have more wind turbines and more jobs created.

There was heteroscedasticity in preference for jobs among the underprivileged respondent group. This heteroscedasticity was explained by gender (the preference for the jobs attribute was similar for individuals of the same gender).

A primary objective of this dissertation was to calculated compensation to (affluent) residents negatively affected by close proximity to new wind turbines erected. Should the government approve the developer locate the wind turbine farm within 0.5km of a residential area, instead of at least 2km away, there is a strong argument that the government that approves and subsidises the project, should also compensate the relevant affected affluent resident household R1088 per month, and the relevant underprivileged negatively affected resident household R21 per month. Should the approval be granted for the developer to locate the wind turbines within 2km of a residential area, instead of at least 6km away, the case for compensation declines to R228 per month per negatively affected affluent resident household.

Some of the affluent residents should be compensated even greater amounts because their costs and losses may be considerable as a result of the wind farm development. When they purchased their property in the area they may not have envisaged it becoming a site for harnessing wind energy to generate electricity, and were not in a position to prevent it. The maximum compensation this study calculated was R4 302 per household per month for the location of the wind farm within 0.5 km of their residences, as against 120 km away from the area (about R50 000 per annum). The results clearly indicate that the wind turbine project is expected to have a non-marginal impact on the values of homes of affluent residents located near the turbines.

The results of the DCE were consistent with economic theory. The affluent respondents' attitudes and knowledge of the wind farm was fair. As the underprivileged respondents' knowledge was less comprehensive than the affluent respondent group, the results of the choice experiment for this group may be less reliable. The respondents did not indicate that the choice experiment was overly difficult and most respondents chose a wind farm option rather than the status quo, indicating that the alternative choices generated through the experimental design were valid.

5.2 Recommendations

The following general recommendations are deduced from the choice experiment with regard to the development of Red Cap Investment Pty (Ltd)'s proposed wind farm in the Kouga Local municipality.

5.2.1 The underprivileged residents

(a) Wind turbine farms should be located a minimum of 2km away from residential areas.

(b) The number of new jobs created by the wind farm development was an important indicator of choice for the underprivileged respondent choices, so the net employment benefit to this community should be real. This potential needs further investigation as there may be job losses as well, caused by discouragement of affluent resident settlement in the area.

5.2.2 The affluent residents

(a) There needs to be further investigation undertaken into the creation of a legal framework to support the compensation of residents negatively affected by industrial projects. The National Environmental Management Act of 1998 provides for the polluter pays principle but provide little guidance on the mechanisms for compensating those negatively affected by the reduced environmental attractiveness.

(b) The most important attribute that determined choice selection for the affluent respondents was distance away from residential areas. The wind farm should be located as far away from the affluent residential areas as is economically feasible. A minimum distance of 2km is essential but further than 6km is preferred.

(c) The developers should avoid positioning the turbines too close to each other because a spacing arrangement of “close together” was determined to be the most unfavourable of the clustering arrangements.

5.2.3 Cost benefit analysis relevance

The results of this research provide an indication of the indirect social costs that a wind turbine farm would have on the residents located in proximity to the proposed developments. These costs should be incorporated into a social cost benefit analysis to provide the developer with a holistic view of the proposed project’s feasibility.

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SOFTWARE USED:

Limdep Nlogit 4.0

Microsoft Excel 2010

SPSS 12.0.1

APPENDICES

APPENDIX A: Focus group results

Two focus group sessions were held. One session was held with representatives of the affluent population (10 people) and one with the representatives from the underprivileged population (4 people). The individuals that participated in the focus group are listed in Appendix B. A questionnaire was handed out at theses focus group sessions. The results of the focus group questionnaire are discussed in detail below.

A.1 Affluent focus group survey results

The summary of the affluent representative's attitude and knowledge toward wind energy and the proposed wind farm in the Kouga local municipality is shown in Table A. 1.

Table A. 1: Summary of affluent representative's attitude and knowledge of wind farms

Question	Option	Response	Percentage
Have you ever seen a wind turbine in operation?	Yes	7	88%
	No	1	13%
What is you general attitude toward wind power?	Very Negative	3	38%
	Negative	3	38%
	Neutral	1	13%
	Positive	1	13%
	Very Positive	0	0%
Would you support or oppose the project in the Kouga local municipality?	Support	1	13%
	Oppose	7	88%
	Other	0	0%

From the results in Table A. 1, most of the individuals had seen an operating wind turbine before. The general attitude of the representatives toward wind energy was a negative one. This may be a contributing factor explaining why 88% of the individuals were opposed to the project proposed for the Kouga local municipality.

The representatives were asked to rank a selection of aspects that could be affected by the development of a wind farm in the area. The representative's opinions on the impacts that a wind farm would have on the environment are shown in Table A. 2.

Table A. 2: The affluent focus group's opinion on the impacts of wind farms

Do you think the Kouga wind energy project will have a positive impact, negative impact or no impact on the following:					
	Negative	**Neutral**	**Positive**	**Not Sure**	**Result**
Tourism	7	1	0	0	87.5 % Negative
Job Creation	2	5	1	0	62.5 % Neutral
Electricity Rates	6	2	0	0	75 % Negative
Aesthetics of Landscape Views	8	0	0	0	100 % Negative
Property values	7	1	0	0	87.5 % Negative
Bird life	8	0	0	0	100 % Negative
Noise	5	2	0	1	62.5 % Negative

As can be seen in Table A. 2, the focus group was unanimous in their perception that the landscape views and the bird population in the area would be negatively affected. More than 75% of the focus group also held the perception that tourism, electricity prices and property values would be significantly worse off if the wind farm were built. The perceptions of the focus group toward job creation and the noise impact from wind turbines were not consistent for the whole group. This indicates that the focus group did not feel that these aspects were as significant relative to the other aspects presented.

The impact on the larger birds was a great concern to the group. Most identified that the mortality of large birds such as raptors, buzzards and cranes caused by collision with the turbine blades was a significant impact of concern. The solution to which was given by fewer turbines placed further apart. The destruction of local biodiversity and the aesthetics of the land caused by the construction of the wind turbines was also a highlighted concern. To a lesser extent the impact on property values, electricity prices and the lack of government policy concerning wind energy was also mentioned.

The individuals were asked if they would be willing to pay toward the development of the wind farm. All respondents indicated that they would not be willing to pay for it. When asked where they would appropriate any rent or royalties accrued to the community of St. Francis bay for the inconvenience of having the wind turbines located in their vicinity, the answers were divided. Three individuals indicated that they would like the money to go into a fund to improving the St. Francis Bay area. Two individuals indicated that they would not accept any money. One individual indicated that the money be used toward reducing rising electricity costs, another individual toward the betterment of the local indigent communities and the last individual had no preference for the allocation of the money. None of the individuals specified a percentage that they would be willing to accept.

The preference for a local representative's involvement with the wind farm development, updating the residents on the wind farm progress was divided across the group. Half indicated that it would improve their feelings toward the wind farm

There was concern over the loss of sense of place from the Kouga area moving away from being a tourism area to an industrial electricity generating area. Fewer, larger turbines placed further apart (ideally on devastated land) to allow space for large terrestrial birds is preferred.

Two interviews were conducted to include the opinions of the residents of Paradise Beach, Oyster Bay and Cape St. Francis. The first interview was conducted with a prominent member of the Paradise Bay community. Paradise Beach is a community of approximately 500 households with over 1000 residents. The second interview was conducted with the 2006-2010 Ward Councillor for the Oyster Bay and St. Francis Bay. Oyster Bay comprises 62 households of approximately 400 residents. The concerns of the resident in Paradise Beach and Oyster Bay were highlighted in these interviews.

From the interviews, it was determined that both the Oyster Bay and Paradise Beach residents shared similar sentiments as those of St. Francis Bay. Specifically, the residents are concerned about the negative impacts on tourism, birds and the aesthetics of the landscape views. The residents also feel that there will be no impact on noise or job creation. Alike the

St. Francis resident, residents of Paradise Beach and Oyster Bay also acknowledge that their sentiments toward the wind farm would be improved if a representative was to inform them of the wind farm developments. The effect on property prices was not considered significant, especially for the properties located further away from the wind farm, a distance of 6km away was considered further enough not to be affected by the wind farm. The greatest difference between the residents in Paradise Beach and Oyster Bay with that of St. Francis Bay was that the former were positive toward wind energy and approved of the wind farm development in the Kouga local Municipality.

One of the most important concerns of the Paradise Beach residents was security threats arising from the wind farm development. This is because the Paradise Beach community prides itself on it crime free environment due to its active neighbourhood watch. In Oyster Bay the number of turbines planned for development was of considerable concern.

The residents of Paradise Beach indicated that they would prefer any rent or royalties allocated to the area for having the wind turbines located in the vicinity of the settlement to be put toward reducing rates, either property or electricity. The Ward Councillor suggested that the residents of Oyster Bay would consider a reduction in electricity prices. The Ward Councillor also believes that the residents would be interested in allocating any rent or royalties into a fund to improve the Kouga area. This view was shared by some of the Kromme Trust members.

A. 2 The underprivileged focus group representatives results

The representatives for the underprivileged population were from the areas Kruisfontein, Sea Vista and Kwanomzamo. The representatives answered a similar questionnaire to that of the affluent representatives. The results of the preliminary survey questions are displayed in Table A. 3.

Table A. 3: Underprivileged focus group survey summary of preliminary questions

Questions	Yes	No	Cost
Do you know what a wind turbine is?	86%	14%	
Have you ever seen a wind turbine before?	100%	0%	
Do you pay for electricity	100%	0%	
How much do you pay for electricity a month?			R 137
Do you know about the wind farm project?	57%	43%	
Do you think this is a good project	100%	0%	
Would you be happier about the project if you had a friend or local representative who you trusted working with the developers on the project?	86%	14%	

All individuals surveyed indicated that they had seen a wind turbine before even though not all were aware of what a wind turbine was. A picture of a wind turbine was shown to each individual after the first question. After being shown the picture all individuals claimed to have seen a wind turbine before, most identifying that the turbine they had seen was the wind turbine located in Coega Harbour outside of Port Elizabeth.

All the representatives pay for electricity with the average cost of electricity for six of the respondents being R137. Of the seven individuals only 57% were aware of the proposed wind farm. Even though some individuals were unaware of the project, all individuals held the belief that it was a good project.

Each individual was asked to rank a list of aspects similar to those posed to the St. Francis Bay focus group (displayed in Table A. 2). The opinions that the underprivileged representatives held toward the impacts that the wind turbines would have on the environment are shown in Table A. 4.

Table A. 4: Underprivileged focus group's opinion on the impact of the wind farm

Do you think that the Kouga wind energy project will have a good effect, a bad effect, or no effect on the following:					
	Good Effect	**No Effect**	**Bad Effect**	**Result**	
Tourism	6	0	1	86%	Good Effect
Jobs	5	1	1	71%	Good Effect
Electricity prices	6	1	0	86%	Good Effect
The beauty of the land	6	0	1	86%	Good Effect
The animals that live in the area	0	4	3	57%	No Effect
The birds that live in the area	2	3	2	43%	No Effect
Noise	0	7	0	100%	No Effect
Theft and crime	3	3	1	43%	Good/ No Effect

The differences between the two focus groups were very evident from the ranking of the impacts shown in Table A. 2 and Table A. 4. Most of the residents in the three areas, Kruisfontein, Kwanomzamo and Sea Vista perceived that the wind farm development would have only positive or no effect on the aspects listed. The respondents perceived that there would be positive effects on tourism, jobs, electricity prices and the aesthetics of the land once the wind farm was constructed. The respondents were all in agreement in their perception that there would be no noise effect from the wind turbines. The respondents' perception of the effects on animals and birds was divided across the group, however the majority of the individuals felt that there would be no effect. The individuals were similarly split over their perceptions toward theft and crime, half indicated that the wind farm development would improve theft and crime the other half believed that the wind farm would have no effect on crime.

When each individual was asked to list three impacts that that they thought would most affect them, four of the seven respondents indicated that they were worried about the effect on the environment. In addition three respondents reported that they were concerned about the effect on jobs. Three individuals were concerned with the effect that the wind farm would have on the price of electricity. One individual identified that his concern was that the wind farm be properly maintained and that the local community be educated about the wind farm.

The representatives indicated that they would be willing to receive up to 56% additional subsidised electricity if the wind farm was located in the vicinity of their houses. When the respondents were asked where they would choose to locate the wind farm three of the respondents did not mind where the wind farm was located and three indicated that they would like the wind farm to be located in a different place from the current planned location in Kouga.

APPENDIX B: Focus group participants

Table B. 1: Names and contact details of the focus group members representing the affluent population

	Name	Brief Description	Contact details
1	Maggie & Eric Langlands	Kromme Trust Committee Member	Email: langlands@wirelessza.co.za Tel: +27 82 458 8063
2	Frank Silberbauer	Environmental Consultant for Infinity Consulting	Email: infinity@iafrice.com Tel: +27 42 294 0288
3	Bridget Elton	Kromme Trust Committee Member	Email: eltonem@telkomsa.net
4	Yvonne Bosman	Kromme Trust Committee Member	Email: ycraig@iafrica.com
5	Godfried Potgieter	Kromme Trust Committee Member	Email: potgieterga@telkomsa.net
6	Bev Howard	Kromme Trust Committee Member	Email: bevhow@mtnloaded.co.za
7	Peter Bosman	Kromme Trust Committee Member	Email: p.m.b@intekom.co.za
8	Chris Barratt	Kromme Trust Committee Member	Email: chris@barratt.co.za
9	John Wiehahn	Paradise Beach Neighbourhood Watch	Email: paradisebeach.Neighbourhoodwatch@vodamail.co.za Tel: +27 42 292 0369
10	Pieter Butler	Candidate Ward 14 Paradise Beach	Email: dawnviewinn@yahoo.com

Table B. 2: Names and contact details of the focus group members representing the underprivileged population

	Name	Brief Description	Contact details
1	Clive Commons	Kouga local municipality Housing Manager	Tel: +2742 2932929 Cell: +27730181239
2	Vernon Stuurman	Ward 4 proportional representative – Kruisfontein	Tel: +2783 605 9373
3	Ashley Williams	Resident Clark for the Kouga Municipality	Tel: +2778 439 3610
4	Caryl Logie	Housing Department Botanical specialist at the St. Francis Bay Links	Email: b.logie@telkomsa.net

APPENDIX C: Pilot study results

A total of 53 respondents were included in the pilot study sample. This sample was split between affluent and underprivileged residents. The affluent respondents that participated in the pilot study were predominantly from the areas of Humansdorp, Jeffrey's Bay and St Francis Bay. The underprivileged respondent group were mainly from the townships of Sea Vista (St Francis Bay) and Kwanomzamo (Jeffrey's Bay). The demographic and response data for both respondent groups are shown in Table C. 1 below.

Table C. 1: The demographic and socio-economic statistics for the pilot study

Characteristics		**Affluent Pilot Sample**	**Underprivileged Pilot Sample**
Total respondents		27	26
Average age		41	36
Gender:	Males	19%	62%
	Females	85%	38%
Education:	Secondary School	8%	42%
	Matriculation	54%	31%
	University	40%	8%
Average gross annual household income		R465, 835.86	R32, 034.69
Total responses to choice experiment:			
Status quo selected		13%	
Wind farm alternative selected		87%	
Choice proportion for each wind alternative		(87/2) = 43.5%	

From Table C. 1 the affluent respondents were on average better educated, earned larger gross annual household incomes and were older than the underprivileged respondent group. The gross annual household income for the affluent respondent group was R465, 835.86 as opposed to R32, 034.69 for the underprivileged respondent group. From the responses to the choice experiment section of the pilot study survey, the status quo was only selected 13% of the time whereas a wind farm alternative was selected 87% of the time.

The design of the choice experiment included 4 attributes at 3 levels each. A fractional factorial design was used to create 27 unique choice cards. These choice cards were randomly paired to form 27 questionnaires with 4 choice sets of two wind farm scenarios and a status quo each.

For the affluent respondent group the attributes included in the choice experiment were; size of the wind farm, distance away from residential areas, clustering of the wind turbines (effects coded) and a monthly household subsidy.

The results of the affluent and underprivileged group of respondents are shown in Table C. 2 and Table C. 3 respectively. The influence of each attribute on the choice probabilities can be determined by the signs of the coefficients (Krueger, 2007).

Table C. 2: Parameter Estimates for the attributes in the affluent group survey

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]
SIZE	-0.00455	0.008244	-0.552	0.5811
CLUSTER1	6.396119	1.863787	3.432	0.0006
CLUSTER2	6.797046	1.91498	3.549	0.0004
CLUSTER3	6.500913	1.874588	3.468	0.0005
DISTANCE	0.21464	0.064189	3.344	0.0008
SUBSIDY	0.000715	0.00077	0.928	0.3533

From Table C. 2 it can be seen that the sign of the coefficient for size is negative indicating that the respondents' utility decreases as the size of the wind farm increases. The coefficients of cluster1, cluster2 and cluster 3 are all positive and statistically significant (as can be seen from the p-value at a 5% level of significance). This indicates that there is no single clustering arrangement that is preferred over another but the positive coefficients indicate that the respondents derive higher utility from the development of wind farms than the current situation of no wind farms. As expected the distance attribute is positive and significant suggesting that greater utility is derived, the larger the distance between the wind farm developments and residential areas. The subsidy value is positive indicating that respondents prefer larger as opposed to smaller subsidy values per household.

The attributes included in the underprivileged respondent survey were; size of the wind farm, distance away from residential areas, job opportunities created by the wind farm and an increase in the electricity subsidy per month.

Table C. 3: Parameter Estimates for the attributes in the underprivileged group survey

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]
SIZE	0.008548	0.008005	1.068	0.2856
JOBS	0.029557	0.009716	3.042	0.0023
DISTANCE	-0.00871	0.005328	-1.635	0.102
SUBSIDY	0.032227	0.021508	1.498	0.134

In the underprivileged group the size attribute was insignificant at the 5% level however the coefficient of the attribute was positive suggesting that the underprivileged group preferred larger wind farms to smaller wind farms. The job attribute was both significant and positive indicating that the respondents' utility improves when a larger number of long-term jobs are created. The distance attribute was negative as was expected from the focus group. This indicates that the respondents would prefer the wind farm to be located closer to residential areas rather than far away. The subsidy per household is positive indicating that the respondents derived higher utility from increasing the subsidy.

The coefficient for the monetary attribute in both the affluent and underprivileged group is not significant at the 5% level of significance. This finding was unexpected but the explanation for the insignificance may be provided in one of three reasons, firstly, the sample size may be too limited to provide reliable estimates of the coefficients, secondly, the subsidy amount per household may not be a significant determinant of choice for a wind farm scenario and thirdly, there may be some moral bias present that is the respondents may believe that their answers are being judged or that there is a right and wrong answer. Calculations of willingness-to-accept could not be generated from these results due to the insignificance of the coefficient of the monetary attribute.

APPENDIX D: Affluent survey

RENEWABLE ENERGY IN THE KOUGA LOCAL MUNICIPALITY: A SURVEY OF RESIDENTIAL ATTITUDES TOWARD WIND ENERGY

1

Dear Respondent,

As part of a project on renewable energy in South Africa, the Nelson Mandela Metropolitan University is conducting a survey on the residents preference's for the location of wind farms in the Kouga local municipality. As the response from each individual will add to the validity of the results, the time you take to complete this survey will be greatly appreciated. Please note this is an anonomous survey and the results of this study will only be used for research purposes.

If you have any comments or questions please feel free to contact Ms. Jessica Hosking at misshosking@gmail.com or Prof. Mario du Preez at Mario.Dupreez@nmmu.ac.za .

This survey should take approximately 10 minutes to complete.

Are you a permanent resident or do you own property in the Kouga local municipality?

- ☐ Permanent resident
- ☐ Property owner (not permanent resident)

Where do you reside in the Kouga local municipality?

- ☐ St. Francis Bay ☐ Cape St. Francis ☐ Port St. Francis
- ☐ Oyster Bay
- ☐ Paradise Beach
- ☐ Humansdorp
- ☐ Jeffrey's Bay
- ☐ Other: ____________________

Question 1:

Below is a list of questions about wind turbines. Please mark your answers with a cross[X] in the relevant box or write your appropriate response.

1.1 Have you ever seen a wind turbine in operation?

- ☐ Yes
- ☐ No
- ☐ Not Sure

1.2 Do you favour wind as a source of electrical energy generation?

- ☐ Yes

☐ No

☐ Not Sure

1.3 A company called Red Cap Investments has proposed to place 121 wind turbines that stand 150 to 160 meters high in three separate areas in the Kouga local municipality for electricity generation. These wind turbines will provide approximately 300MW per hour[38] of electricity to South Africa. Do you support (or oppose) this project in the Kouga local municipality?

☐ Support

☐ Oppose

☐ Undecided

Comment:

____

1.4 Do you think that this project will have a positive impact, a negative impact or no impact on the following aspects? (tick the appropriate block in each row.)

Aspects	Positive Impact	No Impact	Negative Impact	Not Sure
Tourism				
Job Creation				
Electricity rates				
Aesthetics of landscape views				
Property values				
Bird life				
Noise				
Global environment and climate				

1.5 Do the wind turbines generate electricity if there is no wind present?

☐ Yes

☐ No

☐ Not Sure

[38] An average household uses ± 1.1 MWh per month or 13.2 MWh per annum. In one year the Red Cap investments wind energy development will generate approximately 650 000 MWh, which can supply approximately 50 000 households with electricity each month.

1.6 Would this area (Kouga) still be reliant on fossil fuel generated electricity if the wind farm was established?

- ☐ Yes
- ☐ No
- ☐ Not Sure

1.7 Is the location of a wind turbine relevant to how much electricity it can generate?

- ☐ Yes
- ☐ No
- ☐ Not Sure

1.8 A nuclear power plant has also been proposed in this region for electricity generation. Would you be more or less likely to support the nuclear project rather than the wind project?

- ☐ More likely to support (nuclear)
- ☐ Less likely to support (nuclear)
- ☐ No effect on my decision
- ☐ Other:____

1.9 Would you be more or less supportive of this wind farm project if a local representative was updating you with information about relevant project developments?

- ☐ More likely to support
- ☐ Less likely to support
- ☐ No effect on my decision
- ☐ Other:____

Question 2:
On a scale of 1 to 5 please indicate how strongly you agree or disagree with the statement. [1 = strongly disagree, 3 = neutral, 5 = strongly agree]

2.1 By utilizing wind energy as a source of electricity, South Africa will reduce its carbon footprint.

☐ Strongly disagree ☐ Don't know
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly agree

2.2 The larger the number of wind turbines the greater the positive impact on the environment.

☐ Strongly disagree ☐ Don't know
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly agree

2.3 The presence of a wind turbine in the Kouga local municipality will reduce the happiness of the residents of the Kouga local municipality.

☐ Strongly disagree ☐ Don't know
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly agree

2.4 Land-based wind turbines have an affect on the appearance of the landscape.

☐ Strongly disagree ☐ Don't know
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly agree

2.5 If the wind turbines are positioned close together, birds and bats will be significantly affected.

☐ Strongly disagree ☐ Don't know
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly agree

2.6 Wind turbines should be located far away from residential areas.

☐ Strongly disagree ☐ Don't know
☐ Disagree
☐ Neutral
☐ Agree
☐ Strongly agree

<u>Question 3:</u>

We are now going to ask you ***FOUR*** *questions. In this section you will get to vote on wind power development. The questions will be in the format of the table below. For each question please assume that the option that receives the most votes will be carried out.*

There are four things to consider:

1. A subsidy per household

-> This is a subsidy allocated to each household in the Kouga Municipality for the inconvenience of having the turbines located in their vicinity.

2. The size of the wind farm

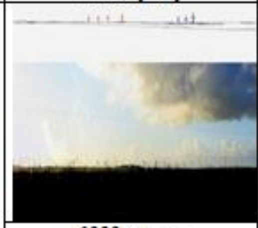
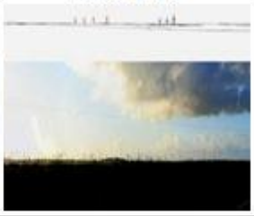
-> The number of turbines in the wind farm

3. The clustering

-> How the wind turbines are placed i.e. "close together" or "widely spaced apart".

4. The distance

-> The distance between the closest turbine and the residential areas.

1.11.3	Option A	Option B	Option C
Amount allocated to each household	*R250 per month*	*R100 per month*	*I choose neither Option A nor Option B (No wind energy development)*
Size of wind farm	 *10 Wind Turbines*	 *53 Wind Turbines*	
Clustering (spread of wind turbines)	 *Close Together (less than 250m apart)*	 *Widely spaced (greater than 501m apart)*	
Distance away from residential areas	 *6000m away*	 *6000m away*	
Selection: (one block please)	A	X	C

Example: This respondent selected Option B because he/she prefered *<u>fewer,</u>* more *<u>widely spaced</u>* turbines at a *<u>greater distance away</u>* from residential areas, even though the *<u>subsidy amount for his/her household was less</u>*.

<u>Please Note:</u>

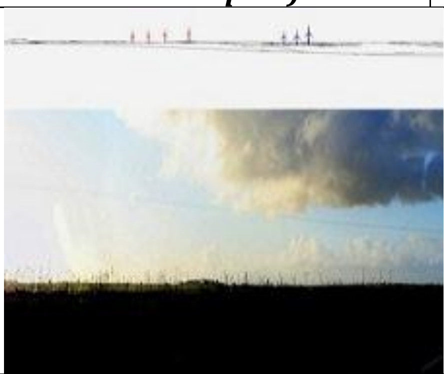
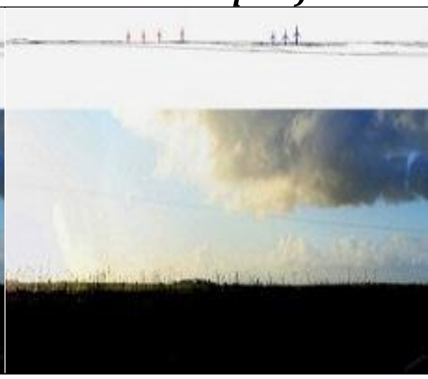
- PLEASE CHOOSE ONLY ONE OPTION ON EACH PAGE!

- Each choice you make should be considered separately from the other choice you make (independent)

- Option A and B are two different scenarios for the wind farm development and Option C is the status quo or 'No wind farm development' option.

- Your responses are not being judged in any way.

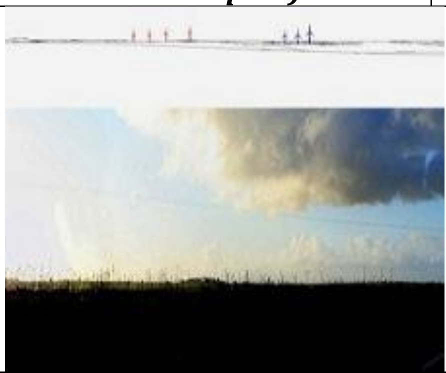
- There are no right or wrong answers. However, you should try to take all the aspects presented into account when making a choice.

Choice 1			
1.11.3	**Option A**	**Option B**	**Option C**
Amount allocated to each household	*R250 per month*	*R100 per month*	*I choose neither Option A nor Option B* *(No wind energy development)*
Size of wind farm	 *10 Wind Turbines*	 *53 Wind Turbines*	
Clustering (spread of wind turbines)	 *Close Together (less than 250m apart)*	 *Widely spaced (greater than 501m apart)*	
Distance away from residential areas	 *6000m away*	 *6000m away*	
Selection: *(one block please)*	A	B	C

Choice 2			
1 . 17 . 25	**Option A**	**Option B**	**Option C**
Amount allocated to each household	*R550 per month*	*R100 per month*	
Size of wind farm	 *10 Wind Turbines*	 *53 Wind Turbines*	*I choose neither Option A nor Option B (No wind energy developmen t)*
Clustering (spread of wind turbines)	 *Close Together (less than 250m apart)*	 *Moderately close together (between 251m and 500m apart)*	
Distance away from residential areas	 *2000m away*	 *500m away*	
Selection: *(one block please)*	A	B	C

Choice 3

1 . 24 . 26	Option A	Option B	Option C
Amount allocated to each household	*R100 per month*	*R550 per month*	*I choose neither Option A nor Option B* *(No wind energy development)*
Size of wind farm	 *53 Wind Turbines*	 *53 Wind Turbines*	
Clustering (spread of wind turbines)	 *Close Together (less than 250m apart)*	 *Widely spaced (greater than 501m apart)*	
Distance away from residential areas	 *2000m away*	 *500m away*	
Selection: *(one block please)*	A	B	C

Choice 4			
1.1.12	**Option A**	**Option B**	**Option C**
Amount allocated to each household	*R550 per month*	*R100 per month*	*I choose neither Option A nor Option B* *(No wind energy developmen t)*
Size of wind farm	 *10 Wind Turbines*	 *10 Wind Turbines*	
Clustering (spread of wind turbines)	 *Widely spaced (greater than 501m apart)*	 *Widely spaced (greater than 501m apart)*	
Distance away from residential areas	 *6000m away*	 *2000m away*	
Selection: *(one block please)*	A	B	C

Question 4:

4.1 Overall how easy or difficult was it to make the choices in question 3?

- ☐ Easy
- ☐ Somewhat easy
- ☐ Somewhat difficult
- ☐ Difficult

4.2 If you answered 'Difficult' or 'somewhat difficult' in question 4.1 above, what made the choices hard?

- ☐ I didn't understand the choices
- ☐ There was too much information to consider
- ☐ It was difficult to choose because several factors were important
- ☐ I don't agree with the placement of the wind farm development in the Kouga area
- ☐ I would need more compensation for the wind farm to be placed in the Kouga area
- ☐ Other____

4.3 Was there any item that was **most** important to you when you made your choices in question 3 or did it vary with every choice you made?

- ☐ Size of the wind farm (number of turbines)
- ☐ Clustering of turbines (spread of wind turbines)
- ☐ Distance away from residential areas
- ☐ Subsidy per household
- ☐ It varied from choice to choice
- ☐ I don't know

4.4 If you chose 'Option C' (I choose neither Option A nor B) for most of the scenarios presented, what were your reasons?

- ☐ Did not choose option C
- ☐ Not in favour of wind energy
- ☐ Do not want the wind farm developed in the Kouga local municipality
- ☐ A preferable option was not presented
- ☐ Other:____

Question 5:

Finally, a few questions about yourself to help us interpret the results of the survey.

5.1 What is your gender?

- ☐ Male
- ☐ Female

5.2 How old are you? ________ years

5.3 Please state the current occupation of the main income earner (breadwinner) in your household (previous occupation if retired)?___________________________

5.4 What is the size of your household's total annual gross income? Please note: This should be income before tax deductions. (*Please indicate one income category only by making a cross [X] in the relevant box below.)*

- ☐ Less than R50 000
- ☐ R50 000- R199 000
- ☐ R200 000 – R399 999
- ☐ R400 000 – R749 999
- ☐ R750 000 – R999 999
- ☐ R1 000 000 or above
- ☐ Not willing to specify
- ☐ If willing please state the number:__________________________________

5.5 What is your highest level of education attainment? (*Please indicate one level of education only by making a cross [X] in the relevant box below)*

- ☐ No education
- ☐ Primary school education
- ☐ Secondary school education
- ☐ Matriculation
- ☐ Technikon diploma
- ☐ University degree
- ☐ University post graduate degree
- ☐ Other____

APPENDIX E: Underprivileged survey

RENEWABLE ENERGY IN THE KOUGA LOCAL MUNICIPALITY: A SURVEY OF RESIDENTIAL ATTITUDES TOWARD WIND ENERGY

1

Dear Respondent,

As part of a project on renewable energy in South Africa, the Nelson Mandela Metropolitan University is conducting a survey on the residents preference's for the location of wind farms in the Kouga local municipality. As the response from each individual will add to the validity of the results, the time you take to complete this survey will be greatly appreciated. Please note this is an anonomous survey and the results of this study will only be used for research purposes.

If you have any comments or questions please feel free to contact Ms. Jessica Hosking at 084 418 48 57 or Prof. Mario du Preez on 041 504 2795.

This survey should take about 10 minutes to complete.

Are you a visitor or do you live in the Kouga local municipality?

- ☐ Visitor
- ☐ Resident

Where do you live in the Kouga local municipality?

- ☐ Sea Vista
- ☐ Kwanomzamo
- ☐ Kruisfontein
- ☐ Tokyo Sexwale
- ☐ Umzamowethu
- ☐ Other: ________________________________

<u>Question 1:</u>

Below is a list of questions about wind turbines. Please mark your answers with a cross[X] in the relevant box or write your answer in the space.

1.1 Have you ever seen a wind turbine before? →

- ☐ Yes
- ☐ No

1.2 Do you know what a wind turbine does?

- ☐ Yes → (It uses wind energy to make electricity)
- ☐ No
- ☐ Not Sure

1.3 Do you have electricity in your home?

- ☐ Yes
- ☐ No

1.4 How much do you pay for electricity per month? R____________ per month

1.5 A company called Red Cap Investments wants to put up 121 wind turbines that are 150 to 160 meters tall in three different areas in the Kouga local municipality. These turbines will be able to create enough electricity to supply 50 000 houses with electricity each month. Do you want these turbines to be built in the Kouga local municipality?

- ☐ Yes
- ☐ No

1.6 Do you think that the Kouga wind energy project will have a good effect, no effect or a bad effect on the following? (Please tick one block in each row).

Items	**Good Effect**	**No Effect**	**Bad Effect**	**Not Sure**
How many people come to Kouga				
New jobs created				
The price of electricity				
How nice the area looks				
Animals that live in the area				
The birds that live in the area				
The amount of noise in the area				

1.7 Why do you think the company Red Cap Investments is building the wind farm in the Kouga area?

- ☐ Because people in Kouga need electricity
- ☐ Because the wind in Kouga is good for a wind farm
- ☐ Because building the wind farm will be profitable for Red Cap Investments
- ☐ Because the people living in Kouga asked them to build it here
- ☐ Not sure

1.8 Would you prefer a nuclear power plant to be built instead of the wind farm in the Kouga area?

- ☐ Yes
- ☐ No
- ☐ Not Sure

Question 2:

Below is a range of statements relating to the proposed wind farm in the Kouga local municipality. Please indicate if the statement is true or false by making a mark[X] in the relevant box.

2.1 Wind turbines help to clean the air (reduce air pollution).

- ☐ True
- ☐ False
- ☐ Not Sure

2.2 The larger the wind farm (lots of wind turbines) the better the effect on the environment and nature.

- ☐ True
- ☐ False
- ☐ Not Sure

2.3 The more wind turbines there are the more jobs will be created.

- ☐ True
- ☐ False
- ☐ Not Sure

2.4 If wind turbines are built here, in the Kouga local municipality, then the people living here will be happier.

- ☐ True
- ☐ False
- ☐ Not Sure

2.5 Wind turbines can spoil the look of the land.

- ☐ True
- ☐ False
- ☐ Not Sure

2.6 Wind turbines should be built far away from where people live.

- ☐ True
- ☐ False
- ☐ Not Sure

2.7 If there is no wind, the wind turbines will still be able to make electricity

- ☐ True
- ☐ False
- ☐ Not Sure

2.8 It does not matter where you place the wind turbines because they will always make the same amount of electricity

- ☐ True
- ☐ False
- ☐ Not Sure

Question 3: Choice experiment

We are now going to ask you to make ***FOUR*** *choices. In this section you will get to vote on wind power development. The choices will similar to that of the choices shown in the table below. For each choice please assume that the option that gets the most votes will be carried out.*

There are four things to consider:

1. An increase in free electricity

-> A percentage increase in the amount of free electricity given to each house in the Kouga Municipality for the having the turbines located near their homes.

2. The size of the wind farm

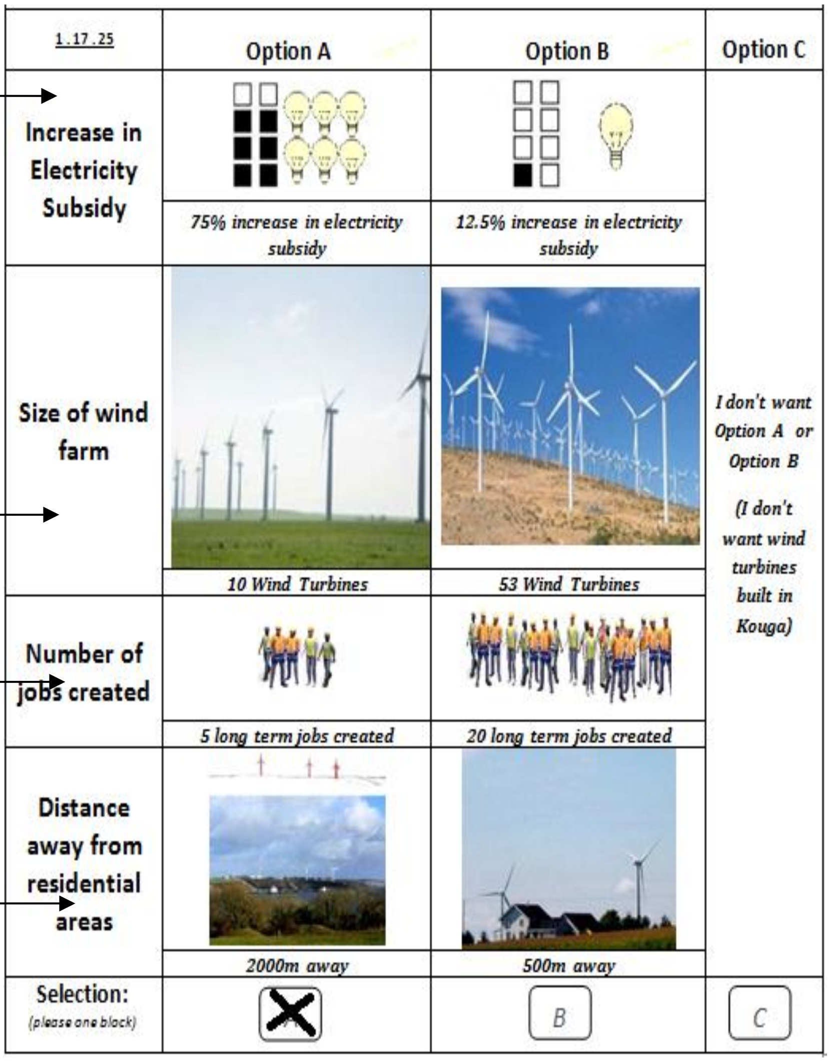
-> The number of turbines in the wind farm

3. The number of jobs created

-> The number of long term jobs created by the wind farm development

4. The distance

-> The distance between the closest turbine and the homes of Kouga residents.



Example: This person chose Option A because he/she likes *<u>less turbines,</u>* at a *greater distance away* from areas where people live, with a bigger *amount of electricity subsidy* even though the *number of jobs created is less*.

Please Note:

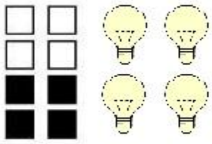
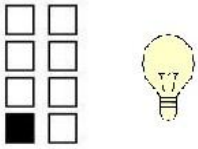
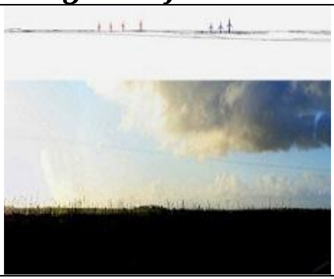
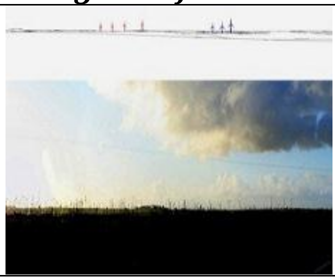
- PLEASE CHOOSE ONLY ONE OPTION!

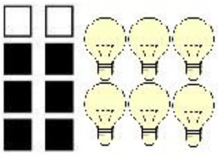
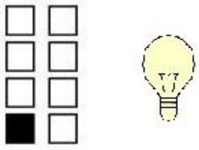
- Each choice should be considered separately from the other choices. There are **FOUR** different choices to make.

- Option A and B are two different scenarios for the wind farm development and Option C is the status quo or 'Neither A nor B' option.

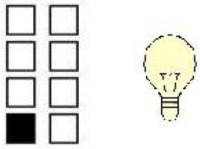
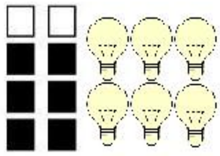
- Your responses are your preference - there is no right or wrong answer.

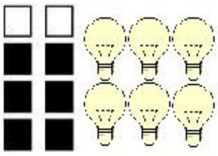
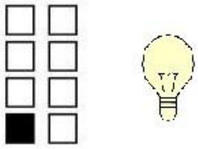
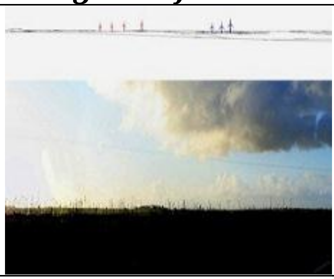
- You should try to use all the information given to you when making a choice.

Choice 1			
1 . 11 . 3	**Option A**	**Option B**	**Option C**
Increase in Electricity Subsidy	 *50% increase in electricity subsidy*	 *12.5% increase in electricity subsidy*	*I don't want Option A or Option B* *(I don't want wind turbines built in Kouga)*
Size of wind farm	 *10 Wind Turbines*	 *53 Wind Turbines*	
Number of jobs created	 *5 long term jobs created*	 *40 long term jobs created*	
Distance away from residential areas	 *6000m away*	 *6000m away*	
Selection: *(please one block)*	A	B	C

Choice 2			
1 . 17 . 25	**Option A**	**Option B**	**Option C**
Increase in Electricity Subsidy	 *75% increase in electricity subsidy*	 *12.5% increase in electricity subsidy*	*I don't want Option A or Option B* *(I don't want wind turbines built in Kouga)*
Size of wind farm	 *10 Wind Turbines*	 *53 Wind Turbines*	
Number of jobs created	 *5 long term jobs created*	 *20 long term jobs created*	
Distance away from residential areas	 *2000m away*	 *500m away*	
Selection: *(please one block)*	A	B	C

Choice 3

1 . 24 . 26	Option A	Option B	Option C
Increase in Electricity Subsidy	 *12.5% increase in electricity subsidy*	 *75% increase in electricity subsidy*	*I don't want Option A or Option B* *(I don't want wind turbines built in Kouga)*
Size of wind farm	 *53 Wind Turbines*	 *53 Wind Turbines*	
Number of jobs created	 *5 long term jobs created*	 *40 long term jobs created*	
Distance away from residential areas	 *2000m away*	 *500m away*	
Selection: *(please one block)*	A	B	C

Choice 4			
1 . 1 . 12	**Option A**	**Option B**	**Option C**
Increase in Electricity Subsidy	 *75% increase in electricity subsidy*	 *12.5% increase in electricity subsidy*	***I don't want Option A or Option B*** ***(I don't want wind turbines built in Kouga)***
Size of wind farm	 ***10 Wind Turbines***	 ***10 Wind Turbines***	
Number of jobs created	 ***40 long term jobs created***	 ***40 long term jobs created***	
Distance away from residential areas	 ***6000m away***	 ***2000m away***	
Selection: *(please one block)*	A	B	C

Question 4:

4.1 How easy or difficult was it to make the choices in question 3?

☐ Easy

☐ Somewhat easy

☐ Somewhat difficult

☐ Difficult

4.2 If you answered 'Difficult' in question 4.1 above, what made the choices hard?

☐ I didn’t understand the choices

☐ There was too much information

☐ It was difficult to choose because several things were important

☐ I don’t want the wind farm to be built in the Kouga area

☐ I would need a larger amount of subsidised electricity to accept the wind farm in the Kouga area

☐ Other

____

4.3 Was there any item that was most important to you when you made your choice in question 3 or did change with every choice?

☐ It was different for each choice

☐ Size of the wind farm (number of turbines)

☐ Distance away from areas where people live

☐ Number of jobs created

☐ Subsidy per household

☐ Don't know

4.4 If you chose 'Option C' (I choose neither option A nor B) for most of the choices, what were your reasons?

☐ Do not like wind energy

☐ Do not want the wind farm built in the Kouga local municipality

☐ A better option was not given

☐ Other:

____

Question 5:

Finally, a few questions about yourself to help us interpret the results of the survey.

5.1 What is your gender?

- ☐ Male
- ☐ Female

5.2 How old are you? ________ years

5.3 Do you earn the most money in your household?

- ☐ Yes, what is your job? (previous if retired or unemployed) ______________
- ☐ No, what is the job of the person who earns the most _________________

5.4 What is the size of your total monthly income? Please note: This is all income from every person that lives in your house, before tax.

- ☐ R0 - R1000
- ☐ R1001 - R2000
- ☐ R2001 – R3500
- ☐ R3501 – R5000
- ☐ R5000 – R10 000
- ☐ R10 000 or above
- ☐ Not willing to say
- ☐ Don't know
- ☐ If willing please state the number:____________________________________

5.5 What is your highest level of education?

- ☐ No education
- ☐ Primary school education
- ☐ Secondary school education
- ☐ Matriculation
- ☐ Technikon diploma
- ☐ University degree
- ☐ University post graduate degree
- ☐ Other____