ECONOMIC VALUATION OF THE VISUAL EXTERNALITIES OF OFF-SHORE WIND FARMS

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Preface

The primary focus of the study presented in this report is visual externalities of off-shore wind farms and the Danish population's willingness to pay for having these externalities reduced. The investigation is part of the *Danish monitoring programme for off-shore wind farms,* comprising several studies of the environmental impact of off-shore wind farms. The programme is coordinated by the *Environmental Group* with representatives from Elsam Engineering, Energy E2, the Danish Forest and Nature Agency, and the Danish Energy Authority.

The present study was initiated in August 2003, and this report concludes the project. An overview of the findings will also be published in a joint publication, comprising all projects under the *Danish monitoring programme for off-shore wind farms*. Further research within this area is taking place in connection with a Ph.D. programme at KVL.

The authors would like to thank all the individuals and institutions who have provided information and advice. We owe special thanks to Associate Professor Ståle Navrud for useful comments during the development of the questionnaire. We are also grateful to the individual members of the project group for information and constructive comments during the whole project period.

Executive Summary

Under the Kyoto Protocol, Denmark has an obligation to reduce its CO_2 emissions by 21 per cent. Expansion of wind power is one of the relevant measures to realize this target. Negative externalities in terms of visual disamenities and noise nuisances may make it difficult to find new areas suitable for land-based wind turbines. Today approximately 420 MW offshore wind power capacity is installed in Denmark. The tendering process for another 400 MW is proceeding – a concession on Horns Rev 2 (200 MW) has already been granted. Further the Danish Government will support the future development of wind power including offshore, *inter alia* by extending the required transmission capacity. Off-shore location of wind turbines eliminates noise nuisances. Visual disamenities can be reduced by extending the distance to the shore. However, the costs per kWh produced increase as the distance is augmented. Hence, the social planner is confronted with a trade-off between minimizing the disamenities, on the one hand, and accepting higher costs of power generation, on the other. To find an optimal solution, the disamenities must be measured in monetary terms. This is the primary objective of the present study.

The social costs associated with visual externalities from off-shore wind farms were estimated using the choice experiment valuation method. The applied choice experiment was designed to estimate the visual externalities as a function of the size of wind farms, number of wind farms and their distance from the coast. Furthermore, the project investigated whether the preferences for the visual externalities vary among the Danish population in general and the populations living in the vicinity of the two existing off-shore wind farms at Horns Rev (HR) and Nysted (NY). The wind farm at Horns Rev is located at a distance of 14-20 km from the coast line and consists of 80 wind turbines, each of 2 MW. At Nysted the wind farm is located at a distance of 9-10 km form the shore line and consists of 72 wind turbines of each 2.3 MW. The survey also examined respondents' opinions on previous and future development of wind power.

With regard to wind power development, the respondents in all three samples expressed a general acceptance of the existing land-based wind turbines as well as off-shore wind farms in Denmark. Where the establishment of *additional* land-based wind turbines is concerned, one out of four respondents expressed a negative or very negative attitude. In contrast, less than 10 per cent of the respondents across the three samples had a negative or very negative attitude towards the construction of *more* off-shore wind farms. In the Nysted sample attitudes towards off-shore wind farms tend to be slightly more negative than in the two other samples. Still, it is safe to conclude that people in the Horns Rev and Nysted areas have attitudes towards off-shore wind power that are fairly similar to those of the Danish population in general.

The study is based on a mail survey of 700 households in a national sample and 350 households in each of two sub-samples in the HR and NY areas, respectively. The survey used four alternative wind farm distances from the coast, namely: 8, 12, 18 and 50 km. The payment vehicle was additional costs of electricity per household per year. Willingness to pay (WTP) for increasing the distance (relative to an 8 km base line) were elicited based on respondents' choices between alternative off-shore wind farm locations – and the associated increase in the electricity bill. The main results are presented in Figure 1.

Taking the *national sample* as the "standard" case, Figure 1 shows the following pattern: WTP for extending the distance from 8 to 12 km is 330 DKK/household/year. The WTP increases by more than 100 per cent for extending the distance from 12 to 18 km, where the visual disamenities are significantly reduced, and by around 30 per cent for having the distance extended from 18 to 50 km, i.e. virtually out of sight. In other words, there is a significant willingness to pay for having wind farms located at distances where the visual disamenities are fairly small, i.e. up to 18 km from the shore. There are not equally strong preferences – in terms of willingness to pay – for having wind farms moved further out to a distance of 50 km where they are virtually invisible from the shore.

Taking the two *local samples,* Figure 1 shows a somewhat different pattern of willingness to pay. In the HR sample, respondents are willing to pay (only) 262 DKK/household/year for having the distance extended from 8 to 12 km. WTP increases by close to 150 per cent for having the distance extended from 12 to 18 km, but surprisingly there is no extra WTP for having wind farms moved from 18 to 50 km from the shore. (The drop in WTP from 643 DKK to 591 DKK when going from 18 to 50 km is not statistically significant).

In the NY area respondents are willing to pay nearly twice as much as in the national sample for having the distance of wind farms extended from 8 to 12 km from the shore. WTP for extending the distance to 18 km is not much higher than WTP for 12 km, but WTP increases by more than 160 per cent for locating wind farms out of sight, i.e. at a distance equal to 50 km from the shore.

It lays near at hand to seek the explanation for these WTP patterns in the different experiences with off-shore wind farms people in the two areas have. The HR wind farm is located at a distance of 14-20 km from the coast line. That is, at a distance where the visual disamenities are significantly reduced. The NY wind farm, on the other hand, is located at a distance of only 9-10 km form the shore. This means that the visual disamenities are rather significant. As noted previously, the NY sample did not have a much greater share of respondents expressing negative attitudes towards wind farms. However, when focussing on respondents expressing preferences for moving wind farms out of sight, this subgroup had considerably *stronger* preferences for this alternative in the NY sample than the similar subgroups in the two other samples. A sociological investigation in the NY area shows a similar pattern (see Kuehn, 2005a and 2005b).

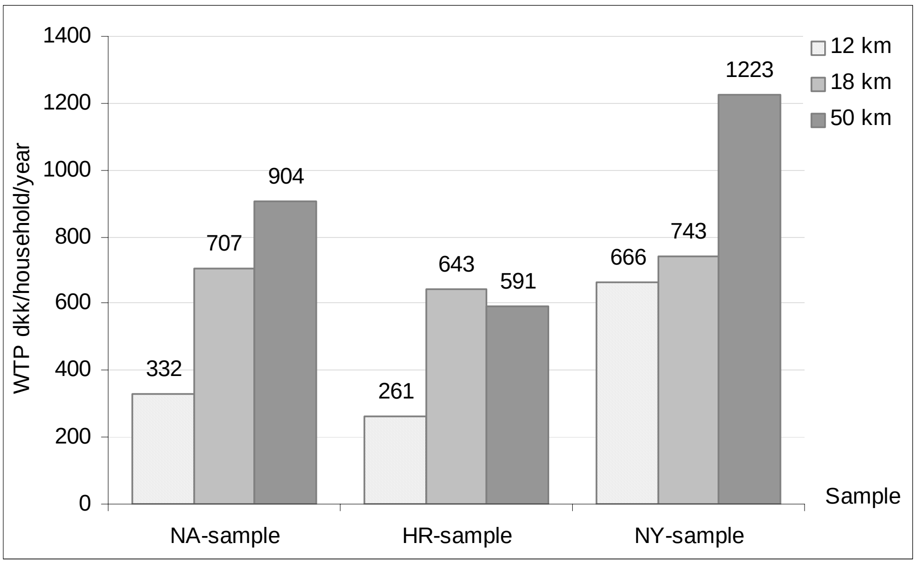

Figure 1: Willingness to pay for having future off-shore wind farms located at the specified distances from the shore – relative to an 8 km

baseline. DKK/household/year. Samples: NA = National, HR = Horns Rev, NY = Nysted.

Generated employment

The employment effects associated with the construction and running of wind farms were calculated using input-output model data. The results are presented in chapter 8. Taking the Horns Rev wind farm as a model, the calculations show that the establishment of an off-shore wind farm with 80, 2 MW turbines creates a total of around 2,000 man years of domestic employment over the construction period. A tentative estimate indicates that up to one quarter of this will be at the local level. Operation and maintenance over the 20-year life time of the park will create an additional 1,700 man years of employment. It is expected that three quarters of this will be at the local level.

Cost Benefit Analysis

The willingness-to-pay estimates can be used in cost-benefit analyses of the optimal location and design of future off-shore wind farms in Denmark – and possibly elsewhere in the world. At the time of writing it has not been possible to get access to project specific or generic data on the costs of placing off-shore wind farms at different distances from the coast. Consequently, the present report does not contain any appraisals regarding the future policies in this context. It is the aim to collect/estimate the relevant cost data in a subsequent study.

Extended Abstract of Results

Survey Design, Samples and Response Rates

The study is based on a mail survey including 700 households in a national sample, and 350 households in two sub samples in the Horns Rev and Nysted areas. In the choice experiment, four alternative off-shore wind farm distances from the coast were used namely: 8, 12, 18 and 50 km. Based on the respondents' choices between alternative locations of off-shore wind farms their willingness to pay (WTP) for increasing the distance was elicited using three different sub samples for each of the three locations. These sub samples were constructed using the full sample (B-model), a sample containing respondents who were certain in their choice (C-model) and finally a sample containing respondents, who according to a defined set of questions were considered consistent and rational in their choice (R-model).

Response Rate

Of the 1400 randomly selected households in the three samples close to 50 per cent returned the questionnaires. Only 3 per cent were discarded because of lack of information, leaving 48 per cent or 672 respondents in the three samples. The number of respondents was 362 for the national sample, and 140 and 170 for the Horns Rev and Nysted samples, respectively.

Socio-economic characteristic

The preferences for the location and the size of off-shore wind farms might differ between the respondents as a function of their socio-economics characteristics. Therefore, the representativity of the sample was examined for the four characteristics: gender, education, income and age, comparing respondents between samples and to the national average.

It was found that, in general, no respondents differed substantially from the local or the Danish average. The largest difference identified was that all three samples contained a larger proportion of well-educated individuals compared to the Danish average. Surprisingly, this was not reflected in a similar difference in income. It is concluded that socio-economic differences between the samples and national/local averages are so small that they do not affect the estimated level of willingness to pay. Furthermore, it was established that the exclusion of respondents required for the derivation of the C and R models, did not have an effect on the composition of the respondent's socio-economic characteristics. Consequently, it is concluded that comparisons of preferences across models in each sample can be done with relatively little loss of generality.

Distribution of choice sets

The statistical design of the mailed questionnaires was made to ensure that the different choice sets and the levels of the attributes appeared in the same proportions. There is no guarantee that the 50 per cent returned questionnaires still hold these properties. Also, the trimming of the dataset when deriving the C- and R-models, might cause a change in the relative distribution between choice sets. In fact, statistical analyses showed that the distribution was no longer uniform in these samples. However, the deviations were not of a magnitude which could seriously affect the estimation results.

Attitudes towards Wind Power and Energy Policy in General

In the survey respondents were asked to indicate their attitudes towards wind power and other types of alternative energy on a five point scale, ranging from very positive to very negative and a "do not know option".

Energy Policy

One of the attitudinal questions addressed respondents' opinions about how Denmark should realize its international obligations to reduce CO_2 emissions. In all three samples around 80 per cent of the respondents answered that wind and solar power should be applied "to a large extent". Between 60 and 70 per cent gave a similar ranking to energy savings. Only about 5 per cent indicated that the CO_2 quota trade should be applied "to a large extent". In other words, there were strong preferences for measures reducing CO_2 emissions domestically.

Land-based wind turbines

Across the three samples, less than 15 per cent of the respondents indicated a negative attitude towards existing land-based wind turbines. In the two local samples, though, the attitudes were a bit more negative than in the national sample. It is possible that this difference in attitude can be explained by the relatively high density of (land-based) wind turbines in the local sample areas compared to the national density level. However, it is the general conclusion that there is a high level of public support for this part of the Danish energy policy.

The attitude towards the erection of *more* land-based wind turbines is also quite positive, but the number of respondents with a negative attitude has almost doubled. Between one fifth and one fourth of the respondents have a negative attitude towards *more* land-based wind turbines. The respondents in the NY sample are the most negative. Here more than 25 per cent of the respondents indicate a negative attitude towards more land-based turbines. A negative attitude towards land-based wind power is highly correlated with the stated opinion that wind turbines have a negative impact on landscape amenities.

Off-shore wind turbines

The attitudes towards off-shore wind farms are even more positive than the attitudes towards land-based turbines. Less than 10 per cent of the respondents across the three samples have a negative attitude towards existing off-shore wind farms. The same holds for an expansion of off-shore wind power generation. The respondents in the HR sample have the most positive attitude among the three samples. The Horns Rev off-shore wind farm is located 14-20 km from the coast. The NY sample is the most negative. Here the wind farm is located relatively close to the coast, i.e. 10-14 km. Nevertheless, it is the general conclusion that there is a high level of public support for further wind power development in Denmark – also in the two areas where large wind farms have already been established.

Willingness to Pay for Reduced Visual Externalities

A positive attitude towards off-shore wind power development does not necessarily imply that people are content with whatever level of visual disamenities which this might create. The survey investigated if there is a willingness to pay for reducing the visual disamenities associated with future off-shore wind power development. The respondents each evaluated three choice sets containing two alternative off-shore development plans. An off-shore development plan is characterised by a set of attributes which define the size, distance, cost and visual impact of a wind farm.

The respondents in all three samples hold significant preferences for reducing the visual externalities of the future off-shore wind farms in the valuation scenario – comprising the off-shore erection of 720 turbines. The WTPs for reducing the visual externalities of off-shore wind farms in this scenario is presented in Figure 2 for each sample.

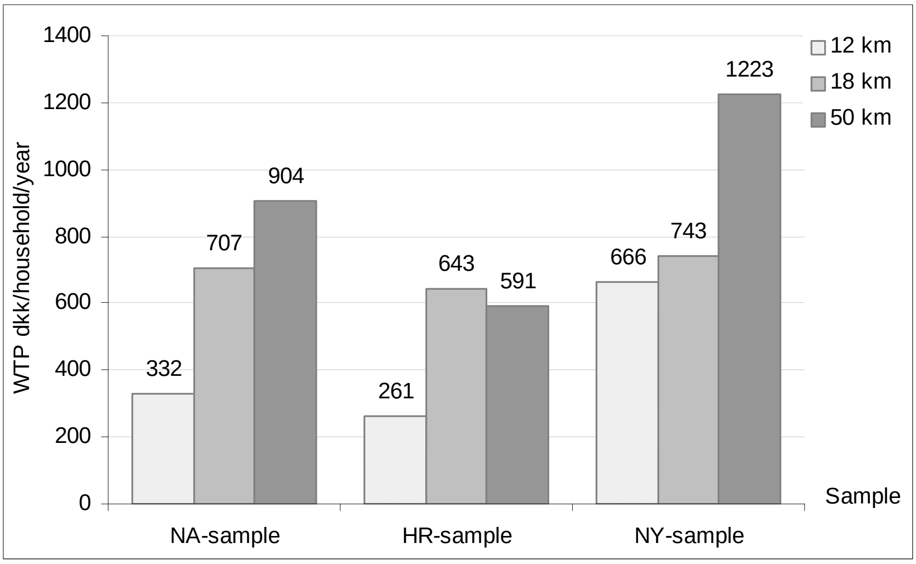

Figure 2: Willingness to pay in Basic Model for locating future off-shore wind farms at the specified distances from the shore – relative to an 8 km baseline. DKK/household/year. NA: National, HR: Horns Rev, NY: Nysted.

National sample

Starting with the NA sample, the respondents are willing to pay 332 DKK/household/year for having future wind farms located at 12 km distance, compared to 8 km. The WTP for moving the wind farms to 18 and 50 km is 707 and 904 DKK/household/year, respectively. The WTP can also be expressed in terms of how much the respondents are willing to pay for moving the wind farm one more km away, also known as the *marginal* willingness to pay. The marginal WTP is interesting in the sense that it is an estimation of the benefits (of reducing the visual externalities) associated with mowing the wind farms one more km away from the coast. In the national sample WTP is equal to 332 DKK for the 4 km in the interval 8-12 km. This gives a marginal WTP equal to 82 DKK/household/year/km. The marginal WTP for moving the wind farm from 12 to 18 km and 18-50 km can be estimated in a similar way. The marginal WTP in the interval 12-18 km ≈ 62 DKK/household/year/km, and the marginal WTP in the interval 18-50 km ≈ 6 DKK/household/year/km. In other words, the social benefits from reducing the visual disamenities from off-shore wind farms decline sharply for distances beyond the interval 12-18 km.

Horns Rev Sample

In the HR sample, the preferences for reducing the visual externalities are less than in the NA sample. As illustrated in Figure 37 (in Section 9.2.1) the respondents in the HR sample are willing to pay 262, 643 and 591 DKK/household/year for mowing the wind farms from 8 km to 12, 18 or 50 km, respectively. It seems a paradox, of course, that WTP for moving the wind farms to 18 km is larger than WTP for moving them out to 50 km. However, the difference between the two WTP measures is not statistically significant. The marginal WTP in the interval 8 to12 km is 66

DKK/household/year/km. In the interval 12 to 18 km, marginal WTP is 64 DKK/household/-year/km. Given that the respondents are indifferent to having the wind farms at 18 or 50 km the marginal WTP in this interval is = 0.

Nysted Sample
The respondents in the NY sample hold the strongest preferences for locating wind farms as far from the coast as possible and preferably out of sight. This is reflected in the fact that WTP for each of the three distances is the highest across the three samples. WTP for locating the off-shore wind farms at 12 km compared to 8 km is 666 DKK/household/year. This is at more than twice as much as in the two other samples. For the distance 18 km WTP = 743 DKK/household/year. This is not much more than in the two other samples. WTP for locating the farms at a distance of 50 km = 1223 DKK/household/year. The marginal WTPs are 167 DKK/km, 13 DKK/km and 15 DKK/km, respectively, for the three intervals.

Socio-economic Impact

The national and local employment effects associated with the establishment and running of wind farms have been calculated using input-output model data. The results of the analysis are divided between direct and indirect employment and an estimate is made of the proportion of local employment in the Nysted and Horns Rev areas.

Total employment
The total employment effects for the two wind farms are detailed on activities associated with the investments and the operation and maintenance activities over the 20-year operation period. *Investment activities* created *direct* employment equal to 1,275 and 1,202 man years for Horns Rev and Nysted, respectively. The *indirect* employment generated by the investments was found to be 756 man years for Horns Rev and 832 man years for Nysted. In total, direct and indirect employment generated by investment sums to 2,031 man years for the Horns Rev wind farm and 2,034 man years for the Nysted wind farm.

The *running activities* during the expected 20 years of operation also generate employment. For the Horns Rev wind farm accumulated employment associated with *maintenance* and *operation* was calculated to be 1,728 man years in total - distributed on 1,031 man years in terms of direct employment and 697 man years in indirect employment. For the Nysted wind farm employment figures were provided by the operator, who expects that *operation activities* will create employment equal to 360 man years in total over the operation period. This is equivalent to an on average permanent staff of 18 employees over the years.

Local employment
It was estimated that 50 per cent of the *direct* and 25 per cent of the *indirect* employment effects associated with construction activities are local. This implies that the investments have created 438 man years of employment in the Nysted area, while the establishment of the Horns Rev wind farm has generated 287 man years of local employment.

Concerning the *maintenance* activities, we assume that 90 per cent of the direct and 50 per cent of the indirect employment effects are local. For *operation* activities alone the local share of the employment is assumed to be 100 per cent. Accordingly, at Nysted operation is assumed to create 360 man years of employment at the local level (equal to 18 man years on an annual basis). For the Horns Rev wind farm it is not possible to distinguish between maintenance and operation activities.

A conservative estimate indicates that over 20 maintenance and operation years will create a total of 1,277 man years of local employment - distributed on 928 man years in terms of direct employment and 349 man years of indirect employment.

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Abbreviations

(See also Table 2 and 3)

B-model	Basic model
CE	Choice Experiments
CMM	Choice Modelling Methods
C-model	Certain choice model
CRM	Contingent Ranking Method
CVM	Contingent Valuation Method
DCE	Discrete Choice Experiment
DCM	Discrete Choice Method
DKK	Danish krone(r). One DKK ≈ €0.13
HPM	Hedonic House Price Method
HR	Horns Rev
MW	Mega Watt
NA	National
Na	Not available
NY	Nysted
PBM	Preference based methods
PBM	Preference Based Methods
PM	Pricing methods
PM	Pricing Methods
R-model	Rational choice model
TCM	Travel Cost Method
WTP	Willingness to pay

1 Introduction

As most other developed countries Denmark has committed itself to make significant reductions of greenhouse gas emissions (DEA 2005a). Increasing wind power production capacity could potentially be an important component of the Danish reduction strategy (MF 2003). Presently, wind turbines are located in most parts of the country with somewhat varying density between regions (DEA 2000). The density of turbines has increased during the past couple of decades and so has the capacity. Also the size of turbines has increased, implying that the individual turbines constructed now have a much more dominating impact on the surrounding environment than the turbines built 10 or 20 years ago. The larger the turbines are, the greater are the visual and other impacts, and the greater are the areas, where potentially people may be bothered by various externalities (visual, noise etc) generated by the wind turbines on-land. Thus it is increasingly difficult to find areas that are technically and socially acceptable for new land-based turbines.

Since the scope for expanding wind power production capacity on land is apparently limited, any potential increase in wind power production capacity must be expected to take place primarily off-shore[1]. There are both advantages and disadvantages associated with placing wind turbines off-shore. The main disadvantage is that off-shore wind turbines are more expensive to construct, operate and maintain. The exact magnitude of the cost differential is not readily available as, among other things, it depends on the distance from the shore, the hydro- and geological conditions at the site, the size and layout of the farm, the offshore to land net, and the size and foundation of the turbines. On the positive side it seems reasonable to expect that an off-shore wind farm will give rise to fewer and less severe externalities in terms of noise and visual obstruction than the establishment of an equal production capacity on land. Moreover, it is likely to benefit from the fact that the wind regimes are much better off-shore that on land, when it comes to wind power production.

Despite the intuitive appeal of taking wind power production to sea, off-shore wind farm projects have meet opposition both at the national and at the local level. The motives underlying the opposition may be of an attitudinal or psychological character; e.g. it may be motivated by a – perhaps only temporary – opposition to change, a sense of having been left out of the decision process, a desire to express discontent with the underlying energy policy or a strong ecological conviction that the sea should remain untouched (see sociological studies by Kuehn 2003). The motives may, however, also be economic in the sense that the opposition may be caused by a rational concern for the biological and marine environment, actual or expected losses of amenity value due to visual externalities, reduced earnings in the tourist sector and/or a decline in areas available for professional fisheries (DEA 2003). These different issues have to some extent been investigated on either national or international levels. However, concerning the visual externalities of off-shore wind farms the knowledge in some of the areas is incomplete.

1.1 Aim and Approach

The present study was initiated in august 2003 and is part of The Danish Off-shore Wind Farm Demonstration Project - *environmental study*. The demonstration encompasses a number of more specific projects and it is administered by *The Environmental Group*, a cooperation between Elsam,

[1] Due to the agreements on substituting smaller land based wind turbines with new and larger ones (also land based), an increase in capacity on land but and decrease in the number of wind turbines is expected.

Energy E2, Danish Forest and Nature Agency, the Danish Energy Authority. The programme is evaluated by the International Advisory Panel of Experts on Marine Ecology (IAPEME).

The purpose of the study is to elicit the Danish peoples´ preferences for the visual externalities of off-shore wind farms, thereby facilitating the estimate the welfare economic value associated with moving off-shore wind farms to greater distances from the coast.

With reference to the overall purpose of the project, the following sub-objectives for the project are formulated:

- Identify the general preferences for wind power development in Denmark.
- Elicit preferences for increasing the distance to shore of off-shore wind farms from 8 km to 12, 18 and 50 km.
- Examine the preference for difference in farm size and thereby number of farms to be built.
- Estimate WTP based on the elicited preferences for increasing the distance of off-shore wind farms to the shore.
- Construct different models for eliciting WTP of different sub-samples to verify the results.
- Examine if the preferences for visual externalities associated with off-shore wind farms differ between the populations in general (National sample) and the population in the two areas close to the two existing large-scale off-shore wind farms (Nysted and Horns Rev).
- Estimate the effects on employment of the two existing wind farms at Horns Rev and Nysted.

The study is based on a Discrete Choice Experiment (DCE) in the form of a mail administered questionnaire. Three samples were used to identify potential differences in preferences. The three samples were a National sample, a sample from Horns Rev and a sample from Nysted. The construction of the questionnaire included the use of focus-groups followed by a pre-test (see appendix 2). Apart from analysing the visual externalities, the externalities in connection to employment on a local and national level are discussed.

2 Economic Valuation and Cost Benefit Analysis

The aesthetic qualities of landscapes and recreation possibilities are goods for which no market, and therefore no market price, exists. The provision or obliteration of such goods is termed an *externality* – provided it is an unintended effect of some activity. Despite the fact that externalities do not manifest themselves in monetary terms they nevertheless represent costs and benefits that are relevant from a social point of view (Hanley & Spash, 1993). Consequently, they should be included in project evaluations. A prerequisite for doing so is that the externalities are assessed in units that are comparable to the units in which other goods are assessed. In a cost-benefit analysis framework this means monetary units. The task of estimating the monetary value of non-market goods is termed *economic valuation* (Freeman, 2004)

The point of departure of economic valuation is the preferences of individuals for both market and non-market goods, and individuals' willingness to make trade-offs between different goods (Freeman, 2004). This way the value of a good can be assessed as the amount of one good (often money), that the individual is willing to give up (or receive, in the case of a negative externality) in return for one unit of the good in question. That is, individuals' willingness to pay (or accept compensation in the case of a negative externality) so the good in question can be assessed. The results of a valuation study can serve as an input to a cost-benefit analysis assessing if a policy or a project represents a socially efficient use of resources. Thus, the overall purpose of economic valuation and cost-benefit analysis is to provide information to political and administrative decision makers and/or the broader public about the economic desirability of different project or policy alternatives (Johansson, 1991).

2.1 Cost-Benefit Analysis

In relation to carrying out a cost benefit analysis of off-shore wind farms, the analysis may be conducted at two different levels:

1. a general policy level where the desirability of pursuing a large-scale expansion of the wind power capacity is investigated or
2. a project-specific level where a given expansion of the wind power capacity is taken for granted, and the investigation is focussed on how the expansion should be implemented (e.g. the size of the farms, the location of the farms, etc.).

In the present study, the economic analyses are confined to aspects at the project level. More specifically, focus will be on assessing the benefits of different wind farm sizes and different distances from shore. It is assumed that the scale of the visual externalities is negatively correlated with the distance between the wind farm and the shore. That is, the further away the farms, the less noticeable they will be, thereby decreasing the risk that they will be perceived as visually disruptive. Moreover it is expected that the level of visual externalities is correlated with farm size; i.e. since larger farms will occupy a greater proportion of the horizon than smaller farms, they will appear visually more conspicuous than smaller farms[2].

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[2] It is possible, that not all individuals perceive the view to off-shore wind farm as negative or at least are indifferent between distances. Similar some individuals might prefer few but large wind farms in order to concentrate the visual externalities in few areas.

Based solely on considerations related to the visual externalities, it would therefore be tempting to conclude that future wind farms should be as small as possible and should be located as far away from the shore as possible. However, focusing solely on the costs (per kWh) associated with establishing and running wind farms the conclusion is likely to change. In general the costs per kWh produced increase as the distance from shore is augmented, and – at least to some extent – costs increase as farm size is reduced. Based on cost considerations, the immediate conclusion would then be that in general the farms should be as large as possible and as close to shore as possible.

The economic valuation in the present study will seek to identify the trade-off relations between different levels of visual externalities and the costs of reducing the visual externalities. The study results are thus intended to create a basis for identifying the optimal design of future wind farms in terms of the number of turbines per farm and their distance from the shore, however, determining the optimal design requires that costs are known.

2.2 Economic Valuation

Two overall approaches of economic valuation exist.

1. Preference Based Methods (PBM).
    a. The strength of the PBM is the monitoring and analysis of expressed preferences of individuals. The PBM thus estimates economic behaviour relations.
2. Pricing Methods (PM).
    a. PM is based on price relations on the market, and does not as such incorporate the economic behaviour of individuals. In PM, for example, the value of the political goal could be assessed as the cost of achieving the goal. In relation to the present project, the visual externalities of off-shore wind farms could be assessed by using a PM to estimate the cost of moving future wind farms out of sight. But such an analysis would, though, not give any answers as to whether the costs are larger than the benefits or which distance/visual externality would maximise welfare.

The PBM can subsequently be divided into two groups; Market Based Methods (MBM) and Survey Based Methods (SBM), which will be presented in the following sections. Given the obvious limitations of PM from a welfare economic point of view, the different pricing methods will not be commented further, for more details on the different PMs, see Garrod & Willis (1999) and Freeman (2003).

2.3 Market-Based Methods

The MBM are based on the notion that individuals' willingness to pay for a non-market good can be derived from analyses of individuals' demand for a complementary market-good. The market-based methods that could be relevant in relation to assessment of the visual externalities of off-shore wind farms are the Travel Cost Method and the Hedonic House Price Method.

2.3.1 Travel Cost Method

The Travel Cost Method (TCM) is primarily used to estimate the recreation or amenity value of sites. This is done by utilizing information on the interrelationship between travel cost and travel frequency to a particular site. From this information, an estimate of users' willingness to pay to visit the site can be obtained (Hanley et al. 1997), and WTP may be interpreted as an estimate of the value of the benefit provided by the site. In the present project the method could be used to assess the value of wind farms as tourist attractions, specifically the wind farms at Horns Rev and/or Nysted. However, it seems unlikely that estimates obtained would be of much relevant relevance to future wind farm projects. This is due to the fact that - as the number of off-shore wind farms increases, - the attraction value of new farms is expected to decrease. Accordingly, it has been decided not to make use of the travel cost method in the present study.

2.3.2 Hedonic House Price Method

The Hedonic House Price Method (HPM) method utilizes a well-known relationship between environmental quality and property values. An example of the use of the HPM is the study on positive visual externalities of forests and lakes done by Hasler et al. (2002). Here the view and the distance to lakes and forest were compared to the development in house prices. An example of a HPM study measuring negative externalities is the study by Bjørner *et al.* (2003) on noise reduction. Here the willingness to pay for reducing road noise by paying higher house prices was investigated.

In the present study, the possible effect on house prices could be investigated in residential and summer cottages/houses areas, where the Horns Rev and Rødsand/Nysted wind farms are visible. A requirement for carrying out such a study is that the wind farms have been present for a period long enough to ensure that: 1) the housing market has had time to accommodate to the change in the sea view; and 2) that the number of houses traded after the change is large enough to facilitate a statistical analysis of the impact on property prices (Freeman 2003). It is unlikely that the farms at Horn Rev and Rødsand/Nysted have existed long enough to support a statistically well-substantiated house price study. Alternatively, two small-scale off-shore wind farms were considered as study sites (i.e. Vindeby north of Lolland and Tunø Knob east of Jutland). However, as these two farms only consist of 10-11 relatively small (450-500 kW) turbines, it would probably not be relevant to carry out a house price study in these areas, as the farms bear little resemblance to the next generation of wind farms of the future[3]. The possibilities for conducting a hedonic price study will be subjected to further investigations in the future, since it has not been possible to carry out include such a study in connection to this project.

2.4 Survey-Based Methods

Within the class of Survey-Based Methods, the Contingent Valuation Method (CVM) is the most widely used (Batemann & Willis, 1999). Choice Modelling Methods (DCM), however, have become increasingly popular during recent years (Bennett & Blamey, 2001).

2.4.1 Contingent Valuation Method (CVM)

In CVM, the aggregate value of an environmental change or good is estimated holistically, by presenting the individual with a precise description/scenario of the hypothetical good – e.g. change

[3] A small pilot survey was actually conducted by phone interviews of interviewing real estate offices by phone in the coastal areas overlooking Tunø Knob off-shore wind farm (south of Aarhus). All of the interviewed real estate offices responded that the visual externalities of the wind farm at Tunø Knob had no influence on the prices of real estate properties in the area.

in the environment. Based on information regarding the rules of provision, present and future access to the good and method of payment, the individual is asked to state his/her valuation of the good. In Denmark a few studies have used CVM to elicit the preferences for various environmental goods. Both in Dubgaard (1993) and Dubgaard (1998), CVM is used to identify the demand for large existing recreational areas (Mols Bjerge and all Danish forests). In Bjørner et al. (2004), CVM was applied to analyse the welfare economic benefits of reduction of noise externalities associated with residential areas. In connection with the present project, an example of this would be to ask the respondents how much they would be willing to pay to have a wind farm similar to e.g. the Horns Rev farm but moved 25 km away from the coast in stead of its present location at 14-20 km from the coast. In principle, the obtained WTP only applies to the specific scenario considered and as such, the obtained WTP is very static[4]. Thus, it does not give any information on what respondents would be willing to pay if e.g. the wind farm was larger or if the distance from the coast was shorter. If such more dynamic information is perceived to be important, it may be more appropriate to use a Choice Modelling Methods (CMM), as is the basis in the present study.

2.4.2 Choice Modelling Methods

CMM refers to a group of survey-based methods where the value that individuals associate with goods is derived from observations of individuals' choices between different, though similar goods. The methods are based on the theory by Lancaster (1966) and Rosen (1974), stipulating that individuals' preferences for goods are derived from their preferences for the attributes comprising the goods.
In practise, the valuation is accomplished by presenting respondents with a number of alternative goods (A_i). The alternatives define the good or service in terms of their key attributes (a_{ij}). By varying the levels of the attributes of the alternatives, the alternatives in the choice set become different (Garrod & Willis, 1999). The respondents are then asked to either rank, rate, or choose the alternatives they prefer (Louviere *et al.*, 2000; Hanley *et al.*, 2001). By examining the trade-offs between attributes/attribute levels that are implicit in the choices made by respondents, it is possible to derive an estimate of the utility associated with the different attributes. If one of the attributes is measured in monetary units (i.e. price), it is possible to derive estimates of respondents' WTP for the other attributes from the marginal rate of substitution between the monetary attribute and the other attributes (Louviere *et al.*, 2000). It is often argued, that CMM have a relatively high degree of resemblance to real market situations compared to CVM. On the real market, consumers are used to simultaneously evaluating several products with different levels of attributes, and subsequently to choose the one they prefer (Rolfe & Bennett, 2000; Adamowicz *et al.*, 1999).

As stated above, depending on the specific CMM method, the task of the respondent in DCM can from study to study be different in terms of whether respondents are asked to either rank, rate or chose alternatives. This corresponds to three specific methods; Contingent Ranking Method (CRM), Contingent Rating method (CRT) and choice Choice Experiments (CE). Similar for these methods are that value estimates are derived from observations of individuals' choices between alternatives that are characterised by attributes. Thus, for all methods the identification of key attributes, attribute levels, design of alternatives, and choice sets plays an important role in relation to the validity of the method. However, the three methods vary significantly in terms of the way that

[4] In environmental economics benefits from previous studies can - given that certain circumstances are meet - be used in cost benefit analysis of other similar projects, this practice is referred to as Benefit Transfer.

preferences are expressed, the nature of the obtained data, the amount of extractable information per respondent and the quality of the data (Hanley *et al.*, 2001; Louviere *et al.*, 2000).

The three methods are briefly described in the following sections.

2.4.3 Choice Experiments (CE)

The CE approach, initially proposed by Louviere & Hensher (1982), is the most simple of the CMMs, and it appears to be both the most applied and widely recognised (Adamowicz *et al.*, 1998; Louviere *et al.*, 2000; Hanley *et al.*, 2001). In CE, the respondent is presented with a choice set (or several choice sets) containing two or more alternatives, and, if relevant, also a status quo option, and is asked to choose the most preferred alternative (Louiviere & Woodworth; 1983; Bennett & Adamowicz, 2001). Other things equal, the amount of information extractable from a single CE observation is less than the amount of information that can be extracted from the other CMM. However, an advantage of the method is that the task is very simple and the cognitive burden low. Furthermore, when dealing with marketed goods, CE bears very close resemblance to the choices that the respondents are used to make in the market place (Louviere *et al.*, 2000). Thus, intuitively the task is likely to make sense to respondents.

2.4.4 Contingent Ranking

In CRM, the respondent is presented with a choice set consisting of three or more alternatives, which the respondent is asked to rank from the most preferred to the least preferred alternative (Beggs et al. 1981; Chapman & Staelin, 1982). The CRM provides the analyst with much more information on the preference structure of the respondents compared to CE (McFadden, 1986; Hanley *et al.*, 2001; Holmes & Boyle, 2003; McFadden, 1986). However, the task of the respondents in CRM is also more cumbersome. It is therefore likely that respondents will find it difficult and strenuous to provide a complete ranking of the alternatives (Hausmann & Ruud, 1987; Ben-Akiva *et al.*, 1991; Foster & Mourato 2002). This increased task complexity is suggested to affect the reliability of CRM data (Louviere *et al.*, 2000). Thus, one potential consequence is that CRM data may display inconsistency of preferences across ranks. This inconsistency is suggested to be caused by respondents changing decision protocols across ranks. (Hausmann & Ruud, 1987). However, it must be emphasised that, keeping the ranking task simple might deal with the presented problems. In a study by Ladenburg and Martinsen (2004) on Danish consumers' WTP for various certified wood products, the respondents were able to rank consistently when ranking different types of toilet paper and cutting boards.

2.4.5 Contingent Rating

In CRT, the respondent is presented with a choice set consisting of a number of alternatives, which he/she is asked to rate independently from a predefined scale (Louviere, 1988). The rating approach to CMM is the one that has the potential to provide the greatest amount of information on respondents' preferences. The reason is that besides the implicit ranking of the alternatives – the rating approach also provides information on how much one alternative is better than the other alternatives. Also, the method is able to accommodate tied situations where two alternatives are equally preferred (Mackenzie, 1993). In practice it is though difficult to take advantage of this extra information. The reason is that the ratings have cardinal properties. Consequently, it cannot be verified if for example a rating of 10 is twice as good as a rating of 5, or if it four times better. The way individuals use the ratings scale may additionally vary significantly across individuals

(Mackenzie, 1993). More specifically, this makes aggregation of ratings across individuals problematic (McFadden, 1986). Consequently it is often advised not to use the CRT (Bateman 2002; Hanley et al. 2002; Holmes & Adamowicz, 2002).

2.5 Choice of Method in the Study

As discussed, the CVM is typically used to identify the demand for goods that can be viewed holistically, such as large recreational areas or a specific well-defined policy problem. In the present project, it is believed that the good in focus (visual externalities) should not be seen holistically. First of all, the visual externalities are expected to be functions of the distance of the off-shore wind farm to the coast. Secondly, the visual externalities are also expected to depend on the size of the wind farm. Lastly, the scenario used in the questionnaire, see 3.1.1, takes its point of origin in a development of a fixed level of established MW off-shore. This means that the number of wind farms, and thereby the distribution the visual externalities depends on the size of the individual wind farms (larger wind farms => fewer wind farms). Consequently the visual externalities are expected to vary in at least three physical dimensions (distance, size and number of wind farms), which would require quite a large sample, if CVM was to be applied. Given the more attractive properties of the CE compared to CRM and CRT to elicit preferences for multidimensional goods, this method has been chosen in the present study.

3 The Survey

The purpose of this chapter is to describe the process of designing the questionnaire used in the survey. In this relation, the attributes and attribute levels used to describe the off-shore wind farms in the CE are presented. Furthermore, the definition of variables which could potentially have a significant influence of the choice of the respondents and the associated hypotheses regarding their specific impact (negative/positive) is put forward. Finally, the theory of creating efficient experimental designs is introduced, and the present application is discussed and illustrated. For a full version of the questionnaire, see Appendix 1 and 2.

3.1 Definition of the questionnaire

The process of defining the questionnaire started in September 2003.The questionnaires were printed in mid-April and mailed in the end of April 2004. A presentation of all the considerations, tests and trial questionnaires will be far too extensive to review in this report. Instead the main subjects and features of the questionnaire are discussed in the following.

3.1.1 The Valuation Scenario

In 1997 the government in office set out the objective that the total Danish off-shore wind-power production capacity should reach 4.000 MW by 2030 (DEA, 1996). It is this objective that creates the context of the choice experiment used in the present study. Though it may be argued that this set-up is out-dated, it is nevertheless considered to be the best option as it presently represents the most tangible vision. Of these 4.000 MW specified in the objective, around 400 MW[5] have already been established implying that the expansion to be considered in the survey involves approximately 3.600 MW.

Policy Background

Alternatively, the survey could be based on a scenario, where the expansion is limited to only concern the construction of 2 wind farms. Such a scenario would probably be more in line with what can be expected to happen in the near future (before 2008), considering the strategy adopted by the current government[6]. Using such a – at least in comparative terms – small-scale scenario could, however, create severe problems in relation to deriving meaningful estimates of peoples' willingness to pay for reducing the visual externalities associated with the wind farms. Hence, unless the considered expansion is quite large, it is unlikely that the expansion – no matter how it takes place – will have a significant impact on the cost of electricity production as such. That is, even if the most expensive type of farm is chosen over the cheapest, the extra costs incurred by this choice are likely to be so low that they, once they have been distributed across all households in Denmark, will be insignificant.

Thus, using a small-scale expansion scenario, an irreconcilable conflict arises between 1) the wish to create a scenario where the costs used in the survey reflect the realistic level of anticipated costs, and 2) the need to have a significant cost variable. If the former consideration is granted highest priority, the relative level of the costs attribute with which the respondents are faced will be low. This may imply that respondents will be indifferent concerning the cost-attributes of different

[5] The existing off-shore wind farms and their production capacity are: Horns Rev (160 MW), Nysted (160 MW), Middelgrunden (40 MW), Samsø (23 MW), Tunø (5 MW), Frederikshavn (7.6 MW) and Vindeby (5 MW).
[6] Besides the two existing wind farms, the present government has decided to establish two more off-shore wind farms of approximately 400 MW each, (ED 2004).

alternatives, and, therefore, they will disregard the cost-attribute when making their choices between alternatives in the choice experiment. If something like this happens, it may prove very difficult, if not impossible, to identify the weight that respondents attach to costs[7]. Subsequently, it will be difficult, or impossible, to derive reliable and valid estimates of respondents' willingness-to-pay for reducing the visual externalities of off-shore wind farms. On the other hand, if securing the significance of the cost attribute is granted the highest priority, then one runs the risk that respondents reject the scenario, or they do not consider it worthwhile to answer truthfully because they perceive the scenario to be unrealistic. Moreover, the relevance and thereby also the usefulness of the results may be jeopardised as the obtained information does not relate to reality. In the present study, the choice is to operate with a very large-scale expansion which allows a realistic correspondence between the costs used in the scenario and the costs that would be anticipated in reality, while also making it possible to use a relative price level that is likely to be significant for respondents.

In the two existing large-scale off-shore wind farms at Horns Rev and Rødsand/Nysted, turbines with a capacity of 2-2.3 MW have been used. As the considered expansion will not proceed until sometime in the future, it is expected that the relevant type of turbine will have a significantly larger capacity than those that are used currently. Exactly how large the turbines are going to be cannot be predicted with certainty. In lack of more specific information, it is chosen to operate with a turbine size of 5 MW. Compared to the turbines used today, this represents a very large turbine. However, in light of the speed of technological developments within the field of wind-power production, it does not appear unrealistic that turbines with a capacity of 5 MW will be a reality within a foreseeable future. Presently, 5 MW turbines are in fact beginning to move from the drawing-board to the test faze (DEA 2005b).

Undertaking a total expansion of approximately 3.600 MW with 5 MW turbines requires that in theory around 720 turbines have to be erected off the Danish shores. In terms of specifying where the wind farms are to be located, it was considered to use a map from a report made by the Danish Energy Authority in 2003 (DEA 2003). The map shows areas designated as potential areas for the location of off-shore wind farms. However, for several reasons it was decided not to include the map. Firstly, the map could potentially create more confusion than clarification as it does not depict exact locations. Secondly, it is expected that denoting specific (but nevertheless still hypothetical) locations could cause unnecessary – and in particular unwanted – furore. Consequently, the only thing mentioned in relation to location is that considerations related to the surroundings, including both the landscape and animals, will play a prominent role.

3.1.2 Focus Groups

Prior to the actual launch of the survey, the questionnaire was tested first in focus groups and subsequently through a pre-test. These tests are intended to make sure that the questionnaire can be understood by people without any prior interest in or knowledge about the issue and to check that none of the formulations are considered offensive (Bateman *et. al.* 2002).

[7] If respondents are more or less indifferent between the level of the price attributes, the coefficient becomes very small (little sensitivity to price changes), which leads to very high WTP, as WTP=$\text{Coefficient}_{\text{Attribute}}/\text{Coefficient}_{\text{PRICE}}$, see Hensher & Johnson (1981)

Eight persons attended the focus group interview and they did in an overall perspective confirm that the questionnaire was understandable and easy to access. They confirmed that the payment vehicle[8] and scenarios were acceptable and comprehendible. Using photos to exemplify the view was perceived as a good and comprehensive way of presenting the scenarios. Participants in the focus group also confirmed that they did have preferences for avoiding the negative externalities concerning off-shore wind farms and were willing to pay for avoiding the view of wind farms. Additionally, they put emphasis on the fact that wind energy is a good thing and that off-shore wind farms are preferable to land-based turbines.

Also important information concerning the structure and wording of the questionnaire was obtained. First of all, a series of questions were rephrased upon the request of the interview persons. This amounted to several, though not radical changes. A request from all the focus group participants was that it should be possible in connection with each choice to express which attributes had been the main focal points. At the same time the respondents found the debriefing questions (questions just after the choice sets) confusing and not easy to understand. Considering these two requests, the debriefing questions were changed, and subsequently respondents were given the possibility to rate the attributes in terms of the weights attached to them.

As described, the focus group had a large effect on the final layout of the questionnaire and it is beyond doubt that the focus group delivered essential information and inspiration.

3.1.3 Cover Letter

The survey is administered as a mail delivered questionnaire. An important disadvantage of this survey format is that potentially it suffers from low response rates, which in the worst case may limit the reliability of the survey (Mitchell and Carson, 1989; Bateman et al. 2004). As the cover letter of the questionnaire is the first thing that meets the respondents when they open the envelope, the content and appearance of the letter is often considered to play an important role in relation to the recipients decision as to whether or not he/she should participate in the survey. Accordingly, significant effort has been devoted to the composition of the cover in order to improve the response rate.

The basic purpose of the cover letter is to; inform respondents of who is conducting the survey, make it clear that it is a scientific survey, introduce the background and purpose of the survey, and clarify how respondents have been identified. The reason for providing this kind of information is to familiarize the respondents with the context of the survey and to make them comfortable about participating. It is also specified that it is important that all recipients participate regardless of their initial knowledge, and interest in the subject. Thus, it is considered important to emphasise that people should not feel embarrassed about filling out the questionnaire due to lack of in-depth knowledge about the issue at hand. Likewise the confidentiality of all answers is emphasised; this is primarily considered important as the respondents are asked to provide quite personal information e.g. questions regarding income. Finally, the letter contains contact information, and respondents are encouraged to call or send an e-mail if they have any questions or comments.

[8] A payment vehicle is a definition of how money is being transferred from the individual in order to obtain the good in focus. An example could be a tax, an entrance fee or donation to a foundation, etc. (Mitchell & Carson 1989)

3.1.4 The Attributes Defining the Alternatives

One of the main advantages of using the choice experiment method is the joint focus on all the attributes, comprising a good rather than focusing on a specific good per se. This makes it possible to obtain a more nuanced and dynamic picture of people's preferences for the good subjected to valuation, see 2.4.2. Also, provided the attributes chosen to describe the good are policy relevant, it increases the likelihood that the obtained results may serve as important input to the planning of how best to conduct the expected expansion of the off-shore wind power production capacity.

In the present study, the choice experiment is designed to facilitate the distinction between two different attributes. The two attributes are believed to have a significant influence on the level of visual externality associated with off-shore wind farms while also being of policy relevance. The two attributes are the number of turbines per wind farm, and the distance between the wind farm and the shore. In addition to these two attributes, each alternative is also defined by a cost attribute in order to facilitate the derivation of a monetary estimate (WTP) of respondents' preferences for reduced visual externalities associated with off-shore wind farms.

Size attribute
In terms of the number of turbines per farm, it is chosen to operate with 3 levels; 49 turbines, 100 turbines and 144 turbines. The apparently odd numbers are due to the fact that all farm sizes need to fit a quadratic farm-layout in order to ensure similar appearance of the farms. The three farm sizes have been chosen to reflect the interval that is of primary relevance in relation to the desired capacity of future farms. With reference to the fact that the overall scenario specifies a total expansion of 3.600 MW, the different farm sizes are tantamount to different numbers of farms. If it is chosen to operate with farm sizes of 49 turbines, it will be necessary to establish around 15 farms in order to attain the overall objective of 3.600 MW. For 100 and 144 turbines per farm, the corresponding numbers of necessary farms are around 7 and 5, respectively.

Distance Attribute
In terms of the distance between the farms and the adjacent shore, it is chosen to operate with 4 different distances; 8 km, 12 km, 18 km and 50 km. If focus is solely on visual externalities, then the latter situation corresponds to the situation where there is no farm; that is, it represents a situation where there are no visual externalities from the farm.

Cost Attribute
The cost attribute is stated in the form of an annual "renewable" energy fee to be paid by each household over the electricity bill, and it has 6 different levels. The specific levels are 0, 75, 175, 300, 600, and 1,300 DKK. Originally, the plan was to use changes in the electricity price as cost attribute[9]. This choice was based on the expectation that the electricity price would represent an intuitively understandable and uncontroversial payment-vehicle. However, in relation to the interpretation of results, and aggregation of willingness to pay estimates, it would be rather problematic. Using the change in the electricity price would also make it difficult to set up a comprehensible presentation of the alternatives.

Visualization in Questionnaire
The visualization of wind farms at 12, 18 and 50 km is an essential part of the CE set up. The visualisations are made by Elsam-engineering and the height/size of the wind mills is scaled to fit

[9] A change in electricity price was used in a study on location of wind turbines done by Ek (2002).

the exact distance, making the different views as realistic as possible. The different visualisations are based on the same picture to ensure the same appearance (foreground, background, light, etc.). This is important as the choice between different attributes must not be disturbed by other irrelevant parameters.

3.1.5 Alternative Attributes

Apart from the chosen attributes, see 3.1.4, other potentially relevant attributes have been considered; the type of coast, where the farms would be situated, the layout of the farms, and turbine colour and light marking.

Type of Coast
The extent to which a given wind farm will be perceived to have a negative impact on, the amenity value of a coastal area is likely to depend on the initial amenity value of that area. This factor determines the attribute Type of Coast. As an example, a wind farm is likely to be perceived more visually obstructive in an area characterised by untouched natural and scenic beauty (e.g. the area at Møns Klint, which has been suggested as a potential location for future off-shore wind farms) than in an area where other man-made installations are already present (e.g. Middelgrunden just outside the Copenhagen harbour where an off-shore wind farm has already been established). Despite this potentially important relationship between the type of coast and the level of associated externalities, this aspect is left out of the analysis as it proved too difficult to present in a meaningful way.

Farm Layout
The layout of the farm was considered as it is likely to affect the visual appearance of a farm of a given capacity. As an example, a farm consisting of 100 turbines in 2 rows along the coast is likely to have quite different visual impact than 100 turbines position in a quadratic farm. That is, the former will affect a much larger proportion of the horizon than the latter, which may be perceived as a dense forest of turbines- on the affected part of the horizon. Despite this potentially important effect of layout on the visual perception, statistical and practical considerations related to the visual presentation of alternatives imply, that it is chosen not to include layout as an attribute. Instead it is chosen to operate with a “standard farm” with a quadratic layout, which – as far as we have been informed – in most cases represents the technically most relevant layout (Gaarde, 2003).

Colour and Light
Aspects such as the colour of the turbines, site specific weather conditions, and in particular the presence of light-markings, may have an important bearing on how the wind farm is perceived from the shore. No doubt it would be both interesting and relevant to include such aspects in the analysis. However, it has not been within the frame of the present survey to include those aspects[10].

3.2 *Definition of Attributes and Variables*

In Table 1, the variables which are used in the analysis of the choice models are presented. In the first column the abbreviation of the variable is specified. The abbreviation of the variables will be used in the report and therefore Table 1 might serve as reference. In the second column a definition of the variable is made and the third column holds the description of the contrast category. The reason why a contrast category is presented is that all variables enter the analysis as dummy

[10] New and less visible light markers are expected to be a result of a forthcoming regulation (Nielsen, 2005). The choice of not including the light markers in the present survey is thus considered to be of less significance.

variables, implying that the value of the variable can either be 1 (definition of variables) or zero (contrast category). In the fourth column, reference to the relevant question in the questionnaire is made.

Table 1: The definition and abbreviation of the variable is specified, the description of the contrast category is specified.

Variable	Definition	Contrast category	Question
Attribute Variables			
DIST12	1 for alternatives where the farms are situated 12 km from shore; 0 otherwise.	Alternatives where the farms are situated 8 km from shore.	6
DIST18	1 for alternatives where the farms are situated 18 km from shore; 0 otherwise.	Alternatives where the farms are situated 8 km from shore.	6
DIST50	1 for alternatives where the farms are situated 50 km from shore; 0 otherwise.	Alternatives where the farms are situated 8 km from shore.	6
SIZEL	1 for alternatives where the farms consist of 144 turbines; 0 otherwise.	Alternatives where the farms consist of 49 turbines.	6
SIZEM	1 for alternatives where the farms consist of 100 turbines; 0 otherwise.	Alternatives where the farms consist of 49 turbines.	6
PRICE	The "price" of the alternative. Attain one of the following levels: 0, 75, 175, 300, 600 or 1,300 DKK.	Continuous variable.	6
Socio-Economic Variables a.m.o.			
INC1	Yearly household income between 150.000-299.999 DKK.	Household income < 150.000 DKK/year	8.13
INC2	Yearly household income between 300.000-499.999 DKK.	Household income < 150.000 DKK/year	8.13
INC3	Yearly household income between 500.000-799.999 DKK.	Household income < 150.000 DKK/year	8.13
INC4	Yearly household income > 800.000 DKK.	Household income < 150.000 DKK/year	8.13
SEX	1 if female; 0 otherwise.	Male	8.1
AGE	Respondents' age in years.	Continuous variable	8.1
ENVORG	1 if member of environmental organisation; 0 otherwise.	Persons without membership of environmental organisation.	8.4a
OUTORG	1 if member of outdoor organisation; 0 otherwise.	Persons without membership of outdoor organisation.	8.5a
VBEACH1	1 if visiting beach at least once a week during the summer period; 0 otherwise.	People visiting beaches no more than once every second month during the summer period.	8.7
VBEACH2	1 if visiting beach 1-3 times a month during the summer period; 0 otherwise.	People visiting beaches no more than once every second month during the summer period.	8.7
JV	1 if often reading Jydske Vestkysten; 0 otherwise.	People not reading Jydske Vestkysten often.	8.11
LFF	1 if often reading Lolland-Falsters Folketidende; 0 otherwise.	People not reading Lolland-Falsters Folketidende often.	8.11
Attitudes, Opinions a.m.o.			
COAST1	1 if believing that off-shore wind farms have a *positive* effect on the appearance of the coastal landscape; 0 otherwise.	People believing that off-shore wind farms have a *neutral* effect on the appearance of the coastal landscape.	3.3
COAST2	1 if believing that off-shore wind farms have a *negative* effect on the appearance of the coastal landscape; 0 otherwise.	People believing that off-shore wind farms have a *neutral* effect on the appearance of the coastal landscape.	3.3
WLAND	1 if land-based turbines visible from permanent or summer residence; 0 otherwise.	Land-based turbines not visible from permanent or summer residence	4.3
WSEA	1 if off-shore turbines visible from permanent or	Off-shore turbines not visible from	4.4

	summer residence; 0 otherwise.	permanent or summer residence	
WVISUAL1	1 if experiencing *significant* negative visual impacts from wind turbines; 0 otherwise.	People not exposed to visual impacts from wind turbines.	4.5a
WVISUAL2	1 if experiencing *moderate* negative visual impacts from wind turbines; 0 otherwise.	People not exposed to visual impacts from wind turbines.	4.5a
WLIGHT1	1 if experiencing *significant* negative light/reflexion impacts from wind turbines; 0 otherwise.	People not exposed to light/reflexion impacts from wind turbines.	4.5c
WLIGHT2	1 if experiencing *moderate* negative light/reflexion impacts from wind turbines; 0 otherwise.	People not exposed to light/reflexion impacts from wind turbines.	4.5c
Debriefing Questions			
SIZE1	1 if the size of the farms was deemed the most important attribute for choice; 0 otherwise.	People to whom the size of the farms was not the most important.	7.3
FARMS1	1 if the no. of farms was deemed the most important attribute for choice; 0 otherwise.	People to whom the no. of farms was not the most important.	7.3
DIST1	1 if the distance from shore was deemed the most important attribute for choice; 0 otherwise.	People to whom the distance from shore was not the most important.	7.3
COST1	1 if the size of the annual fee to be paid was deemed the most important attribute for choice; 0 otherwise.	People to whom the size of the annual fee to be paid was not the most important.	7.3
NONVIS	1 if disagreeing that off-shore turbines should be non-visible from shore; 0 otherwise.	People agreeing that off-shore turbines should be non-visible from shore.	7.4
CONC	1 if agreeing that off-shore wind-turbines should be concentrated in few areas; 0 otherwise.	People disagreeing that off-shore turbines should be concentrated in few areas.	7.4
CLOSE	1 if agreeing that off-shore turbines may be placed fairly close to shore, provided that the surroundings are taken into account; 0 otherwise.	People disagreeing that off-shore turbines may be placed fairly close to shore, even if the surroundings are taken into account.	7.4
SPREAD	1 if agreeing that off-shore turbines should be spread out along the shore in small groups; 0 otherwise.	People disagreeing that off-shore turbines should be spread out along the shore in small groups.	7.4

3.2.1 Hypothesis and Interaction Effects

Interaction effects

Through their choices, respondents express their preferences for the attributes defining the alternative wind farms in the choice sets. The attributes, as illustrated in Table 3, are represented by the variables; distance (DIST12, DIST18, DIST 50), size (SIZEM, SIZEL), and price (PRICE). As the respondents make a choice between two alternatives, the observations on attribute levels enter the model analysis as differences. However, the respondent's characteristics do not contrast between choices, meaning that they will factor out when changed into differences (Train 2003). To include the effect of the respondent's characteristics on the utility, these are entered in the model analysis by *interacting them with the main attributes (DIST, SIZE, and PRICE).* An example of the outcome is P_SEX, which explains the extent to which the effect (see 3.3.2) price is dependent on the sex of the respondent.

Hypothesis

Combining the six main effects with the large number of attitudinal and socio-economic characteristics, a larger number of interaction effects are made possible. As it is highly unlikely that all of them will make sense, they have to be evaluated prior to the analysis of data. This is done by setting up hypotheses and evaluating these, keeping only the most important interactions. In Table 2 the potentially important interactions are presented. The first column represents the abbreviation of the main and interaction effect in focus. The second column specifies the label of the coefficient, and the third and fourth present the hypotheses mathematically and verbally.

Table 2: Hypotheses and relevant interaction effects and the hypothesis.

Effect	**Parameter**	**Hypotheses - mathematically (Utility=U)**	**Hypotheses - in words**
Main effect hypotheses			
DIST50	β_{DIST50}	dU/d(DIST50)>0	The utility associated with off-shore wind-farms is expected to increase as the distance from the shore is increased.
DIST18	β_{DIST18}	dU/d(DIST18)>0	Do.
DIST12	β_{DIST12}	dU/d(DIST12)>0	Do.
NB: It is expected that: DIST50<DIST18>DIST12			
SIZEL	β_{SIZEL}	dU/d(SIZEL)><0	The utility associated with off-shore wind-farms is expected to vary with the size of the farms. However, in the scenario used in the present study, where an aggregate expansion of a certain size is considered, the relationship may be either positive or negative, depending on the preferences of the individual.
SIZEM	β_{SIZEM}	dU/d(SIZEM)><0	Do.
NB: It is expected that: |SIZEL|>|SIZEM|			
PRICE	β_{PRICE}	dU/d(PRICE)<0	The utility associated with an alternative is expected to decrease as the price charges for the alternative increase.
Interaction effects hypotheses			
Interaction between distance and respondents opinion about the impact of off-shore wind-farms on the visual appearance of the coastal landscape.			
DIST12_COAST1	β_{DIST12_COAST1}	dU/d(DIST12_COAST1)>0	People who believe that off-shore wind-farms have a *positive* effect on the appearance of the coastal landscape are expected to associate less disutility with a given distance from shore than people who believe the effect to be neutral.
DIST18_COAST1	β_{DIST18_COAST1}	dU/d(DIST18_COAST1)>0	Do.
DIST50_COAST1	β_{DIST50_COAST1}	dU/d(DIST50_COAST1)>0	Do
DIST12_COAST2	β_{DIST12_COAST2}	dU/d(DIST12_COAST2)<0	People who believe that off-shore wind-farms have a *negative* effect on the appearance of the coastal landscape are expected to associate more disutility with a given distance from shore than people who believe the effect to be neutral.
DIST18_COAST2	β_{DIST18_COAST2}	dU/d(DIST18_COAST2)<0	Do.
DIST50_COAST2	β_{DIST50_COAST2}	dU/d(DIST50_COAST2)<0	Do.
Interaction between distance and whether or not respondents can see wind-turbines, either on land or off-shore, from their residence.			
DIST12_WLAND	β_{DIST12_WLAND}	dU/d(DIST12_WLAND)><0	The utility associated with a given distance from shore may depend on whether or not people can see land-based turbines from their residence.
DIST18_WLAND	β_{DIST18_WLAND}	dU/d(DIST18_WLAND)><0	Do.

DIST50_WLAND	β_{DIST50_WLAND}	dU/d(DIST50_WLAND)><0	Do
DIST12_WSEA	β_{DIST12_WSEA}	dU/d(DIST12_WSEA)><0	Do. for turbines based off-shore.
DIST18_WSEA	β_{DIST18_WSEA}	dU/d(DIST18_WSEA)><0	Do.
DIST50_WSEA	β_{DIST50_WSEA}	dU/d(DIST50_WSEA)><0	Do.

Interaction between distance and the extent to which respondents experience negative visual impacts from wind turbines.

DIST12_WVISUAL1	$\beta_{DIST12\_WVISUAL1}$	dU/d(DIST12_WVISUAL1)<0	The disutility associated with a given distance from shore is expected to be higher for people who experience negative visual impacts from wind-turbines than for those experiencing no impacts.
DIST12_WVISUAL2	$\beta_{DIST12\_WVISUAL2}$	dU/d(DIST12_WVISUAL2)<0	Do.
DIST18_WVISUAL1	$\beta_{DIST18\_WVISUAL1}$	dU/d(DIST18_WVISUAL1)<0	Do.
DIST18_WVISUAL2	$\beta_{DIST18\_WVISUAL2}$	dU/d(DIST18_WVISUAL2)<0	Do
DIST50_WVISUAL1	$\beta_{DIST50\_WVISUAL1}$	dU/d(DIST50_WVISUAL1)<0	Do
DIST50_WVISUAL2	$\beta_{DIST50\_WVISUAL2}$	dU/d(DIST50_WVISUAL2)<0	Do.

NB: It is expected that:
|DIST12_WVISUAL1|>|DIST12_WVISUAL2|; |DIST18_WVISUAL1|>|DIST18_WVISUAL2|;
|DIST50_WVISUAL1|>|DIST50_WVISUAL2|

Interaction between distance and the extent to which respondents experience negative light/reflexion impacts from wind turbines.

DIST12_WLIGHT1	$\beta_{DIST12\_WLIGHT1}$	dU/d(DIST12_WLIGHT1)<0	The disutility associated with a given distance from shore is expected to be higher for people who experience negative light/reflexion impacts from wind-turbines than for those experiencing no impacts.
DIST12_WLIGHT2	$\beta_{DIST12\_WLIGHT1}$	dU/d(DIST12_WLIGHT2)<0	Do.
DIST18_WLIGHT1	$\beta_{DIST18\_WLIGHT1}$	dU/d(DIST18_WLIGHT1)<0	Do.
DIST18_WLIGHT2	$\beta_{DIST18\_WLIGHT2}$	dU/d(DIST18_WLIGHT2)<0	Do
DIST50_WLIGHT1	$\beta_{DIST50\_WLIGHT1}$	dU/d(DIST50_WLIGHT1)<0	Do
DIST50_WLIGHT2	$\beta_{DIST50\_WLIGHT2}$	dU/d(DIST50_WLIGHT2)<0	Do.

NB: It is expected that: |DIST12_WLIGHT1|>|DIST12_WLIGHT2|; |DIST18_WLIGHT1|>|DIST18_WLIGHT2|;
|DIST50_WLIGHT1|>|DIST50_WLIGHT2|

Interaction between household income and price of the alternative.

INC1_PRICE	β_{INC1_PRICE}	dU/d(INC1_PRICE)>0	The disutility of cost is expected to decrease with increasing household income.
INC2_PRICE	β_{INC2_PRICE}	dU/d(INC2_PRICE)>0	Do.
INC3_PRICE	β_{INC3_PRICE}	dU/d(INC3_PRICE)>0	Do.
INC4_PRICE	β_{INC4_PRICE}	dU/d(INC4_PRICE)>0	Do.
PRICE/INC1	$\beta_{PRICE/INC1}$	dU/d(PRICE/INC1)<0	Do.
PRICE/INC2	$\beta_{PRICE/INC2}$	dU/d(PRICE/INC2)<0	Do.
PRICE/INC3	$\beta_{PRICE/INC3}$	dU/d(PRICE/INC3)<0	Do
PRICE/INC4	$\beta_{PRICE/INC4}$	dU/d(PRICE/INC4)<0	Do.

NB: It is expected that:
INC1_PRICE>INC2_PRICE >INC3_PRICE>INC4_PRICE;
PRICE/INC1< PRICE/INC2< PRICE/INC3< PRICE/INC4

Interaction between sex and price of the alternative.

PRICE_SEX	β_{PRICE_SEX}	dU/d(PRICE_SEX)>0	The disutility cost is expected to be lower for women than for men.

Interaction between sex and distance.

DIST12_SEX	β_{DIST12_SEX}	dU/d(DIST12_SEX)><0	The utility associated with a given distance from shore may vary according to sex.
DIST18_SEX	β_{DIST18_SEX}	dU/d(DIST18_SEX)><0	Do.
DIST50_SEX	β_{DIST50_SEX}	dU/d(DIST50_SEX)><0	Do

Interaction between sex and farm size.

SIZEL_SEX	β_{SIZEL_SEX}	dU/d(SIZEL_SEX)><0	The utility associated with a given farm size may vary with sex.
SIZEM_SEX	β_{SIZEM_SEX}	dU/d(SIZEM_SEX)><0	
Interaction between distance and membership of organisations.			
DIST12_ENVORG	β_{DIST12_ENVORG}	dU/d(DIST12_ENVORG)><0	The utility associated with a given distance from shore may vary with membership of environmental organisations.
DIST18_ENVORG	β_{DIST18_ENVORG}	dU/d(DIST18_ENVORG)><0	Do.
DIST50_ENVORG	β_{DIST50_ENVORG}	dU/d(DIST50_ENVORG)><0	Do.
DIST12_OUTORG	β_{DIST12_OUTORG}	dU/d(DIST12_OUTORG)><0	Do. for membership of outdoor organisations.
DIST18_OUTORG	β_{DIST18_OUTORG}	dU/d(DIST18_OUTORG)><0	Do.
DIST50_OUTORG	β_{DIST50_OUTORG}	dU/d(DIST50_OUTORG)><0	Do.
Interaction between farm size and membership of organisations.			
SIZEL_ENVORG	β_{SIZEL_ENVORG}	dU/d(SIZEL_ENVORG)><0	The utility associated with a given farm size may vary with membership of environmental organisations.
SIZEM_ENVORG	β_{SIZEM_ENVORG}	dU/d(SIZEM_ENVORG)><0	Do.
SIZEL_OUTORG	β_{SIZEL_OUTORG}	dU/d(SIZEL_OUTORG)><0	Do. for membership of outdoor organisations.
SIZEM_OUTORG	β_{SIZEM_OUTORG}	dU/d(SIZEM_OUTORG)><0	Do.
Interaction between distance and frequency of beach visits during the summer period.			
DIST12_VBEACH1	$\beta_{DIST12\_VBEACH1}$	dU/d(DIST12_VBEACH1)><0	The utility associated with a given distance from shore may vary according to frequency of beach visits.
DIST12_VBEACH2	$\beta_{DIST12\_VBEACH2}$	dU/d(DIST12_VBEACH2)><0	Do.
DIST18_VBEACH1	$\beta_{DIST18\_VBEACH1}$	dU/d(DIST18_VBEACH1)><0	Do.
DIST18_VBEACH2	$\beta_{DIST18\_VBEACH2}$	dU/d(DIST18_VBEACH2)><0	Do.
DIST50_VBEACH1	$\beta_{DIST50\_VBEACH1}$	dU/d(DIST50_VBEACH1)><0	Do.
DIST50_VBEACH2	$\beta_{DIST50\_VBEACH2}$	dU/d(DIST50_VBEACH2)><0	Do.
Interaction between farm size and frequency of beach visits during the summer period.			
SIZEL_VBEACH1	$\beta_{SIZEL\_VBEACH1}$	dU/d(SIZEL_VBEACH1)><0	The utility associated with a given farm size may vary with frequency of beach visits.
SIZEL_VBEACH2	$\beta_{SIZEL\_VBEACH2}$	dU/d(SIZEL_VBEACH2)><0	Do.
SIZEM_VBEACH1	$\beta_{SIZEM\_VBEACH1}$	dU/d(SIZEM_VBEACH1)><0	Do.
SIZEM_VBEACH2	$\beta_{SIZEM\_VBEACH2}$	dU/d(SIZEM_VBEACH2)><0	Do.
Interaction between distance and newspaper reading.			
DIST12_JV	β_{DIST12_JV}	dU/d(DIST12_JV)><0	The utility associated with a given distance may be different for those reading Jydske Vestkysten than for others.
DIST18_JV	β_{DIST18_JV}	dU/d(DIST18_JV)><0	Do.
DIST50_JV	β_{DIST50_JV}	dU/d(DIST50_JV)><0	Do.
DIST12_LFF	β_{DIST12_LFF}	dU/d(DIST12_LFF)><0	Do. for Lolland-Falsters Folketidende.
DIST18_LFF	β_{DIST18_LFF}	dU/d(DIST18_LFF)><0	Do.
DIST50_LFF	β_{DIST50_LFF}	dU/d(DIST50_LFF)><0	Do.
Interaction between farm size and newspaper reading.			
SIZEL_JV	β_{SIZEL_JV}	dU/d(SIZEL_JV)><0	The utility associated with a given farm size may be different for those reading Jydske Vestkysten than for others.
SIMEM_JV	β_{SIZEM_JV}	dU/d(SIZEM_JV)><0	Do.
SIZEL_LFF	β_{SIZEL_LFF}	dU/d(SIZEL_LFF)><0	Do. for Lolland-Falsters Folketidende.
SIZEM_LFF	β_{SIZEM_LFF}	dU/d(SIZEM_LFF)><0	Do.
Interaction between distance and debriefing questions			
DIST50_NONVIS	β_{DIST50_NONVIS}	dU/d(DIST50_NONVIS)<0	The utility associated with a given distance is expected to be lower for those who do not believe that wind-farms should be at a distance where they are invisible from shore than for others.

DIST18_NONVIS	β_{DIST18_NONVIS}	dU/d(DIST18_NONVIS)<0	Do.
DIST12_NONVIS	β_{DIST12_NONVIS}	dU/d(DIST12_NONVIS)<0	Do.
Interaction between farm size and debriefing questions			
SIZEL_CONC	β_{SIZEL_CONC}	dU/d(SIZEL_CONC)>0	The utility associated with farm sizes larger than the smallest is expected to be grater for people who prefer off-shore wind-turbines to be concentrated in few areas than for others.
SIZEM_CONC	β_{SIZEM_CONC}	dU/d(SIZEM_CONC)>0	Do.

Not many of these interaction effects turned out to be significant in the final models, however, it is important to recognise them before deriving the models.

3.3 Properties of the statistical design

A crucial aspect in stated preference modelling is the construction of the experimental design that specifies the alternatives which the respondents in the survey are to evaluate. The choice of how to design the experiment is thus central for the outcome of the subsequent discrete choice analysis. The design determines which effects can be estimated from the data and to what degree the effects are measured with the lowest variance. Several methods to identify designs are available, each with different abilities with regards to discrete choice modelling (Kuhfeldt *et al.*, 1994; Kuhfeldt, 2000; Bunch *et al.*, 1996). In general, two types of designs exist:

- Full factorial design.
- Fractional factorial design.

3.3.1 Full Factorial Design

A full factorial design is a design where each level of one attribute is combined with every level of all other attributes (Louviere, 1988). Full factorial designs have attractive statistical properties, and ensure that main effects along with certain interaction effects can be independently estimated[11]. In relation to the present study, this means that each price level (6 levels) is represented with each distance level (3 levels) and wind farm size level (3 levels), so that every possible alternative is presented in the design. Though the product of the levels of the different attributes gives the number of possible alternatives, even small discrete choice problems have many possible alternatives. Given that each alternative in the dataset should preferably be evaluated at least 30 times using full factorial designs can easily require large samples. In this project a full factorial design would thus require 6·3·4·30= 2160 valid choice sets in each sample. The size of the sample depends, of course, on how many choice sets each respondent are presented with. In this study it is decided to use only three binary choice sets per respondent. Consequently, each respondent evaluates 6 alternatives. This would reduce the needed sample size to a minimum 1620/6/0.4 = 900 respondents assuming a response rate of 40 per cent. In this project, there are 3 different samples (NA sample, HR sample and NY sample), why the total "respondent budget" at a minimum should be 3·900= 2700 respondents. This was out of scope in relation to the budget. So on this basis and given that empirical evidence suggests that main effects account for 70-90 per cent of the explained variance of choice (Louviere *et al.*, 2000), a full factorial design was not implemented.

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[11] A main effect can be defined as the pure effect an attribute has on the probability of choice. Similarly an interaction effect represents the joint effect of two or more attributes on the probability of choice.

3.3.2 Fractional Factorial Design

A fractional factorial design only contains a subset of all possible alternatives, and is thus smaller than the full factorial design. Depending on how the subset comprising the fractional factorial design is specified, it is possible to make a design, which allows pre-specified effects to be estimated from a reduced number of alternatives. It is in this relation important to ensure that the estimable effects are unbiased. A fractional design may thus suffer from the impact of omitted interactions. Therefore, the estimated effect of an attribute may be confounded with an omitted interaction. That is, the estimated effect will, in fact, reflect the effect of both the attribute and the omitted interaction. If the omitted interaction is significant, this implies that the estimated effect of the attribute is biased (Cochran & Cox, 1992). In relation to the present project, it could be the case that the choice of the respondents does not only depend on the main effects of the attributes (price, distance to the coast and size of wind farm). The visual impacts from a large wind farm could be larger than a small wind farm at a given distance (interaction effect between size and distance). If the main effect for size, for example, is confounded with the two-way interaction effect size-distance, this could influence the validity of the estimated effect of wind farm size. Such a confounding could have the following form; $\beta_{size} = \tilde{\beta}_{size} + \alpha \cdot \tilde{\beta}_{size \cdot distance}$ If size-distance is omitted from the fractional factorial design, then the β_{size} parameter is biased by α times $\tilde{\beta}_{size \cdot distance}$. The seriousness of the problem of course depends on the magnitude of α and $\tilde{\beta}_{size \cdot distance}$. If the prior expectations are that $\tilde{\beta}_{size \cdot distance}$ are relatively large, then it must be ensured that either $\tilde{\beta}_{size \cdot distance}$ can be estimated individually or that β_{size} can be estimated non-confounded with two-level interactions or only confounded with three-way interactions or higher[12].

3.3.3 Design Efficiency

In the construction of the design, four criteria can be set up for identifying efficient designs (Kuhfeld *et al.*, 1994; Huber & Zwerina, 1996). The measurement of design efficiency is based on the *information matrix* $\mathbf{X'X}$ (A, D and G efficiency, which are relative measurements). The information matrix is proportional to the variance covariance matrix of the parameters in a least square analysis (Kuhfeld *et al.*, 1994). The efficiency of a design is thus a function of the variance and covariance of the estimable parameters, so that efficiency increases as variance decreases. Stated differently, this means that there are many different designs which will enable the analysis to estimate the some specified effects. But some designs do a poor job, since the variance of the estimable effects is higher here than in other designs. Subsequently the latter designs are more efficient than the first designs. The four criteria mentioned above are; level balance, orthogonality, minimum overlap and utility balance.

Level Balance

Level balance occurs, when each level of an attribute appears with equal frequencies. As an example, each level of a four level attribute, such as the distance attribute (8, 12, 18 and 50 km) should occur in 25 per cent of the alternatives. This ensures equal weight to each level in the trade-off options of the respondents. All else equal level balance probably also ensures that each attribute level is estimable with the same accuracy. If one level of the distance attribute is present in 50 per cent of the sample, the trade offs related to that level are measured with a relatively higher accuracy than the other levels, which are perhaps only presents in 16.67 (50/3) per cent of the sample.

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[12] Three-way or higher levels of interactions totally only account for 5-15 per cent of the total variance, that is why the impact of an omitted variable is minimal if a main effect is confounded with a three-way – or higher level interaction

Orthogonality
Orthogonality implies that the occurrence of an attribute level is independent of the levels of other attributes. Orthogonal designs therefore minimise correlation/multicollinearity among the variables in a choice set/design. As an example, orthogonality ensures that an increased distance is not always associated with a decrease in price in the choice set. If this was so, it would not be possible to separate the effect of distance and price. Stated differently, it would not be possible to verify, if the respondents make their choices because the distance increases or because the prices decreases. So if the design is not orthogonal within certain limits, multicollinearity can become a problem in the analysis of data.

Minimum Overlap
Minimum overlap is satisfied, when the alternatives within the choice set have non-overlapping attribute levels. That is, if the alternatives are pair-wise different in all attributes. Since in discrete choice modelling, choices are modelled as a function of differences between alternatives, minimum overlap maximizes the amount of information extractable from each choice set. To illustrate, consider a binary choice set with two attributes A and B which both have two levels, 1 and 2. In this case four different alternatives can be made: (A1,B1); (A1,B2); (A2,B1) and (A2,B2). These four alternatives can be combined in 3 different ways.

Table 3:Illustration of the importance of minimum overlap

	Choice set 1			Choice set2		
	Alternative I	Alternative II	Trade off /Information	Alternative III	Alternative IV	Trade off /Information
Design 1	(A1,B1)	(A1,B2)	(0,B1-B2)	(A2,B1)	(A2,B2)	(0,B1-B2)
Design 2	(A1,B1)	(A2,B1)	(A1-A2,0)	(A1,B2)	(A2,B2)	(A2-A1,0)
Design 3	(A1,B1)	(A2,B2)	(A1-A2,B1-B2)	(A1,B2)	(A2,B1)	(A1-A2,B2-B1)

Looking only at the minimum overlap properties, Table 3 nicely illustrates the importance of minimum overlap. In design 1 and design 2, the levels of attribute A and B, respectively, overlap in choice sets 1 and 2. Consequently the trade-offs that the respondent makes when choosing between alternative I vs. II and III vs. IV are limited to the non-overlapping attribute (B1-B2 in choice set 1 and A2-A1 in choice set 2). In the 3rd choice set however, there are no overlapping attribute levels. Consequently the respondents have to trade with regards to both attributes, which gives the analyst much more information on the preferences of the respondents.

Utility Balance
Utility balance implies that choice sets should be defined in a way that the utilities across the alternatives are of a similar magnitude. Thus utility balance ensures that the respondents do make trade-offs. As such a utility balanced design increases the significance on parameter estimates, since the level of information produced by a utility-balanced design is relatively higher, compared to a non- balanced design. But it can also increase the level of collinearity between attributes, and thereby reduce the efficiency of the choice set. Introducing utility balance in the choice set is therefore a trade-off between improved models and reduced orthogonality in the design. The gain in information in a utility-balanced design/choice set must also be viewed in relation to the trade-off with the increase in variance on the error component, due to the much harder task of choosing a utility-balanced choice set (Swait & Adamowicz, 1996).

The criterion of utility balance is difficult to satisfy, since it demands prior knowledge of the true distribution of the parameters, which can be difficult to predict. Huber & Zwerina (1996) have found potential gains in design efficiency by the inclusion of such prior knowledge. In the present study prior knowledge was not available, so the criterion for creating a utility balanced design was not met. However, a reasonable level of utility balance was achieved by swapping the attribute levels, see 3.3.4 below.

3.3.4 Construction of Fractional Factorial Designs

Construction of efficient designs can be done relatively easy in SAS, see Kuhfeld (2002). In the design procedures, the three first properties of efficient design are taken into account, Level Balance, Orthogonality and Minimum Overlap.

In the present project, the SAS procedures were used to find an initial design, however the initial design contained too many dominated choice sets, and choice sets which seemed too unrealistic, such as small wind farms size, distance 50 km from the coast, and no extra cost, and vice versa. In order to increase the utility balance in the choice sets and to reduce the number of unrealistic alternatives, a swapping procedure was used (Louviere *et. al.* 2000). In this procedure the attribute levels within the attribute are swapped. Thereby it is possible to create new designs which entail the same efficiency properties as the initial design SAS has created (Louviere *et. al.* 2000). To illustrate the swapping, an example is presented below. In the initial choice set, one of the alternatives dominates the other, meaning that the choice of the respondent is self evident[13]. In the initial choice set 1, alternative 1 is dominating alternative 2, since no visual externalities can be obtained at any cost compared with visual externalities associated with a cost. The situation is somewhat similar in the initial choice set 2. The problem here is, however, not only the issue of dominating alternatives. Besides that alternative 2 is dominating, alternative 1 is also rather unrealistic. However by swapping the levels 8 and 50 km in the distance attribute, the problems in both choice sets are fixed. In both of the new choice sets the respondents have to trade-off between distance, wind farms size and cost, and the alternatives all appear realistic.

Initial choice set 1		*Swapping*	New choice set 1	
Alternative 1	Alternative 2		Alternative 1	Alternative 2
50 km	8 km		50 km	8 km
100 turbines/farm	144 turbines/farm	→	100 turbines/farm	144 turbines/farm
0 DKK	100 DKK		100 DKK	0 DKK
Initial choice set 2			**New choice set 2**	
8 km	18 km		50 km	12 km
100 wind turbines/farm	49 turbines/farm	→	100 wind turbines/farm	49 turbines/farm
1,500 DKK	350 DKK		1,500 DKK	350 DKK

Figure 3:Illustrating the swapping procedure used in the survey

The fractional factorial design used in the survey consists of 18 alternatives, which are blocked two and two and swapped as explained above. The choice sets are distributed in 3 blocks, each

[13] In this example it is assumed that the respondents have a positive preference for reduced visual externalities (increased distance and fewer wind turbines/farm).

consisting of 6 alternatives in three choice sets. Each respondent thus evaluates 3 choice sets of two alternatives.

3.4 Sample Populations and Sample Sizes

The questionnaire was mailed to a total of 1.400 respondents aged between 20 and 65 years, divided into three sub samples (Table 4). Two sub samples of each 350 respondents consisted of randomly chosen persons between the age of 20 and 65 years from the areas in the vicinity of the Horns Rev (HR) wind farm and the Nysted (NY) wind farm, respectively. The third sample, named the National (NA) sample, held 700 respondents chosen randomly among the Danish population. Compared to the Danish population in general, the populations in the two sub samples were expected to have much more well-defined and well-articulated preferences for off-shore wind farms. That is, in the course of projecting/planning and constructing the now operating wind farms, they have been through a long "learning/familiarisation" process. A process that is likely to imply that they have spent more time reflecting upon both the advantages and disadvantages of large-scale off-shore wind farms than other Danes. Accordingly the populations of the areas in the vicinity of HR and NY were of particular interest in relation to the identification of valid and stable preferences for off-shore wind farms.

Table 4: The sample size of the three sub samples.

Sample	NA sample	HR sample	NY sample
Questionnaires in sample	700	350	350

In connection to the two area-specific samples, it is interesting to note that it will most likely be erroneous to assume that the populations of the two specific locations have been through identical processes just because they both have had to come to terms with the fact that an off-shore wind farm has been established close to their home. Therefore it will presumable be erroneous *a priori* to assume that the output of the two processes – i.e. the resulting attitudes and preferences of the affected populations – will be identical. With this in mind, it is considered to be not only very interesting but also highly relevant to compare the results of the identical surveys conducted in the two different areas, see chapter 7. Thus, in combination with the results of the sociological studies conducted in both areas (Kuehn, 2003), a unique opportunity is created not only for identifying differences and similarities, but also for gaining an insight into the relationship between process and creation of attitudes and preferences.

As mentioned, the remaining sub sample consisted of 700 respondents who were randomly selected from the Danish population and aged between 20 and 65. This sample reflects a representative cross-section of the Danish population and serves two purposes. Firstly, it serves as the basis for the derivation of aggregate willingness-to-pay estimates. Secondly, it is intended to serve as a reference for the interpretation of the results from the two location-specific sub samples. Thus, apart from uncovering the preferences of people with prior experience with off-shore wind farms – represented by the two location specific sub samples – the survey is also intended to provide information on the attitudes and preferences of the Danes in general. In this respect the present study distinguishes itself significantly from the sociological part of the project, where focus is on disclosing the full extent of the spectrum of attitudes, along with the origin of different attitudes. Hence the focus of the present study is centred on quantifying the prevalence and welfare economic implications of different attitudes, among others some of the attitudes identified in the sociological study (Kuehn, 2003).

Lastly, it is noted that the difference in sample-sizes between the national and the two location-specific samples is motivated by the expectation that people living close to the existing wind farms will be more inclined to participate in the survey because of the greater exposure to the off-shore wind farm debate. Accordingly it is expected that significantly smaller sample-sizes will be sufficient to secure a satisfactory number of responses. In this connection it may be noted that it – for the chosen sample sizes - even with response rates as low as around 25 per cent, most probably will be possible to estimate reliable models for all samples. However, such low response rates are neither desirable nor expected. Hence, experience from other surveys suggests that response rates around 50 per cent can be expected. This is not as high as the response rates advocated by some, but for most practitioners it will be very satisfactory. The actual response rates, in fact, turned out to be close to 50 percent as presented in section 5.1.

4 Analysis of Data and Model Design

The aim of the present chapter is to elaborate on the theoretical and practical issues concerning the implementation of the discrete choice experiment. First the theoretical background is presented. This is followed by a presentation of the main models and the model elicitation procedure.

4.1 *Choice Experience Models*

In this section, the Random Utility Theory underlying choice experiments is presented. In this relation binary logit and random-effect models are commented and discussed in relation to the project. Subsequently the procedure for eliciting willingness to pay for the attributes in discrete-choice modelling in general is described.

4.1.1 Discrete Choices

From early in the morning, when people get up till they go to bed in the evening, they are continually confronted with choices; what to eat for breakfast, which clothes to wear, which task to complete/initiate at work, what to buy for dinner, etc. Some of these choices are rather trivial or predetermined by previous choices, such as what to eat for breakfast or whether to take the car to work. Other choices are more complicated and might require evaluation of a complete new set of alternatives with new attributes. Independently of the type of choice, the basic assumption is that the individual chooses the alternative, which gives the individual the most joy, or in economic terms the most utility in the present choice situation. This means that inherent in these choices are trade-offs between the characteristics of the alternatives available.

The trade-offs might be measurable in well defined cardinal and/or quantitative units such as minutes, cost, kg, etc. But the choices most often also involve attributes that cannot be defined in such units. Instead, the trade-offs involve ordinal/qualitative units (Ben-Akiva & Lerman 1985; Louviere 1988). An example could be whether to have coffee or tea for breakfast. Besides the fact, that coffee might be more expensive than tea (or vice versa), the choice also depends on specific taste that specific morning - do I feel like having coffee or tea? In relation to the present study where focus is on the visual externalities associated with off-shore wind farms, choices are based on a combination of ordinal and cardinal trade-offs. The respondents thus have to trade off- between visual impacts (ordinal) and costs (cardinal).

Choice data does not directly reveal the respondents' (marginal) utility associated with the attributes of the alternatives in the choice set presented to the individual. Consequently it is not possible directly to estimate demand and WTP for the different attributes just by looking at the data. The demand has to be deducted from the trade-offs inherent in the choices that the respondents in the study make between different visual impacts and cost in the choice sets. The choice set and the alternatives included in the choice set, have to meet certain requirements in order to allow such indirect elicitation of demand for reduced visual externalities.

From a theoretical point of view, a discrete choice may be defined as a choice where an individual is faced with a choice set of alternatives from which he/she is only allowed to choose one. The choice set has to meet the following criteria (Train, 2003):

- The alternatives must be *mutually exclusive*.
- The choice set has to be *exhaustive*.
- The number of alternatives must be *finite*.

The criterion stating that the alternatives must be mutually exclusive implies that given alternatives A and B, choosing A means *not* choosing B. This can also be interpreted differently, that is, that one of the alternatives can not be contained in the other alternative. In Discrete Choice Experiments this might be a problem, if completely dominant alternatives are included in the choice set. As an example, a choice set could consist of two alternatives with 3 attributes, which all are quantitative/cardinal of nature, see Table 5.

Table 5: Example of the problem of mutually exclusiveness in DCE

	Alternative A	Alternative B
Attribute 1	7	5
Attribute 2	4	3
Attribute 3	2	2
Choice	√	

Given that the individual has a positive marginal utility of the attributes, Alternative A is chosen, since it in all attributes is at least equally as good as or better than Alternative B. However, the two alternatives are not mutually exclusive since alternative B is contained in alternative A. Such choice sets do not give much information regarding the preference structure of the respondents, and if possible such choice sets should therefore be avoided. It should, however, be mentioned that even though some choice sets appear to include a dominant alternative, it does not necessarily mean that alternatives in the choice set are not mutually exclusive. This is especially evident, when there are qualitative/ordinal attributes in the choice set.

The criterion of exhaustiveness implies that all possible alternatives must be included. This may appear restrictive, but if respondents are provided with a no-option, the criterion can be met. The last criterion, i.e. that the choice set must be finite, can be restrictive. Thus, if the levels characterising an attribute are continuous – i.e. there is an infinite number of levels – rather than a discrete, there is, in effect, an infinite number of alternatives. This could be a potential problem in stated preference data, where the number of discrete levels of the attributes is kept relatively low due to design related properties. In the present study, an example could be the distance to the coast, which could have infinitively many levels. To model discrete choices as a function of such attributes, the continuous characteristics have to be converted into to discrete variables. Thus, the appropriateness of discrete-choice modelling in a given context depends on the extent to which continuous characteristics can be transformed into a finite number of discrete variables in a meaningful way.

Provided the choice sets satisfy the above mentioned criteria, and that the alternatives included in the choice set meet the requirements presented in section 6.4, a model can be estimated, from which the Marginal Rates of Substitution (MRS) between different attributes defining the alternatives can be derived, see 4.1.7.

4.1.2 The Random Utility Model

The utility model underlying DCM is the Random Utility Theory first introduced by Thurstone (1927) and further developed by Marschak (1960) and Manski (1977). A general model of the choices of individuals requires (Louviere *et al.*, 2000):

- That the choice set available to the decision maker, and the choice made by the decision maker from that choice set, is known.
- That the characteristics of the decision maker, which are relevant for the choice, are known.
- That a model of individual choice and behaviour is constructed.

Provided these requirements are met, a Random Utility Model (RUM) describing the individual's choices can be derived as follows:

Assume that an individual, $n=1,2...N$, is confronted with a finite number of alternatives, $j=1,2,...,J$, where the individual is expected to obtain utility from each alternative, j. The individual and alternative specific utility is denoted as U_{nj}. Among the different j alternatives the individual chooses the alternative i, which yield him/her the highest level of utility, subsequently it must be that:
$U_{in} > U_{jn} \forall i \neq j$.
The exact level of utility gained by the individual is only known by the individual he/her self. Consequently the analyst engaging in the modelling of the individual's choice can observe neither U_{ni} nor U_{nj}.[14] However, the researcher has access to information regarding the attributes of the alternatives facing the decision maker, labelled $x_{nj} \; \forall \; j$. In the present study, the x_{nj}'s are the attributes of the wind farm (distance from the coast, number of wind turbines and cost). Furthermore, the researcher might have some information regarding the attributes of the decision maker, labelled s_n, such as income level, gender, etc. Based on this information the researcher can define a function, which relates the information on x_{nj} and s_n to the choices and thereby the utility of the decision maker. The utility function is denoted $V_{nj} = (x_{nj}, s_n) \; \forall \; j$. However, it is unlikely that all the information defining the utility of the decision maker is available for the researcher, why $V_{nj} \neq U_{nj}$.

This gives rise to the partitioning of the utility functions in two components $U_{nj} = V_{nj} + \varepsilon_{nj}$, where V_{nj} is referred to as the *systematic component* or *representative utility* and ε_{nj} is referred to as the *random component*. The inclusion of the random-utility component is solely a consequence of the fact that the variables known to the researcher – i.e. the variables included in the model – fail to capture all factors determining U_{nj}, and that the remaining part of the utility is assumed to be random among individuals, due to for example unobserved taste variation, attributes unaccounted for, etc. See Ben Akiva & Lerman (1985)[15]. In this context, it is important to note, that the inclusion of a random component does not imply that the decision maker maximises utility randomly. Thus, he/she is still assumed to behave rationally (Manski, 1977).

[14] The Analyst cannot read the mind of the individuals.
[15] For a more thorough description, see Manski (1977)

Based on the above specification of the utility function, the probability, P_{ni}, that individual *n* chooses alternative *i* over alternatives *j* is given by:

$$P_{ni} = \Pr(U_{ni} > U_{nj}\ \forall j \neq i) = \Pr(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}\ \forall j \neq i)$$
$$= \Pr(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj}\ \forall j \neq i) \qquad (7.1)$$

7.1 states that the probability of *n* choosing *i*, from a set of $J = 2$ alternatives is equal to the probability that the difference in random utility between *j* and *i* is less than the difference in systematic utility between *i* and *j*. Defining $\varepsilon_n = \varepsilon_{nj} - \varepsilon_{ni}$, P_{ni} can be expressed as a cumulative probability:

$$P_{ni} = \Pr\left(\varepsilon_{\mathrm{n}} < \mathrm{V}_{\mathrm{ni}} - V_{nj}\ \forall\ \mathrm{j} \neq \mathrm{i}\right) = \int_{\varepsilon} \mathrm{I}\left(\varepsilon_{\mathrm{n}} < \mathrm{V}_{\mathrm{ni}} - V_{nj} \forall\ \mathrm{j} \neq \mathrm{i}\right) f\left(\varepsilon_n\right) d\varepsilon_n \qquad (7.2)$$

where *I* is the indicator function, which is equal to 1 when the expression is true – i.e. if the respondent chooses product *i* – and $f(\varepsilon_n)$ represents the density distribution of the random component. The exact definition of the choice models depends on the distribution of the random utility component. Different assumptions on distributions and correlation structures result in different models.

4.1.3 The Functional Form of the Utility Function

The systematic component of utility is a function of both alternative specific attributes (X_{nj}) and individual specific (S_n) attributes, denoted as $V_{nj} = (x_{nj}, s_n)\ \forall j$. The fit of the model not only depends on how well the attributes included in the utility function represent the choice of the individual, and which distribution is chosen for the random component. It also depends on the specification of V_{nj} in terms of how the attributes affect the utility of the individual.

The most commonly used and simple specification of the utility function is the *linear additive utility function* (Manski, 1977, Louviere & Woodworth, 1983; Louviere *et al.*, 2000). The linear additive function is denoted by (Train, 2003):

$$V_{nj} = x_{nj}'\beta + s_n'\delta \qquad (7.3)$$

Where x_{nj} denotes the vector of attributes of alternative *j,* facing individual *n*, and s_n denotes the vector specifying the characteristics of individual *n*, and β and δ are the coefficients of those vectors. By adopting this specification, the total utility of an alternative is given by the sum of the utilities associated with each of the components entering the utility function. In this study, the linear additive form is used in the modelling.

4.1.4 The Binary Logit Model

As mentioned in section 4.1.2, the exact nature of a choice model depends on the chosen distribution of the random component ε_{nj}, and as a consequence a variety of different models can be formulated. However, since the development of the logit model, initially formulated by Luce (1959) and further developed by McFadden (1974), this model has been used intensively in discrete choice modelling. In this section, the binary logit model (MNL[16]) will be presented and discussed in relation to the survey.

The MNL is used to model choices where one alternative is chosen from a choice set consisting of $J \geq 2$ alternatives (McFadden, 2001). It is based on the assumption that the ε_{nj} is independently Identically Distributed (IID). The assumption of independence means, that each ε_{nj} is independent of the other ε_{ni} $\forall j \neq i$, why information related to ε_{nj} cannot explain ε_{ni}. More specifically, the ε_{ni}'s are assumed to follow a Gumbel or type 1 extreme value distribution. As such the density of each of the random utility components is:

$$f(\varepsilon_{nj}) = e^{-\varepsilon_{nj}} e^{e^{-\varepsilon_{nj}}}$$

This gives the cumulative distribution of

$$F(\varepsilon_{nj}) = e^{e^{-\varepsilon_{nj}}}$$

The difference between two Gumbel distributed functions (with equal means) is distributed logistically with a zero mean, consequently if ε_n and ε_{ni} are IID, then $\varepsilon_n = \varepsilon_{nj} - \varepsilon_{ni}$ follows a logistic distribution, so that

$$F(\varepsilon_n) = \frac{e^{\varepsilon_n}}{1 + e^{\varepsilon_n}}$$

This distribution is characterised by a scale parameter μ and a location parameter δ, which in practice are usually set to 1 and 0, respectively, thereby obtaining the standard Gumbel distribution (Alpizar *et al.*, 2001). The scale parameter is related to the variance of the distribution such that $\text{var}\varepsilon = \pi^2/6\mu^2$. The higher μ, the lower the variance, and vice versa. Compared to the normal distribution, the Gumbel distribution has a flatter tail, implying that it can accommodate aberrant choices, such as potentially strong preferences for reducing the visual externalities of off-shore wind farms.

Assuming that the difference between the random components is Gumbel distributed, the binary choice probability is given by (Alzipar *et al.*, 2001):

$$P_{ni} = \frac{e^{\mu V_{ni}}}{\sum_j e^{\mu V_{nj}}} \qquad (7.4)$$

As it is seen from 7.4, the coefficients that are estimated for the model are confounded with the scale parameter. Usually, this correlation between the scale parameter and the obtained coefficient estimates is irrelevant when dealing with a specific model (Ben-Akiva & Lerman, 1985). However, for example, when merging data from different surveys, the scale parameter has an important role, since the variance of the random utility must be expected to differ between datasets, see Swait and Louivere (1993).

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[16] In the case where the number of alternatives (J) =2 the MNL model collapses to a binary logit model, see Ben Akiva & Lerman (1985).

Inserting the linear and additive representative utility function $V_{nj} = x_{nj}'\beta + s_n'\delta$, and applying the standard Gumbel distribution with μ=1, the logit probability becomes:

$$P_{ni} = \frac{e^{x_{nj}'\beta + s_n'\delta}}{\sum_j e^{x_{nj}'\beta + s_n'\delta}}$$

4.1.5 Limitations of the Logit model

The reason to why the Logit model has been so popular in discrete choice modelling is due to its relatively easy computation, made possible by the IID restrictions. However, the logit model has certain limitations; some of them are directly caused by the IID assumption. The limitation of the binary logit model and potential extensions of the binary logit model will briefly be commented on in this section.

Taste variation
The logit model cannot capture unobserved taste variation; that is, variation in the dataset which cannot be captured by the model specifications or which can only be identified using endogenous variables. Unobserved taste variations can, however, be captured in Mixed Logit Models, see (Hensher & Greene, 2003).

Unobserved factors correlated over time
The logit model cannot handle some unobserved factors that are correlated over time or choices, since it is assumed that the random utility is IID. This can be problematic if there are multiple observations per individual, as is the case in panel data.

In the present survey, and as presented in section 3.3.4, each respondent is presented with 3 binary choice sets in the questionnaire. If the unobserved factors not are independent over the repeated choices, then the logit model might not be the most appropriate model. In this case other models, such as random effect models, which are able to take the unobserved correlated factors into account, might be more appropriate.

4.1.6 Random effect model

In the random effect model, it is possible to control for possible individual specific variation in the error component and thereby potential unobserved correlation within respondents (Verbeek, 2004).

The standard expression for the utility function is:

$$U_{nj} = V_{nj} + \varepsilon_{nj}$$

where V_{nj} represents the observed utility and ε_{nj} the unobserved utility/error component. In the random effect logit, the error component ε_{nj} is specified as systematic individual effect $\tilde{\varepsilon}_n$ and an independent effect $\tilde{\varepsilon}_{nj}$ so that:

$$\varepsilon_{nj} = \tilde{\varepsilon}_n + \tilde{\varepsilon}_{nj}$$

Based on the random effect assumption, the proportional (ρ) contribution of the panel data component $\tilde{\varepsilon}_n$ to the total variance can be estimated as (StataCorp. 2003):

$$\rho = \frac{\sigma_n^2}{\sigma_n^2 + \sigma_{nj}^2}$$

where σ_n^2 corresponds to the variance of the individual effect $\tilde{\varepsilon}_n$ and σ_{nj}^2 correspond to the variance of the independent effect $\tilde{\varepsilon}_{nj}$ in the model. It is important to notice that if σ_n^2 is small compared to σ_{nj}^2, ρ goes to zero, indicating that the variances associated with the individual effect is relatively unimportant. If this is the case, the random effect model is, in practice, not different from the standard logit model, where all observations/choices are pooled.
In the present study, both random effect logit and random effect probit models were applied to the data originating from the three samples; NA sample, HR sample and NY sample. However, in all three samples ρ turned out to be close to zero. A likelihood-ratio test comparing the logit (pooled estimator) with the random effect model all turned out to be insignificant. This means that the random effect model is not significantly different from the logit model[17], why the logit model has been used to elicit the preferences for off-shore wind farm locations.

4.1.7 Estimations of the marginal rates of substitution and WTP

In section 4.1.3, the *X* in the utility functions represents the attributes of the alternatives evaluated by the respondents. It is with regards to the levels of these attributes that the respondents are assumed to make their choices between the different alternatives. Based on the choices, the relative weight/utility, which the respondents attach to each attribute, can be estimated. These weights are represented by the coefficients of the variables representing the attribute/attribute level, see Hensher and Johnson (1981) for further details. Based on the observed weights, the marginal rates of substitution[18] between attributes can be estimated, as illustrated in the following general example.

In 7.3 the utility function was defined as:

$V_{nj} = x_{nj}'\beta + s_n'\delta$

Where x_{nj} correspond to the attributes of the alternatives and s_n corresponds to the characteristics of the respondents. Assuming, for simplicity, that the utility of the alternatives does not depend on the characteristics of the respondent, the utility function can be reduced to the following expression:

$V_{nj} = x_{nj}'\beta$

Let x_{nj} be defined by a price attribute ***P*** and a vector ***T*** representing other attributes of the alternatives. The indirect utility function can now be expressed by:

$V_{nj} = P'\beta_P + T'\beta_T$

[17] A possible explanation could be that, the dataset only contains 3 observations per respondent, giving the random effect estimator little information to work with.
[18] The marginal rate of substitutions is the ratio of marginal utilities of two attributes, and thus expresses how much the individual must be compensated with attribute 1 to forgo attribute 2.

where β_P represents the marginal utility of the price and β_T represents a vector of marginal utilities of the other attributes. Total differentiating the indirect utility function, holding utility constant (dV/dx_{nj}=0) gives:

$$\mathrm{d}V = \beta_P \cdot dP + \beta_T \cdot dT = 0$$

Rearranging the equation yields:

$$\frac{dT}{dP} = -\frac{\beta_T}{\beta_P}$$

The above expression is the marginal rate of the substitution between the price attribute and the other attributes of the alternatives. Given that a price attribute is contained in the design, the marginal rate of substitution can be interpreted as the maximal amount the individual is willing to pay to achieve/avoid a change in one of the other attributes. That is, it specifies the amount required to make the individual indifferent to the choice between the current level of the attribute and the proposed change in the level of the attributes. For a more detailed description see Hensher and Jonhson (1981).

Referring to the present study, the properties of the marginal rate of substitution can be illustrated with the following example:

Let P represent the price attribute and D represent the attribute associated with distance (km) from the coast of the off-shore wind farm. The indirect utility function can be expressed by:

$$V_{nj} = P'\beta_P + D'\beta_D$$

The marginal rate of substitution is now

$$\frac{dD}{dP} = -\frac{\beta_D}{\beta_P}$$

Assuming that P=-0,01 DKK and D=0.850 KM then

$$\frac{dD}{dP} = -\frac{\beta_D}{\beta_P} = -\frac{0.850}{-0.001} = 85 \text{ DKK/KM}$$

This means that the respondent is willing to pay 85 DKK per kilometre the off-shore wind farms are moved from the coast.

4.2 Construction of Models

Based on the datasets from the three samples (National, Nysted and Horns Rev), binary logistic choice models are derived in order to identify the preferences for the attributes of the presented off-shore wind farms. In this section the procedure of deriving the final choice models is presented.

4.2.1 Background of Models

In the initial stage of the model analysis, seven different sub samples of each of the three geographical samples were used to deduct seven different choice-models of each sample. Each sub sample was created by excluding respondents on the basis of some of their answers to specific questions in the questionnaire. On the basis of the initial seven sub samples, three sub samples of each geographical sample were selected for the choice models in the analysis of the respondents' preferences for off-shore wind farms. The three sub samples and the resulting models are described in the following, and the consequences of reducing the number of respondents are scrutinised in the last part of the section.

Model 1 - Basic model

The models derived as the basic model (B-model) include the full dataset of each sample[19]. Given that the B-model is based on the full sample, the model can be seen as the "unrestricted" model.

Model 2 - Certain Choice Model

In the certain choice model (C-model) the aim is to identify if the preferences between certain and uncertain respondents are different. This is done by excluding respondents who are uncertain of their choices in the CE. The split of respondents into certain and uncertain is done on the basis of question 7.2, where respondents are asked to specify how certain they are of their choices on a scale from 0 to 10 (1 being very uncertain and 10 being very certain). In the dataset for this model the limit of "certainty" is set at 7. The respondents who have stated that they were more certain of their choices than 7 are thus included in the C-model. The chosen values are based on the distribution of the levels of certainty among the respondents and on the experience from a previous study, see Ladenburg & Martinsen (2004). Nevertheless, is should be kept in mind that the application of different discriminating values would most probably give different results.

Model 3 – Rational Choice Model

The Rational choice model (R-model) is based on the sample used in model 2 and thereby only contains respondents who feel certain in their choices. In addition, however, respondents who have made inconsistent answers to the debriefing answer 7.4, have also been excluded from the datasets. The "test" which is used to identify inconsistent respondents, is based on the following four statements:

7.4a Off-shore wind farms must be placed so they are not visible from the coastline: Agree/Disagree
7.4b Off-shore wind farms must be concentrated in a few areas: Agree/Disagree
7.4c It is all right to place off-shore wind farms close to the coast line as long as the surrounding area is safeguarded: Agree/Disagree
7.4d Off-shore wind farms must be distributed along the coastline in small groups: Agree/Disagree

The identification of inconsistent answers is made by analysing the answers to these questions. These analyses are based on the criteria that are set up in Table 6 below.

Table 6: Consistency test for use in Rational-model. The respondents answering inconsistently (-) are excluded from the sample.

Question I	Agree	Disagree	Question II	Agree	Disagree	Consistency
7.4a	X		7.4c		x	+
7.4a	X		7.4c	x		-

[19] Respondents who have not completed the questionnaire satisfactorily (missing information with regards to income, gender, etc., or missing choices) have been excluded.

7.4a		**X**	7.4c		**x**	**-**
7.4a		**X**	7.4c	**x**		+
7.4b	**X**		7.4d		**x**	+
7.4b	**X**		7.4d	**x**		**-**
7.4b		**X**	7.4d		**x**	**-**
7.4b		**X**	7.4d	**x**		+

In Table 6 the criteria for the exclusion of inconsistent respondents are presented. As an example of inconsistency, it appears from the table that respondents who agree that wind farms must be concentrated in few areas and also agree that the wind farms should be spread along the coastline in small groups are considered inconsistent.
The R-model is constructed, as it may be expected that respondents who answer inconsistently to the questions in 7.4 may not have been paying attention when answering the questions. If this is the case, they might not have paid attention to the alternatives in the choice sets either, when choosing the preferred alternative. Consequently, their answers may lead to a wrong or inaccurate choice models and WTP estimates.

4.2.2 Methods Used for Construction of Models

In the following section, the procedures used to identify the significant variables in the final models are elaborated. Three steps are used in the derivation of the final choice model. The three steps are a univariable analysis, a multivariable analysis, and a model evaluation.

The software used for the derivation of the choice models in the report is the statistics program STATA 8.2.

Step 1: Univariable Analysis
Based on the hypotheses of potentially influential variables relating to socio-economic or attitudinal respondent characteristics (see section 3.2.1), a univariable analysis of each potentially relevant variable is performed as the first step of the analysis. The results of the univariable analysis determine which variables to include in the multivariable analysis. This specific model-building approach is recommended by Hosmer & Lemeshow (2000). Subsequently, potentially important interaction effects are identified by including the interactions one at a time. In this study, a modification of this strategy is used: univariable/bivariable analysis. Estimation of separate models for each potentially important interaction term[20] is used to determine whether or not the proposed hypotheses are significant (see section 3.2.1). To avoid premature rejection of hypotheses – i.e. failing to identify potentially important variables – a p-value of 0.25 is used as a screening criterion. Variables with $p < 0.25$ are considered potentially significant, whereas variables with $p > 0.25$ are deemed insignificant as determinants of choice (Hosmer & Lemeshow, 2000).

It should be mentioned that all the six main effect variables (DIST12, DIST18, DIST50, SIZEM, SIZEL and PRICE) are included in the second step, regardless if one of them is above the 0.25 threshold. The reason is that the main effects variables are included in the choice set presented to the respondents. The fact that main effect variable is not significant is thus a result in its self. Interaction variables with a significance level higher than 0.25 are included when they are closely related to other significant variables. An example could be the interaction between price and income

[20] More specifically, these separate models are estimated with the interaction term along with the relevant off-shore wind farm attribute as the only explanatory variables.

(P_INC). If the interaction between price and the three income groups P_INC1, P_INC2, P_INC4 turns out to be significant, the variable P_INC3 is included in the second step, even if it proves to be insignificant (>0.25) in the univariable analysis.

Step 2 Multivariable Analysis
In the second step in the model derivation – i.e. the multivariable analysis, - all the significant interaction variables and the non-significant variables closely related to significant variables are evaluated together with the 6 main effect variables. The criterion used for excluding variables from the model is a 0.05 level of significance. This means, that if a variables´ level of significance is above 0.05, it is considered to be insignificant, and is subsequently excluded from the model.

The purpose of the multivariate analysis is to derive the three choice models for each sample (B-model, C-model and R-model). These models are derived using the same procedures (see below), but are, of course, based on the different samples described in the section 4.2.1. The different procedures used for deriving the final models are:

- Manual derivation
- Backward selection
- Backward selection with lock term
- Forward selection
- Forward selection with lock term

Aside from these approaches, several other derivation methods were investigated, including stepwise forward and backward selection, and the use of the Wald test instead of the chosen likelihood-ratio test. However, it was found that deriving the five different models by using the listed methods sufficiently covered the choice model space.

The methods in use will not be commented in detail, but the principal points will be singled out. For a more detailed description, please see Long & Freese (2003) and StataCorp. (2003).

Manual Derivation: In the manual derivation, the most non-significant interactions effecting variables are removed one by one considering the possible relations between variables. This process continues until the model only contains variables with coefficients that are different from zero on a 0.05 significance level.

Backward Selection: This procedure in STATA performs stepwise estimation on the full set of variables, excluding the non-significant variables. The procedure differs from the manual derivation by not keeping the main effect variables and by not considering relations between variables.

Forward Selection: Like the backward selection, this is an automatic STATA procedure, but the forward selection performs a stepwise estimation by starting with an empty model, adding variables one at a time, keeping those who are found to be significant, and rejecting those who are non-significant.

Backwards and Forward Selection Using Lock Term: By combining the backward and forward selection with the use of the command *lock term*, the stepwise estimation is made with the *locked* variables in the model. This procedure ensures that the six main variables are present in the derived model.

Step 3: Model Evaluation
Each of the selection procedures identifies a choice model. The multivariable analysis therefore results in five possible choice models for each sample. The third step in the model derivation is therefore to select the best model or combine the models to the final choice model. This is done by evaluating the different model suggestions, both in terms of the statistical fit, and how causal and sensible they are when considering general economic theory. In most cases the derived manual model results in the soundest model, but the models obtained through the STATA procedures have to be considered.

5 Analysis of Samples and Respondents

This chapter starts with a brief presentation of the response rate of the three surveys. This is followed by an analysis of the three samples estimating how representative they are of the population from which they are sampled, with regard to socioeconomic characteristics. Given that the elicitation of the different models is based on different fragments of the samples, the specific models samples are subsequently compared to the initial and unrestricted samples. Finally the choice-set distribution is evaluated across samples and models.

5.1 Response Rate, Distribution between Samples and Rate of Return

The average response rate across the three samples was almost 50 per cent (49.6 per cent) in total. Of those only 3 per cent were discarded because of lack of information, leaving 48 per cent or 672 respondents in the three samples. The distribution of respondents between the three samples can be seen in Table 7. It is worth noticing that the National sample (NA sample) was the only sample that received a second reminder, which may explain the higher rate of response, compared to the Nysted (NY sample) and Horns Rev samples (HR sample).

Table 7: **Sample sizes including response rates and invalid answers.**

Sample	NA sample	HR sample	NY sample
Questionnaires in sample	700	350	350
Returned	375	141	178
Returned, but not valid	13	1	8
Effective sample	362	140	170
Effective response rate (%)	51.7	40.0	48.6

In the random draw of respondents in the three samples, no respondent belonged to more than one sample. However, in the national sample, 13 respondents were residing in two local sample areas. The overlap between the NA sample and the two local samples was very small, except for Esbjerg where 11 respondents from the same area as the HR sample had been included in the national sample (Table 8).

Table 8: **Respondents in the national sample who are situated in the local sample area.**

Sample	Municipality	Number of respondents from the national sample
Nysted	Holeby	0
	Nysted	1
	Sydfalster	1
Horns Rev	Blåvandshuk	0
	Esbjerg	11
	Fanø	0

The pace in which the questionnaires have been returned is presented in Figure 4. It can be seen that approximately 80 percent of the returned questionnaires were returned within the two first weeks. In this relation, it is interesting to note that the mailed reminders have had a significant effect on the response rate. An example is the NY sample, in which the number of returned questionnaires dropped to a low level after the first ten days. After a reminder was mailed on May 10, the response rate rose over the following days. The same is the case for the other samples where reminders were mailed on May 6 and 9 for the HR and NA sample respectively. A second reminder was mailed for the NA sample on May 21, which can also be seen in the distribution, where there is a slight increase in the number of returned questionnaires afterwards.

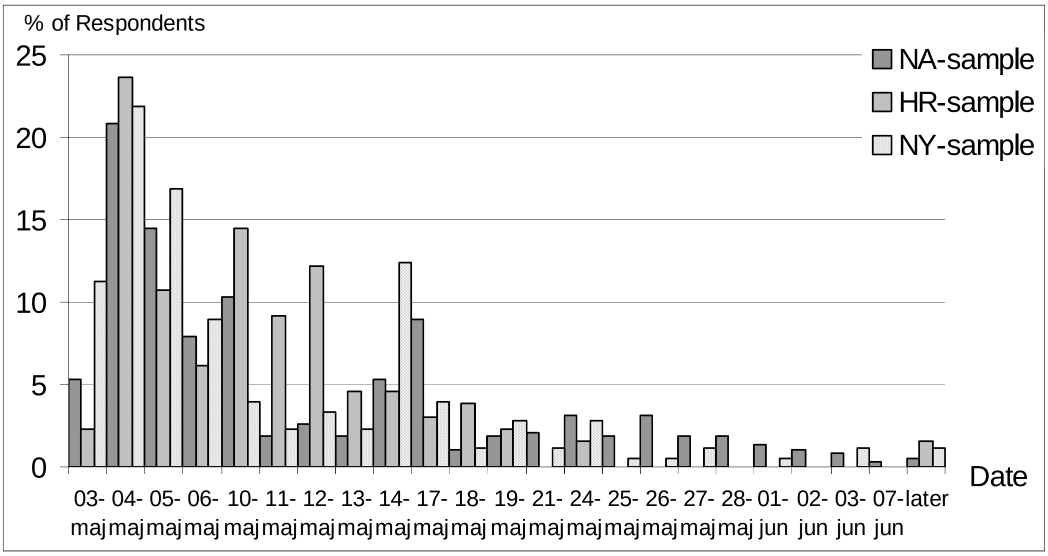


Figure 4: Distribution over time of returned questionnaires in May and June 2004.

5.2 Socio Economic Analysis of samples

With reference to the hypothesis presented in section 3.2.1 (Table 2) it is expected that preferences for the location and the size of off-shore wind farms might differ between the respondents with regard to their socio-economics characteristics. The focus of this section is therefore to compare the socio-economic characteristics of the respondents across the three samples. The comparisons will be done with regard to four characteristics; gender, education, income and age. In addition to the comparisons between samples, the nationwide statistics (DK-stat) of the four characteristics is included to put the samples in a national perspective (Statistics Denmark 2003). In the next main section (5.3) a comparison for each of the three models in each sample will be made with regard to the relevant socio-economic statistics.

In the following, the B-models of three samples are compared. As mentioned, the B-models contain the unrestricted dataset from each sample representing 375 respondents from the NA sample, 140 respondents from the HR sample, and 170 from the NY sample.

5.2.1 Gender

As seen in Table 9, the distribution of gender is relatively identical across the samples and only deviates slightly from the national distribution. The HR and NY- samples, though, have a larger proportion of male respondents, especially when compared to the NA sample. However an X^2-test finds that only the NY sample is significantly different from the NA sample and only just at a 0.05 level of significance. For a comparison with the relevant socio-economic statistics for the NY- and HR-areas, see the next main section (5.3).

Table 9: Distribution of gender between samples. Also presented is nationwide statistics as DK-stat (Statistics Denmark 2003).

	NA sample	HR sample	NY sample	DK-stat.

Female	53	46	45	50
Male	47	54	55	50
Sum	100	100	100	100

5.2.2 Education

Comparing the level of education between the NA sample and the two other samples, it is found that the distribution of the educational level in the NY and HR sample differs significantly from the NA sample on a 0.01 level. The largest differences between the three samples are the percentages of the respondents with a bachelor or master level of education (Edu6 and Edu7), see Figure 5. In the NA sample, the percentage is between 3 and 4 times larger than in the NY and HR sample. The difference between the three samples is most probably due to differences in the populations from which the samples are drawn, see Figure 8 and Figure 10. In all three samples, respondents with a higher level of education are overrepresented compared to the national distribution, which indicates that respondents with a higher educational level have had a relatively higher response rate. The reason is most probably that it has been easier for respondents with a high level of education to understand and fill in the questionnaire. However, as previously mentioned, it must be emphasised that the distribution on the national level is not necessarily representative of the NY and HR samples.

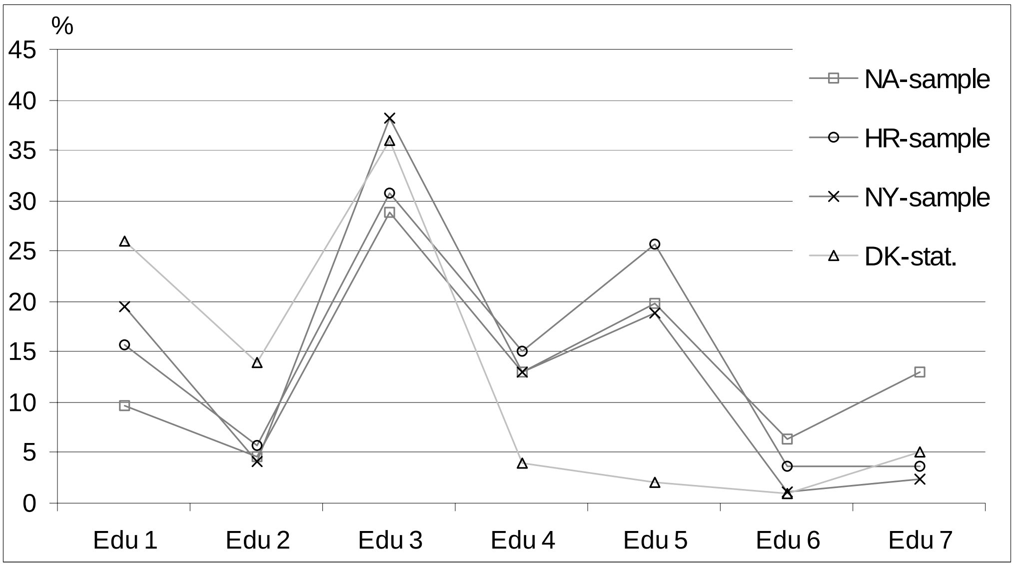


Figure 5: Distribution of respondents in percentage of the different educational levels. .Edu 1 = primary school, Edu 7 = Academic education.

5.2.3 Income

In the analysis of the income levels, the distribution is found not to differ between the NA sample and the HR sample. The NA and the NY-samples are though significantly different. The NA sample does not deviate much from the distribution of the national statistics (DK-stat in Figure 6). This is surprising, given that the higher educational level was expected to result in a larger proportion of respondents with a high income level. It could be explained if the income of educational level 4-6 is reflected in income levels 3 and 4, and not in income level 5. It must, however, be remembered that it is not necessarily straight forward to link education and income, as the income is stated at household level.

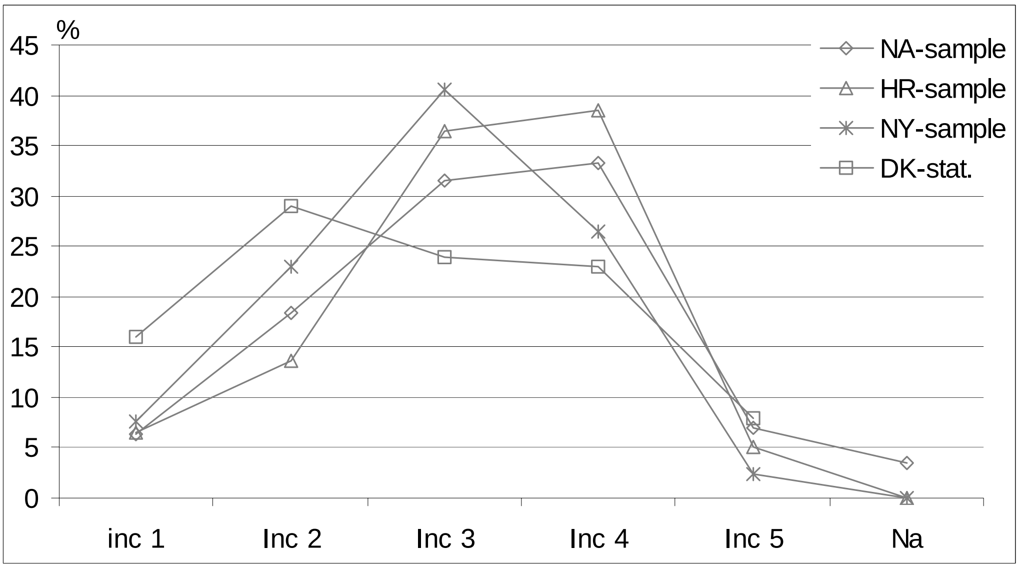


Figure 6: Distribution of respondents' income per household as a percent of the total of each sample. Nationwide statistics are plotted as DK-stat (Statistics Denmark 2003). The income levels are: 1 = under 150,000, inc 2 = 150,000 -299,999, inc 3 = 300,000 – 499,999, inc 4 = 500,000 – 799,999, inc 5 = more than 800,000.

5.2.4 Age

When compared to the age distribution of the NA sample, both the NY and the HR sample are significantly different at the 0.001 level and the 0.01 level, respectively. As seen in Figure 7, the sample from HR shows an especially large deviation in the 1955-1959 category. Comparing the three samples and the distribution on national level (DK-stat), it is evident that all three samples hold more elderly and fewer young respondents. This is not surprising for the NY sample, since the population, from which it is drawn, has a relatively higher number of elderly people, see Figure 16. However, there does not seem to be a straightforward explanation as to why the HR and NA samples show this trend as well. One possible explanation could be that the younger respondents have not been as conscientious about returning the questionnaires.

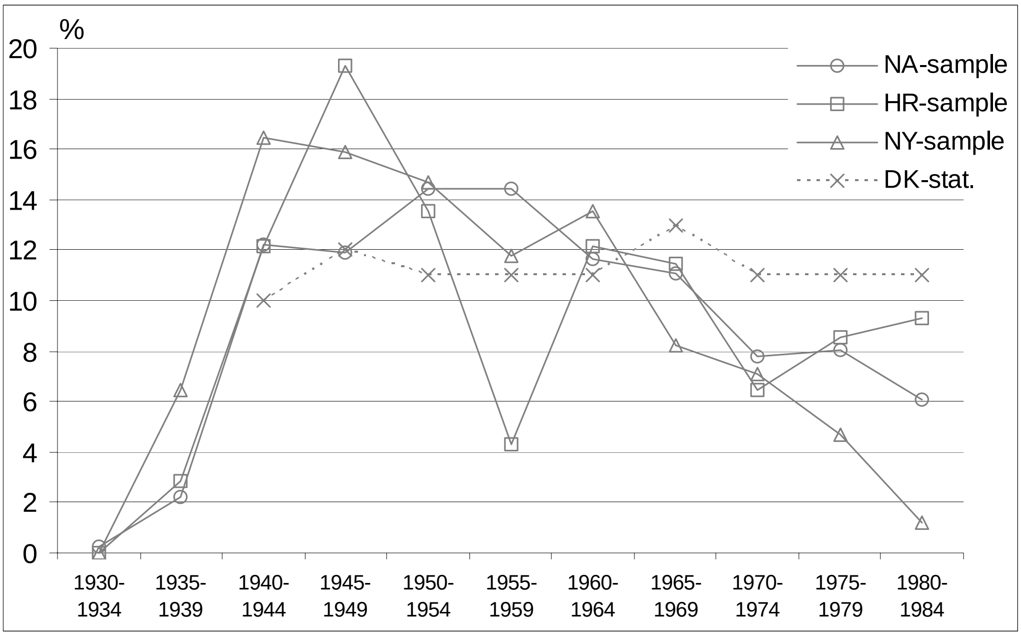


Figure 7: Distribution of respondents in percent over years. DK-stat is representing nationwide average (Statistics Denmark 2003)**.**

5.2.5 Summery

On the basis of the analysis of the socio-economic characteristics, it can be concluded that the three samples are not uniformly identical with regard to the four socio-economic characteristics; gender, education, income and age. However, besides the distribution of age of the HR sample, the various distributions seem to be relatively identical across samples.

It is difficult to conclude whether the differences between samples are of a character which can explain possible differences in preferences across the three samples. Looking at the income levels, both the HR- and NA samples have a high frequency of high income households, which priori and with reference to the hypothesis Table 2 could suggest that these samples will show a lower sensitivity to the price attribute than the NY sample. Subsequently this would result in higher WTPs. However, such an effect, and thereby higher WTPs, will require, though, that the hypothesis is true and significant in the elicited choice models. Similar potential causes for differences in the preferences and WTP can be addressed with regard to the other socio-economic characteristics.

5.3 Socio-economic analysis between Models

As disused in Chapter 4, three different models are elicited for each sample. In the C and R models, the exclusion of respondents might have an effect on the distribution of the socio-economic characteristics of the respondents.

In the present section, it is therefore analysed if exclusion of respondents has an effect on the distribution of the socio-economic characteristics of the respondents comprising the different samples. This is important since if the preferences for off-shore wind farms vary with regard to socio-economic characteristics of the respondents, then changes in the distribution of socio-economic distribution of the respondents could explain possible differences in preferences and WTP between models.

The reduction in number of respondents when deriving the C-model and the R-model is presented in Table 10 below.

Table 10: Reduction of respondents as a cause of derivation of different models.

	B-model	C-model	R-model
NA sample	375 (100 %)	254 (67 %)	162 (43 %)
NY sample	170 (100 %)	113 (66 %)	73 (43 %)
HR sample	140 (100 %)	100 (71 %)	67 (48 %)

In Table 10 it is seen that the number of respondents in each sample decreases as the models get more restrictive (C-model and R-model). It is interesting to see, that the relative reduction in the number of respondents in each model is almost identical across samples. In the C-model, the number of respondents decreases to between 67 and 71 per cent of the number of respondents in the B-model (unrestricted model). In the R-model, the number of respondents decreases to between 43 and 48 per cent of the respondents in the B-model. This indicates that to some degree the proportion of certain respondents (C-model) and rational respondents (R-model) is systematic across the three samples.

The conducted statistical analysis on the differences between the datasets underlying the three models within each sample, reveals that there are no major differences in the socio-economic characteristics between them. This conclusion is based on X^2-tests. In the X^2-tests the hypothesis is that the dataset underlying the C and the R models are distributed like the B-model in terms of their socio economic characteristics. All these tests turn out to be non-significant, and thereby rejecting the hypothesis. This means, that the necessary reduction of the dataset prior to elicitation of the two restrictive models (C and R-models), does not significantly change the distribution of the socio-economic characteristics of the respondents. In this relation, the C and R-models are considered to be equally representative as the unrestrictive B-model.

In the following sections, the socio-economic implications of deducting different models within each sample are elaborated on. Even though the statistic analysis reveals that there are no major differences in the distribution of socio-economic characteristics, the graphical analysis of each characteristic is presented. However, only the differences perceived interesting are discussed.

5.3.1 Gender

The derivation of the two restrictive models results in a change in the distribution of male and female respondents. In the NA and NY samples the result is a reduction of female respondents (Table 11) and a reduction of males in the HR sample. Consequently there does not seem to be any systematic change in the distribution of genders across samples.

Table 11: Development in the composition of female respondents as a result of dataset restrictions.

	B-model	C-model	R-model	DK-stat
National	52	46	48	50
Nysted	45	42	40	50
Horns Rev	46	46	48	50

5.3.2 Education

The change in the level of education is considered relatively small between the three models in each of the samples (Figure 8 to Figure 10). The most dominant change happens in the HR sample where respondents in model R deviate by 9 and 8 percentages points at the educational levels 3 and 4, compared to the B model (Figure 9). The largest deviation between models within samples is between model R and the B models in the NY sample. Here a difference of 11 percentages points is occurring at educational level 1. It is also worth mentioning that there seems to be some small relation between the number of respondents with educational level 1 and the three models. Despite the mentioned differences, it has not been possible to detect any significant changes in the distribution of the educational levels as a result of the exclusion of respondents.

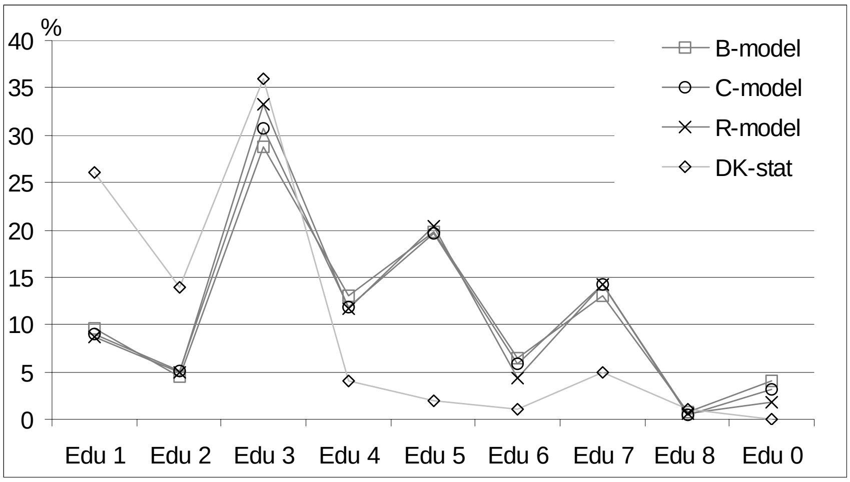


Figure 8: Comparison of the respondents' level of education in the NA sample. National distribution included (Statistics Denmark 2003).

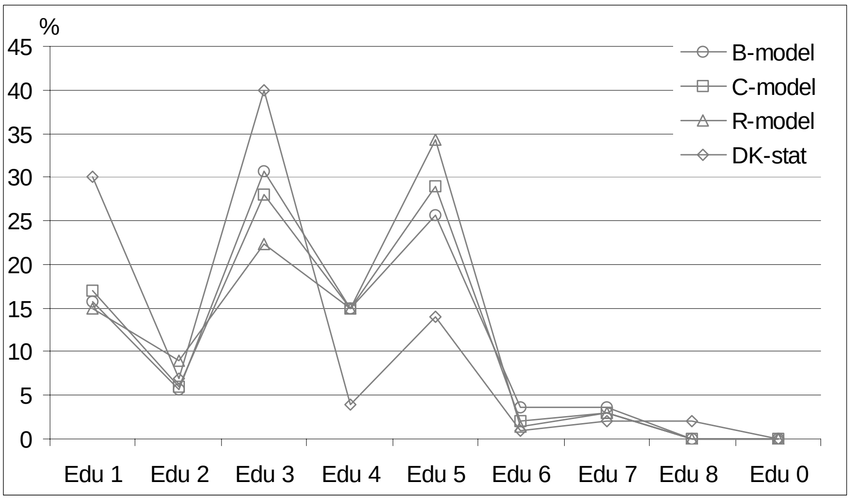


Figure 9: Comparison of the respondents' level of education in the HR sample. HR population distributions included (Statistics Denmark 2003).

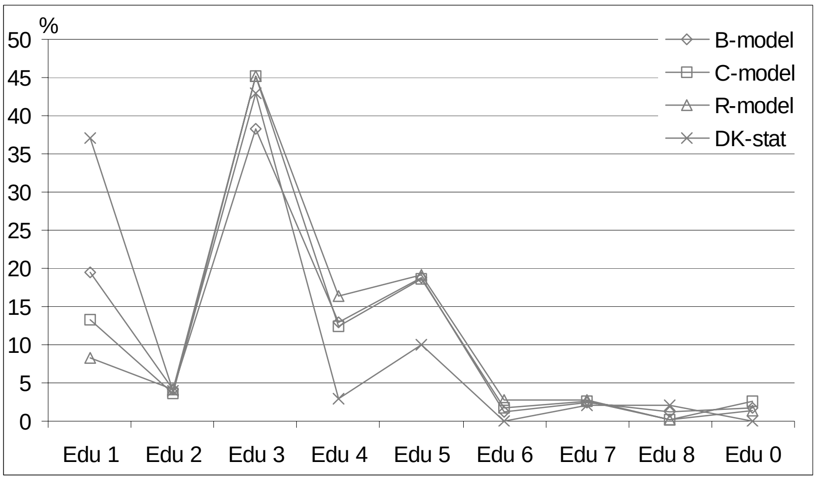


Figure 10: Comparison of the respondents' level of education in the NY-sample. NY-population distribution included (Statistics Denmark 2003).

5.3.3 Income

As for education there are no major deviations in the level of income distribution between different datasets underlying the different models for the three samples (Figure 11 to Figure 13).

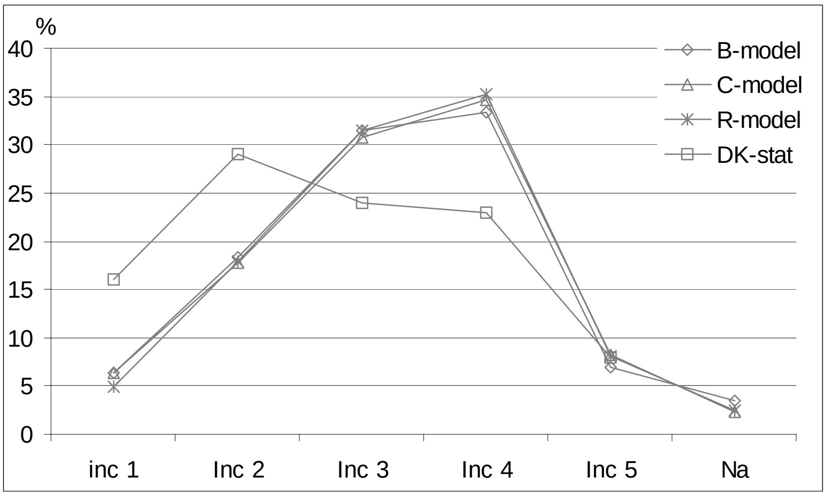


Figure 11: Comparison of the respondents' level of income in the NA sample. National average included (Statistics Denmark 2003).

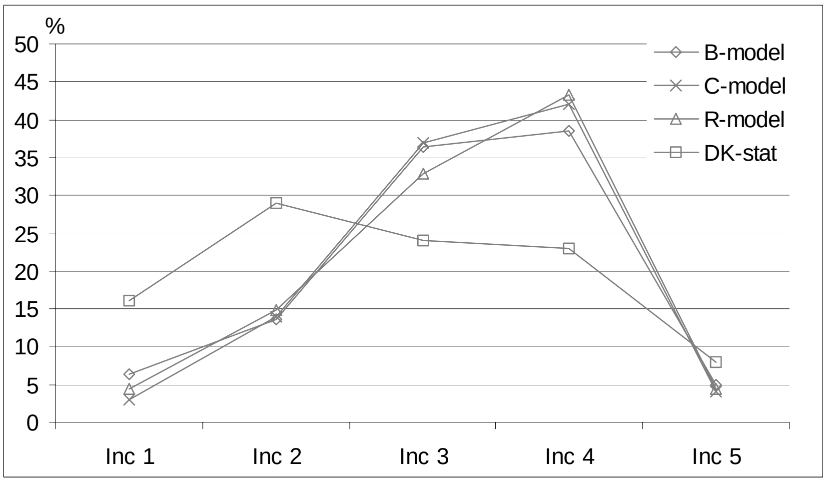


Figure 12: Comparison of the respondents' level of income in the HR sample. National average included (Statistics Denmark 2003).

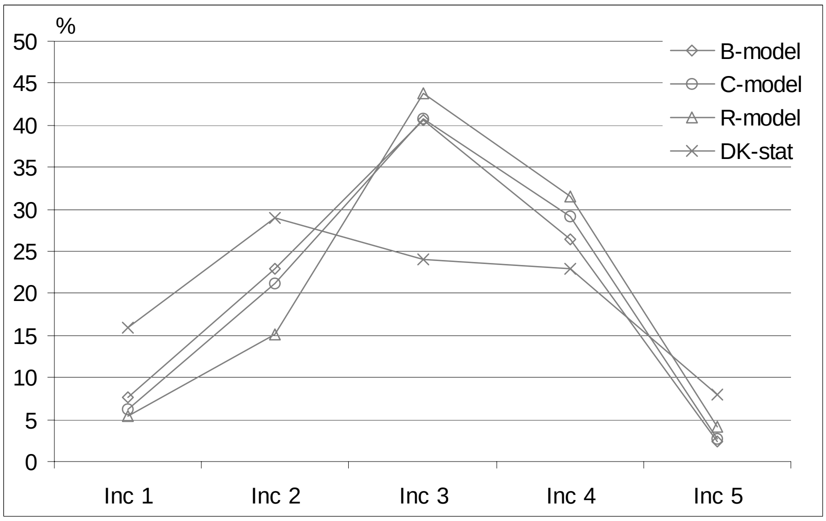


Figure 13: Comparison of the respondents' level of income in the NY-sample. National average included (Statistics Denmark 2003).

As seen from the Figure 11 to Figure 12 when it comes to income, there are no exceptional differences between the distributions in the datasets underlying the three models within each sample. The NA sample is almost completely identical across models, whereas the datasets underlying the C-model deviates a little in the HR and NY-models.

5.3.4 Age

As mentioned earlier, the age distribution between the three geographical samples deviated significantly. However, when the distribution is examined between models in each sample, no significant difference can be detected. This is reflected in the graphical presentation in Figure 14 to Figure 16. It is seen that the largest deviation between models is found between the B-model and the R-model in the HR sample (Figure 15). However, there appears to be no systematic variation. As mentioned in section 5.2.4, the respondents in the HR sample show a large deviation from the other samples within age-groups 1945-49 and 1955-59. However, this is the case for all the three models in the sample.

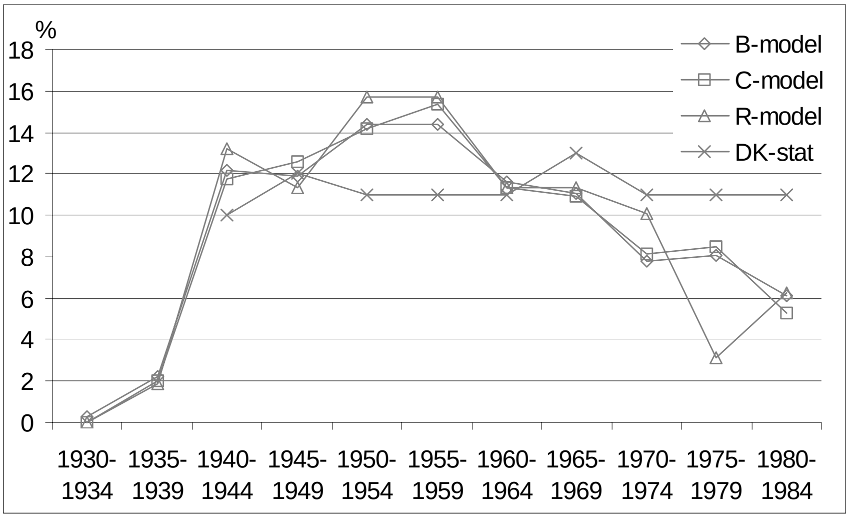


Figure 14: Comparison of the respondents' age in the NA sample. National average included (Statistics Denmark 2003).

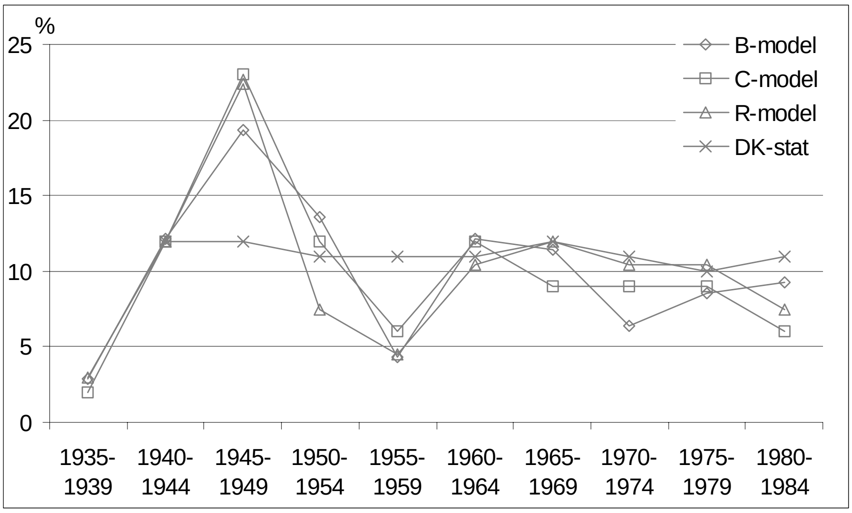


Figure 15: Comparison of the respondents' age in the HR sample. National average included (Statistics Denmark 2003).

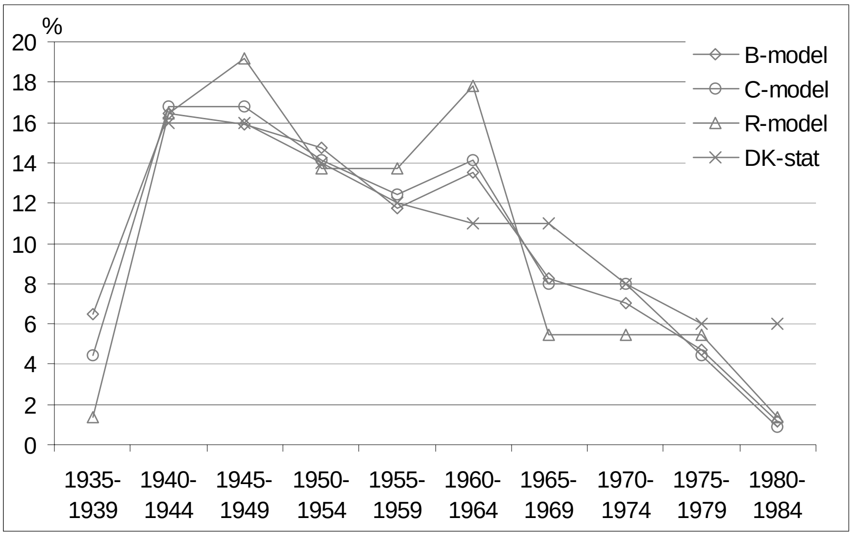


Figure 16: Comparison of the respondents' age in the NY sample. National average included (Statistics Denmark 2003).

5.3.5 Summary

Based on the statistical and graphical analysis of the distribution of socio-economic characteristics across the different datasets underlying the three models derived for each geographical sample, it can be concluded that the socio-economic characteristics of the three-model datasets within each sample are relatively identical. The exclusion of respondents which is required for derivation of the C and R models does not have any effect on the composition of the respondent's socio-economic characteristics. Consequently it is assumed that comparisons of preferences across models in each sample can be done with relatively little loss of generality.

5.4 Distribution of Blocks Between Samples and Models

In a Discrete Choice Experiment (DCE), the experimental design is most often made by the analyst. Therefore it is the analyst who, based on experience and theoretical considerations, decides on the following: how many attributes should be used to define the good subjected to valuation, how many levels for each attribute, and how to design the individual choice sets. The design of the choice sets includes the combination of attributes and the level of these, and in this process an optimal design is important to provide the best possible level of information. One of the features in an optimal design is level balances and orthogonality. This secures that each combination of attributes/alternatives is evaluated by the respondents just as frequently as the other alternatives. However, even though the design of the experiment is made with such an even distribution of choice sets, the fact that some respondents decide not to participate in the survey implies that it cannot be ensured that the returned questionnaires will represent such an even distribution. As so, an uneven distribution might result in a distorted measuring of preferences, since the properties of the choice-experiment design might be changed, see 3.3.2 and 3.3.3.

5.4.1 Distribution of Choice Set in all Samples

In Figure 17 below, the distribution of the 18 choice sets in the questionnaires returned by the respondents in all three samples is presented.

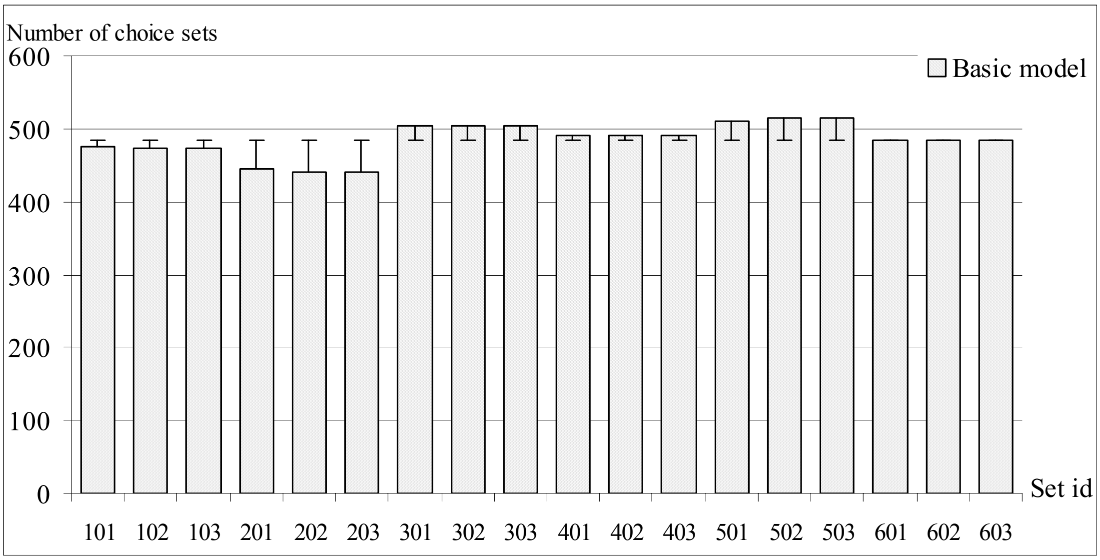


Figure 17: Summarised choice set for the three samples, deviation from mean is presented.

As it can be seen in Figure 17, the different choice sets are almost equally represented in the total effective sample, although the choice sets 201, 202 and 203 deviate somewhat more from the mean than the other choice sets. However, Figure 17 does not bring any information on the distribution of the choice set within each of the samples and across models, consequently the sample-specific choice set distributions are presented in the next three sections.

5.4.2 Distribution of Choice set in NA sample

As seen from Figure 18, the choice sets are fairly evenly distributed in the B-model, though choice sets 501-503 deviate relatively more from the mean than the others. The derivations of the C and R-models result not only in a reduction of the number of choice sets, but also in changes in the relative distribution between choice sets. In the B-model, choice sets 101-103 are over represented, but in the C and R-models the same choice sets are under represented. It is difficult to determine which consequences the somewhat uneven distribution of choice sets along with the changes in relative distribution following the exclusion of respondents, have on the choice models that are derived in the different models. One consequence is that the attribute levels in the dataset are no longer balanced when compared to the initial and ideal design, meaning that some levels are represented relatively more often than other levels, see 3.3.3. Accordingly, all else equal, the dataset is not as efficient with regard to measuring preferences as it could potentially have been. Considering the fairly even distribution of choice sets there does not appear to be any critical missing/under represented choice sets which might jeopardise the results in any of the three models estimated for the NA sample.

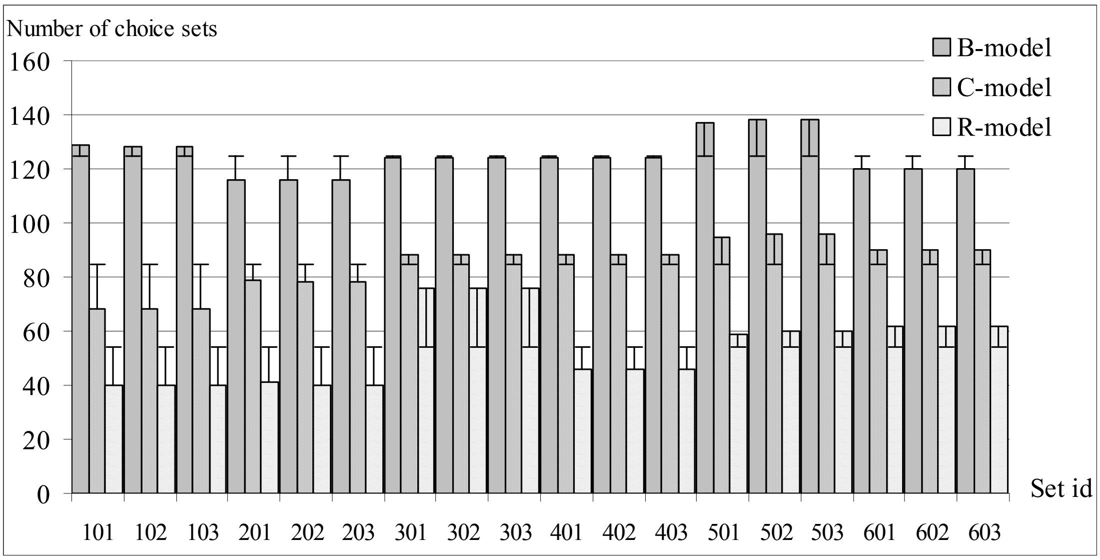


Figure 18: Distribution of choice set of the NA sample, deviations from mean presented.

5.4.3 Distribution in the Horns Rev Sample

The distribution of choice sets in the HR sample is not as even as those of the NA sample, see Figure 19. Especially there are quite large deviations from the mean in the B-model. The deviation from the mean is less pronounced in the C and R-models. However, none of the 18 choice sets are subjected to massive under representation, suggesting that it is unlikely to have a significant impact on the results of the analysis.

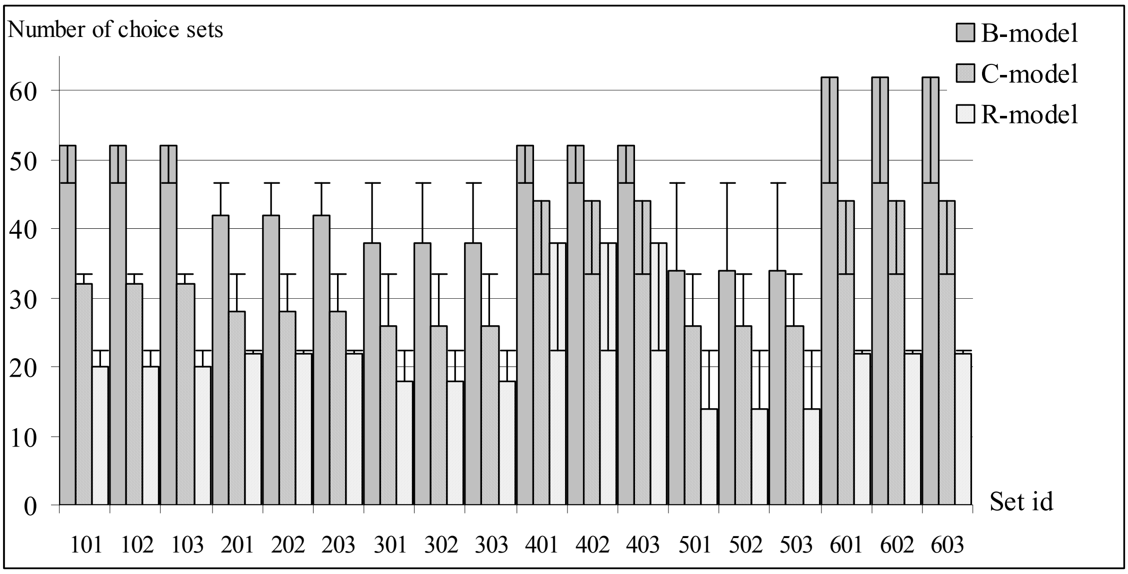


Figure 19: Distribution of choice set for the HR sample, deviations from mean presented.

5.4.4 Distribution in the Nysted Sample

In Figure 20, the distribution of the choice sets in the NY sample is illustrated. Just as in the HR sample, the distribution in the B-model is quite uneven. In relative terms it is especially the choice sets 501-503 and 601-603 which deviate from the mean. In this connection it may be interesting to note that while choice sets 601-603 appear to be overrepresented in the HR sample, it is rather underrepresented in the NY sample. Thus, there appears to be no systematic variation across the sample. However, in the C and R-models, the distributions are relatively more equal.

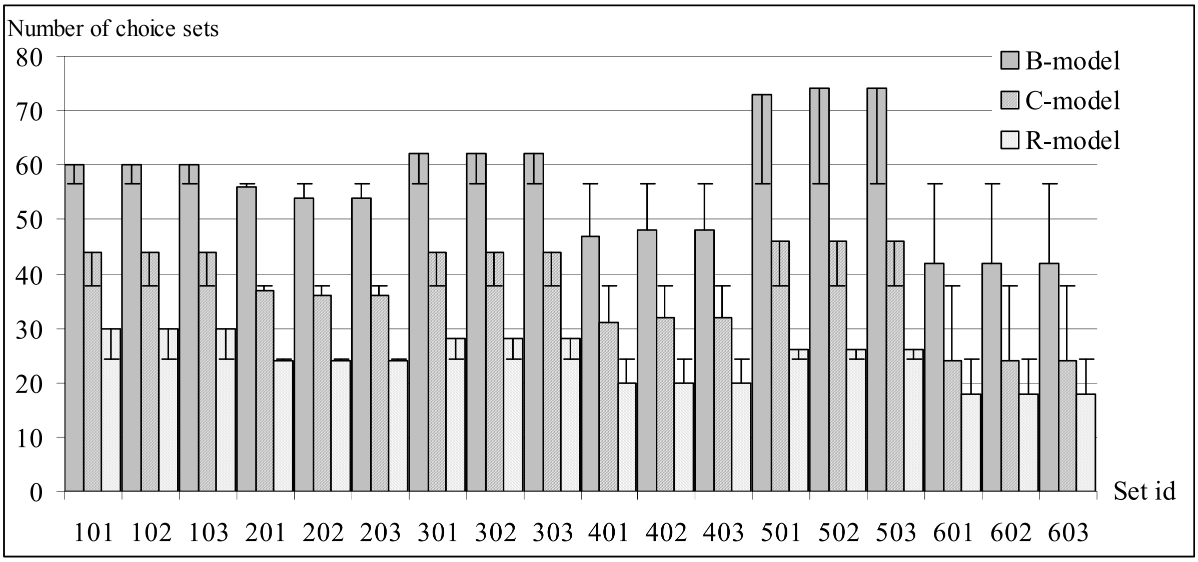


Figure 20: Distribution of choice set for the NY sample, deviations from mean presented.

Just by looking at Figure 20,it is though difficult to determine whether the different distributions for the three models in each sample are significantly different from a uniform distribution or difference between models. These distributional properties will be examined in the following section.

5.4.5 Test of uniform distribution

In Figure 20 the graphical analyses of the distribution of the 18 choice sets in the three samples are displayed for all three models elicited for each sample. In Table 12 statistical tests of whether or not these distributions are uniformly distributed are presented. The performed test is a χ^2–test of the hypothesis that the choice sets are uniformly distributed.

Table 12: χ^2-test of the hypothesis that the choice sets within the individual model are evenly distributed.

	B-model	C-model	R-model
NA sample	NS	NS	***
H sample	**	*	***
NY sample	*	*	NS
All		NS	

NS non-significant, * significant on a 0.05 level, ** significant on a 0.01 level and *** significant on a 0.001 level.

In Table 12 only the distributions in the B and C-models in the NA sample, and the R-model in the NY sample are not significantly different from a uniform distribution. This means that in most cases the different levels of the attributes are not balanced/equally represented in the dataset. It is difficult to determine the degree of consequences this has for the derived choice models and the elicited preferences. However, it is not within the scope of this paper to test for possible unlevelled balance effects.

Aside from testing the sample distribution of choice set, the between-model distribution is also tested with regard to the B, C and R-models in each sample. This is done to identify potential problems caused by the reduction of the sample with regard to the choice set distributions. The hypothesis of the test is that the choice sets in the C and R-models are distributed as in the unrestricted B-model, see Table 13 below.

Table 13: χ^2-test of the hypothesis that the distribution of choice sets in the C-model and R-model is identical to the distribution in the B-model.

	C-model	R-model
NA sample	NS	***
HR sample	NS	*
NY sample	NS	NS

NS non-significant, * significant on a 0.05level, ** significant on a 0.01 level and *** significant on a 0.001 level.

As seen from Table 13, the hypothesis cannot be rejected in four of the six tests. More specifically, the test results in Table 13 strongly indicate that the distribution of the C-models across samples is determined by the initial distribution in the B-model, since all the test-statistics are non-significant. However, the exclusion of respondents moving from the C-model to the R-model seems to significantly change the distributions,, except in the NY sample. Again it is difficult to verify the degree of consequences this has for the derived choice models and the elicited preferences, and is not within the scope of this paper to test further. It is therefore assumed that the observed differences in distribution only affect the efficiency of the models and introduce no biases.

6 Attitudes towards Development in Wind Power Generation

In the questionnaire used in the three surveys (National (NA sample), Horns Rev (HR) and Nysted (NY)), the respondents were initially asked about their attitude towards wind power production, see Appendix A. The purpose of these questions was to introduce the respondents to the centre of attention in the questionnaire; wind power production and associated potential conflicts, such as visual impact on the landscape, etc. Secondly, the intended purpose of the questions was to retrieve some information on respondents' basic attitudes (positive, neutral and negative) towards wind turbines and wind farms. Thirdly, the intention was to elaborate on these attitudes in detail, retrieving information on attitudes towards future development in wind power and specific impacts from wind farms.

6.1 Attitudes towards Energy Policy in General

6.1.1 Choice of Energy Source

The respondents were asked to relate to some simple energy policy statements. One of these was the statement: "The national choice of energy source does not only depend on environmental considerations but also on economic considerations". The respondents' attitudes to this question are presented in Figure 21.

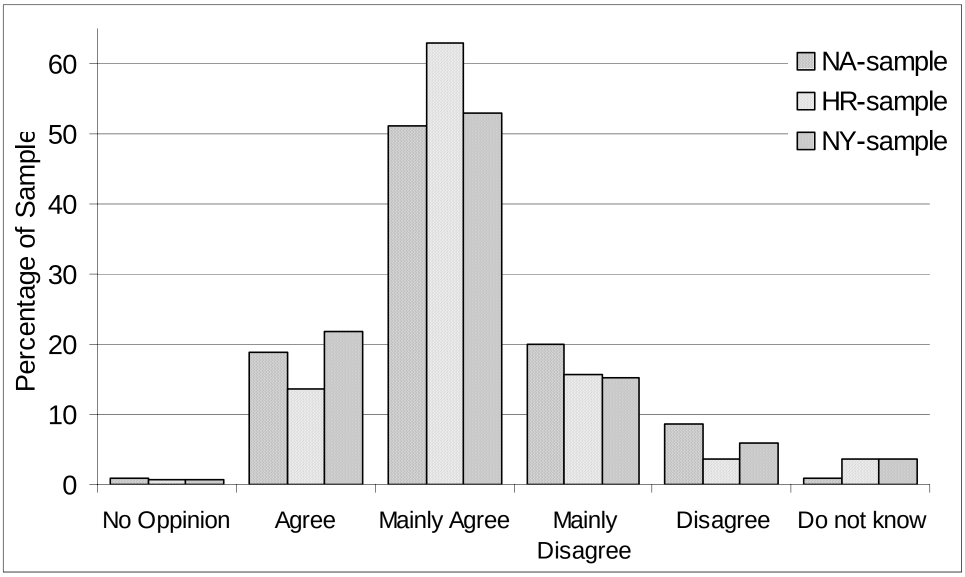


Figure 21: Distribution of respondents when asked if economic considerations should be included when considering environmental issues (Q. 5.1).

6.1.2 CO_2 Reduction

One of the general questions concerns how the Danish obligation towards CO_2 reduction should be fulfilled. The respondents' attitudes are presented in Figure 22, and the figure shows the percentage of respondents who find that each of the seven options should be used to a great extent, contrary to a moderate extent or not at all. For example using nuclear power is stated to be "used to a great extent" by 4-6 percent of the respondents. As seen, the preferred means of reducing the CO_2 outlet is solar power and wind energy, and no major differences can be observed between the three samples. The only energy source which experiences a large difference across samples is the use of biomass. Thus, 63 percent of the respondents in the NY sample find that it should be used to a great extent, whereas the corresponding percentage for the other samples only amounts to around 34 per cent.

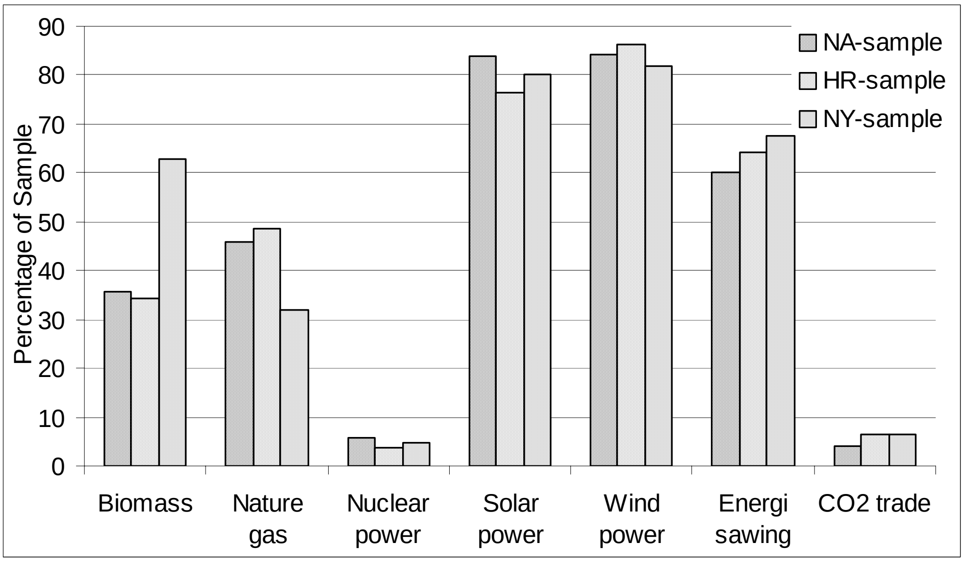


Figure 22: The percentage of each sample respondent when asked if the energy type should be widely used or not, considering the required reduction in Danish CO_2-emission (Q. 1.4).

6.2 Attitudes towards Land-based Wind Turbines

In question 2.1 and 2.2, the respondents were asked to express their attitudes towards existing and new land-based wind turbines. In question 2.3, the respondents were furthermore asked about the visual effects associated with land-based wind turbines. The results of these questions are presented in the following sections.

6.2.1 Attitudes towards Existing Land-based Wind Turbines

As it can be seen in Figure 23, there seems across the three samples to be a general positive attitude towards existing land-based wind turbines in Denmark.

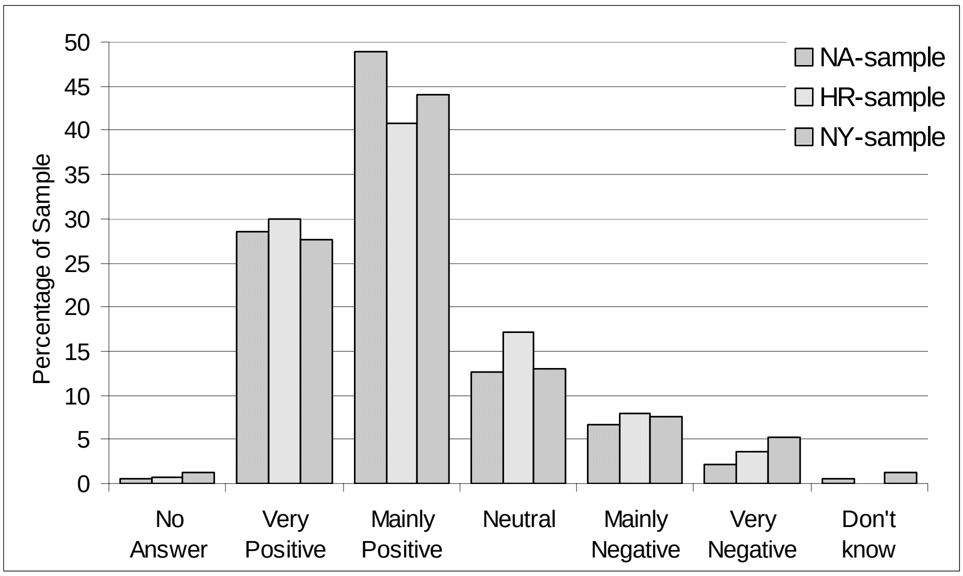


Figure 23: Attitudes toward existing land-based wind turbines (Q. 2.1)

Looking at the numbers behind Figure 23, only between 9 percent (NA sample) and 13 percent (NY sample) of the respondents express a negative attitude towards existing land-based wind turbines. The remaining part of the respondents are either *neutral*, *mainly* - or *very positive*. In general there are only relatively small differences in the respondents´ attitudes across the three samples. It seems, though, as if the respondents in NA sample are a little *more positive,* and the respondents in NY sample a little *less positive* towards existing land-based wind turbines.

6.2.2 Attitude towards new Land-based Wind Turbines

Whereas few respondents expressed a negative attitude towards existing land-based wind turbines, the attitudes towards new land-based wind turbines are, however, more negative. In Figure 24, below, it is seen that more than 22 percent of the respondents across the three samples have a negative attitude towards new turbines on land. Since the ratio of respondents with a neutral attitude is more or less identical to the number in Figure 23,, this means that the number of positive respondents has declined. The differences across samples are not noteworthy. However, the respondents in the NA sample are (again) the most positive, whereas the respondents in the NY sample are the most negative towards new land-based wind turbines.

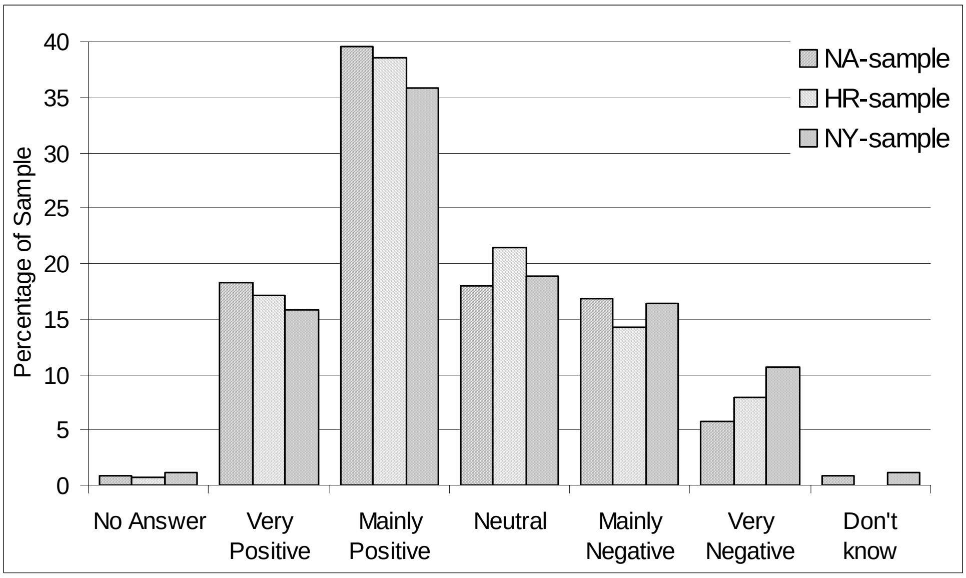


Figure 24: Attitudes towards an increase in land-based wind turbines (Q. 2.2)

6.2.3 Visual Impact of Land-based Wind Turbines

Looking at Figure 25, below, it appears that a large part of the respondents across the three samples associate land-based wind turbines with negative visual impacts on the landscape.

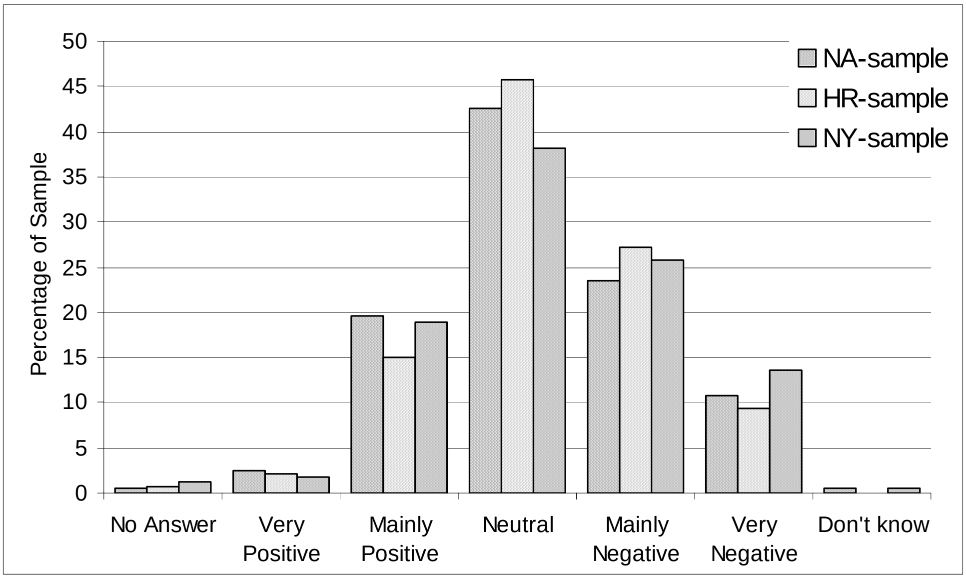


Figure 25: Visual impact of land-based wind turbines (Q. 2.3).

In Figure 25 it is seen that 40 percent in the NY sample, 35 percent in the HR sample, and 32 percent in the NA sample thus consider land-based wind turbines to have a negative impact on the landscape. It is, however, interesting to see that between 38 percent (NY sample) and 45 percent (HR sample) of the respondents express that wind turbines do not have a visual impact on the landscape.

6.3 Attitudes towards Off-shore Wind Farms

In this section, respondents´ attitudes towards off-shore wind farms are presented. The attitudes to off-shore wind farms were explored in question 3.1-3.5. In the questions the respondents were asked to express to what degree they agreed/disagreed with the argument proposed in each question.

6.3.1 Attitudes towards Existing Off-shore Wind Farms

In question 3.1, the respondents were asked about their general attitudes towards existing off-shore wind farms. In Figure 26, the respondents' attitudes are presented.

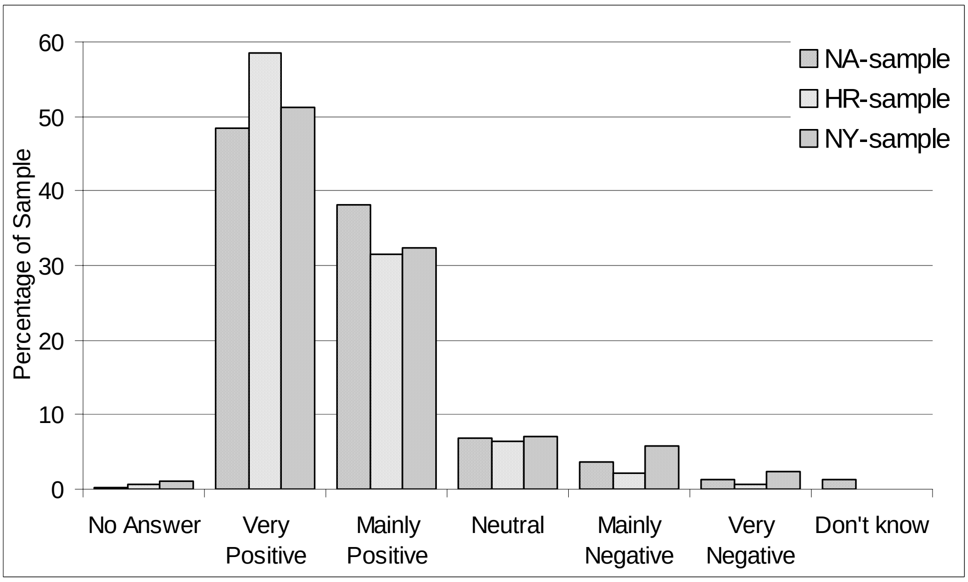


Figure 26: Attitudes towards existing off-shore wind farms (Q. 3.1)

With reference to Figure 26, it is seen that all respondents across all three samples generally have a positive attitude towards the existing off-shore wind farms in Denmark. In the HR sample, 90 percent of the respondents have a positive (very or mainly positive) attitude. The number for the NA sample is 86 percent, and 84 percent for the NY sample. The respondents from the HR sample are more positive, though, when compared to the other two samples. Thus in the HR sample as many as 59 percent of the respondents generally have a very positive attitude, whereas the numbers for the NA sample and the NY sample are 48 percent and 51 percent, respectively. All in all, the attitudes across the samples appear relatively identical, but a Chi-test on equal distributions turns out to be significant on a 0.0001 level, which rejects them being identical. In conclusion, the respondents in the NY sample are a little less positive towards the existing off-shore wind farms, compared to those of the HR sample and NA sample. This corresponds to the findings made by Kuehn (2005a), who conclude that after the establishment of the parks, the interview persons of HR have become more positive towards the park. The same has not happened in the NY area.

6.3.2 Attitudes towards New Off-shore Wind Farms

The respondents in all three samples are, in general, very positive towards the establishment of new off-shore wind farms. Looking at Figure 27, below, the respondents from the HR sample seem in general to be more positive (59 percent very - and 30 percent mainly positive) than the respondents in the NA sample and NY sample (49 percent very- and 37 percent mainly positive).

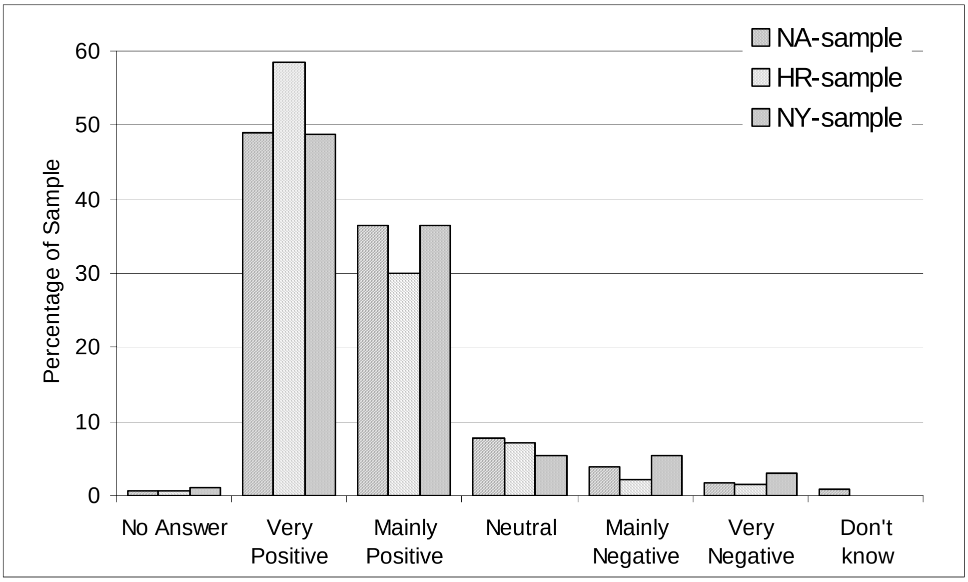


Figure 27: Attitudes towards establishment of new off-shore wind farms (Q. 3.2)

With reference to Figure 27, it is interesting to note that only between 4 percent and 8 percent (HR sample and NY sample, respectively) of the respondents expresses a negative attitude towards new off-shore wind farms. These numbers are significantly smaller than in the case of new land-based wind turbines.

As mentioned, the respondents of the HR sample and the NY sample have already experiences with large off-shore wind farms. From this point of view, the differences in attitudes between the NY and HR samples presented in Figure 26 and Figure 27 intuitively make sense. The off-shore wind farm at HR is thus located at a much larger distance than the off-shore wind farm in NY. Consequently, the visual impacts are expected to be larger in NY than in HR. The difference in the visual impacts could explain why respondents in NY are less positive (though still positive) towards existing and new off-shore wind farms. The properties of these attitudes are presented in more detail in the following section.

6.3.3 Visual Impacts of Off-shore Wind Farms on the Coastal Landscape

As presented in the previous section, there seem to be some differences in the attitudes between the respondents in the HR sample and the NY sample, concerning both existing and new off-shore wind farms. A possible explanation of the nature of these differences is explored in Figure 28 and Table 14, below, where the answers from the three surveys regarding the perception of visual impacts are presented.

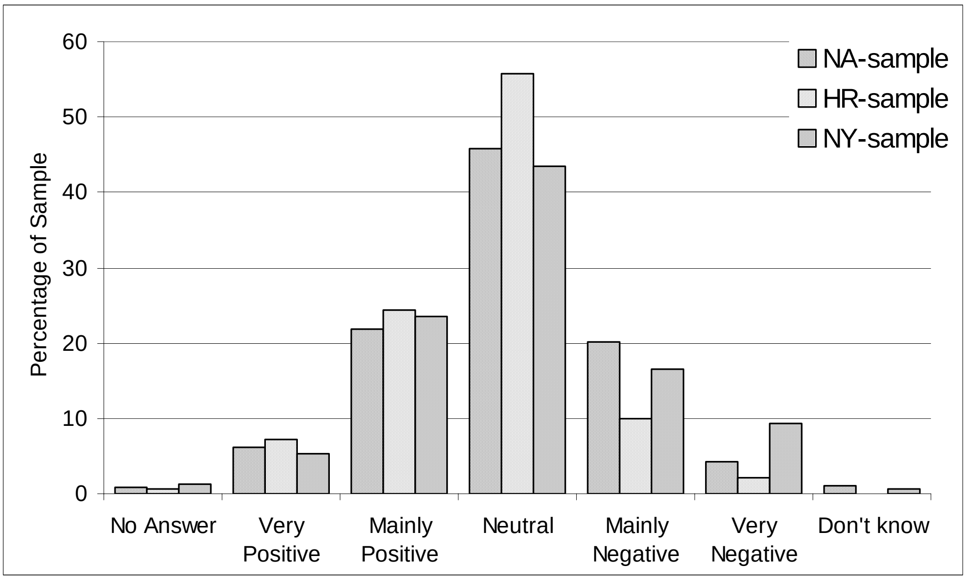


Figure 28: Off-shore wind farms' visual impacts on the coastal landscape (Q. 3.3)

As it can be seen in Figure 28,, the perceptions of the visual impacts are more heterogeneous than the general attitude towards existing and new off-shore wind farms. However, referring to Figure 25,, it seems that the perception of the visual impacts of wind turbines (land-based/off-shore) in general, varies between samples. The majority (56 percent) of the respondents in the HR sample considers the visual impacts to be neutral. In the NA sample and NY sample though, the percentage of respondents with a neutral perception is quite a lot smaller, namely 46 percent and 44 percent, respectively. The percentage of respondents who considers the visual impacts to be positive (very - and mainly positive) are almost equal across the three samples, consequently attitudes must differ across samples in relation to whether or not off-shore wind farms have a negative impact on the coastal landscape. In Figure 28 it appears that almost twice as many respondents in the NA sample and the NY sample state that off-shore wind farms have a *negative* impact compared to the respondents in the HR sample. These differences are even more apparent in the percentage of respondents who find the visual impacts *very negative*. In the HR sample this appears to be 2 percent, whereas the percentage is as high as 4 and 9 for the NA and NY samples, respectively. This points to the fact that experiences regarding off-shore wind farms in the HR and NY samples influence the attitudes of the respondents. The differences between the HR sample and NA sample also indicate that the experiences from HR have left the respondents in the HR sample more positive towards off-shore wind farms than the respondents in the NA sample.

Debriefing Question
In addition to asking the respondents about their perception of the visual impacts of off-shore wind farms, a "debriefing" question (question placed after the choice sets) asked if the respondents agreed or disagreed on the following statement:

- Off-shore wind farms ought to be placed so they are not visible from the coast (question 7.4a)

If respondents disagree on this statement they indicate that they are positive or indifferent when it comes to the visual externalities of offshore wind farms. Consequently it would be expected that respondents who agree must have stronger preferences for moving the wind farms away from the coast than those who disagree.

The survey reveals that 52 percent of the respondents do not like the view of a wind farm (question 7.4a). This result can be seen in Table 14.

Table 14: Distribution in percent of respondents who agree or disagree with the statement that offshore wind farms should be placed so that they are invisible.

	NA sample	HR sample	NY sample
Agree (%)	57	46	43
Disagree (%)	43	54	57
Sum	100	100	100

As seen in Table 14, the attitudes towards the visibility are almost distributed 50/50. For the HR- and NY samples, the dominant attitude is that wind farms do not have to be invisible from the coast. The dominance of respondents disagreeing in the NY sample is surprising given that they have experienced the largest visual externalities. Contrary it would have been expected that a larger proportion of the sample would have agreed. In the NA sample, 57 per cent agrees that wind farms should be located out of sight. Compared to the lower levels of agreement in the HR and NY samples, this indicates that respondents may change attitudes when exposed to wind farms in their local community. In section 7.4, the possible differences in the *strength* of preferences between respondents who agree and those who disagree are analysed. This is done in terms of the magnitudes of the WTP amounts in the two groups for moving wind farms further away from the coast.

6.3.4 Impact on Birdlife and Life in the Sea

Besides the question regarding the visual impacts on the coastal landscape, the perceptions of the impact of off-shore wind farms on the conditions of bird and marine life were also explored. It was acknowledged that for some respondents the questions might be too difficult to answer , as it may be perceived to require rather detailed knowledge of the subject. The answers to the question are presented in Figure 29 and Figure 30 below.

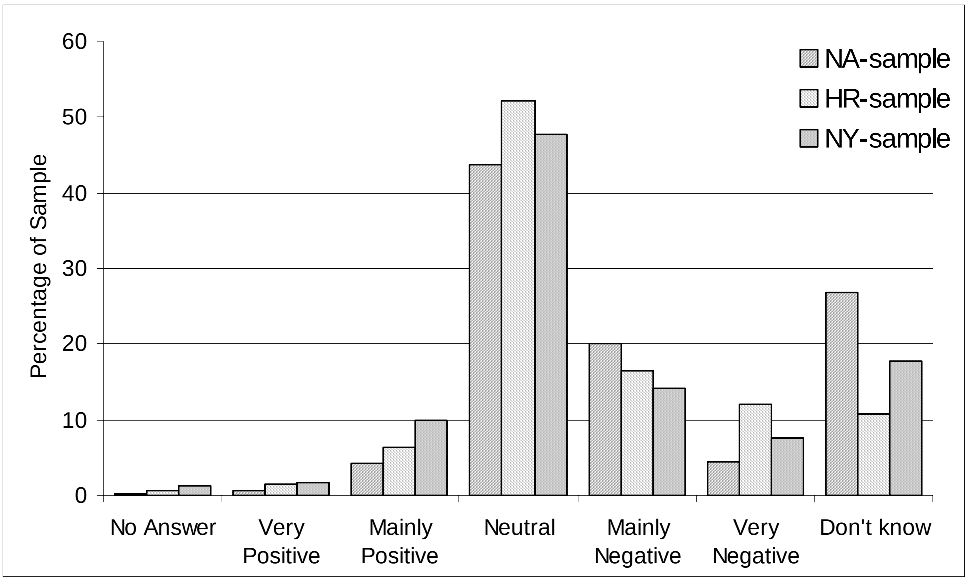


Figure 29: Respondents perception of off-shore wind farms impact on birdlife (Q. 3.4).

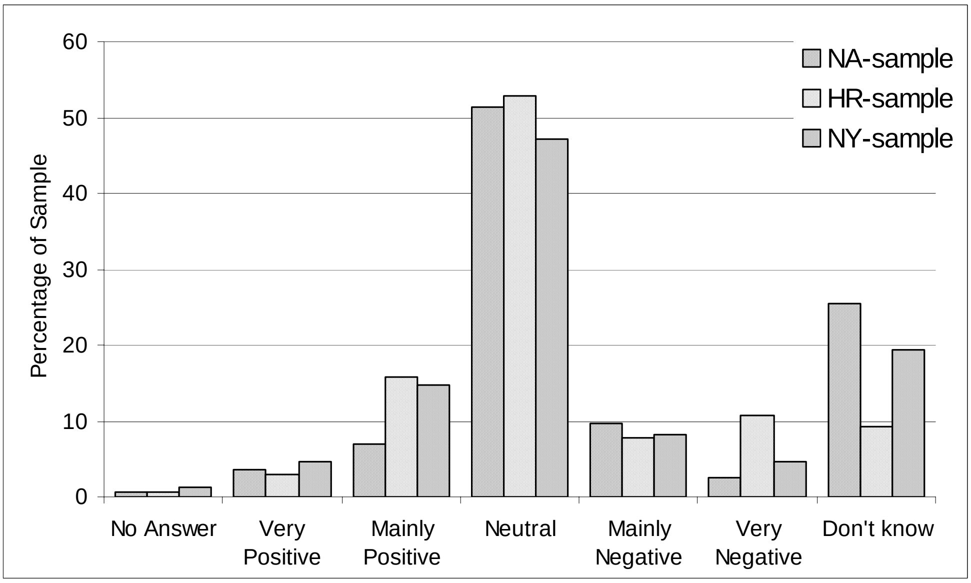


Figure 30: Respondents' perception of the off-shore wind farms' impact on marine life (Q. 3.5).

As it can be seen from Figure 29 and Figure 30, a relatively high percentage (10-27 percent) of respondents have answered that they do not know how off-shore wind farms affect birdlife and life in the sea. This percentage of "don't know" is highest in the NA sample. Given that the respondents in the NA sample most probably do not have the same experience with (and interest in) off-shore wind farms as the respondents in the other samples, the relatively high percentage of *don't knows* make intuitively good sense. Only a relative small percentage of respondents across the three samples believe off-shore wind farms to have a positive impact on both birdlife and life in the sea. From Figure 30, it appears though that approximately twice as many respondents believe that the off-shore wind farms have a somewhat more positive effect on life in the sea than on birds. With regard to the negative impacts, 20-25 percent of the respondents believe there are either very or moderate negative effects on birdlife, whereas the numbers are between 12-19 percent for negative effects on life in the sea.

6.4 Concluding Remarks

Summing up the respondents answers to the question 2.1-2.3 and question 3.1-3.5, there seems to be a general acceptance of the existing land-based wind turbines, existing and new off-shore wind farms in Denmark. This acceptance applies to all three samples (NA sample, HR sample and NY sample). Regarding the establishment of new land-based wind turbines, respondents are less positive. Especially in the NY sample there are a relatively large numbers of respondents who have a *very negative* attitude towards new land-based wind turbines. All in all, it can be concluded that the respondents in the three samples generally prefer to have the future wind power development off-shore compared wind power development on-land. These differences in attitude fit well with the general fact respondents believe there is a higher level of negative visual impacts from land-based wind turbines compared to off-shore wind farms.

It can also be concluded that experience from the existing wind farms at Horns Rev and Nysted has influenced respondents' attitudes and opinions. Especially the respondents at Horns Rev appear to be more positive towards off-shore wind farms compared to the NA and NY samples. An example of this is the attitudes towards existing off-shore wind farms. Here 59 percent of the HR respondents are "very positive" towards the existing wind farms, whereas the same question only obtains 51 and 48 percent "very positive" answers from NY and NA, respectively.

7 Result of Estimation of WTP

The choice models of respondents' preferences for off-shore wind farms in the National Sample (NA sample), the Horns Rev sample (HR sample), and the Nysted sample (NY sample) are presented in the following sections. As presented in section 4.2, three different models; the basis-model (B-model), the certain choice models (C-model), and the rational-model (R-model), are elicited for each sample. In the presentation below, the models will be compared and discussed separately for each sample. Comparisons and discussions across samples are made in chapter 9.

In the final section of the chapter, the preferences of respondents in three samples are investigated with regards to whether the respondents agrees to question 7.4a, which concerns if off-shore wind farms should be located out of sight.

7.1 National Sample

In the National Sample (NA sample), the questionnaire was mailed to 700 respondents, who were randomly drawn from the Danish population. Of these, 375 useful questionnaires were returned.

7.1.1 Basic Model

The B-model is based on the full dataset, and thus consists of 375 respondents with no delimitation except for the invalid responses. Invalid responses were discarded during the keying of the questionnaires and includes those questionnaires which were incomplete The elicited model contains seven variables. There are six variables referring to the main effect attributes in the choice set[21], and one interaction variable between gender (SEX) and the price variable (PRICE). The B-model has a pseudo rho of 0.2494 and is thus well above the critical level of 0.10 (Bateman et al. 2002). The elicited B-model is presented in Table 15.

Table 15: B-model, NA sample

Variable	Coefficient	Std. Error	Z-value	Significance*
DIST12	0.52285	0.12217	4.28	***
DIST18	1.11386	0.12767	8.72	***
DIST50	1.42505	0.14198	10.04	***
SIZEM	-0.02012	0.10556	-0.19	NS
SIZEL	-0.17523	0.09769	-1.79	NS (0.073)
P_SEX	-0.00061	0.00023	-2.66	**
PRICE	-0.00132	0.00016	-8.45	***

Log likelihood = -597.58562 Pseudo R2 = 0.2494

* Level of significance: NS> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

As seen from Table 15, four of the six main effect variables (DIST12, DIST18, DIST50 and PRICE) are very significant. This means that all three variables representing the distance from the coast and the price variable are found to have a significant influence on the choices made by the respondents. The effect of wind farm sizes is not significant even though the variable representing large wind farms (SIZEL) is almost significant on the 0.05 level (0.073). As presented in section 3.2, respondents are expected to associate a higher level of

[21] These variables represent the characteristics of the wind farms in the choice set and will be referred to as *main effect variables* in the rest of the report.

utility as the distance between the wind farms to the coast increases. Based on the size of the coefficients on the distance variables (DIST12, DIST18 and DIST50), the hypothesis $\beta_{DIST12} < \beta_{DIST18} < \beta_{DIST50}$ seems to be valid. Consequently, there is an increasing positive WTP for moving the wind farms to further distances from the coast. This means that respondents in the basic model prefer that wind farms are placed at a non-visible distance of 50 km from the coast. Furthermore, the sign of the coefficients (negative) of the SIZEM and SIZEL variables indicates that the respondents on average associate medium sized and large wind farms (almost significantly) with higher visual externalities than small wind farms. It must be emphasised though that the coefficients are not significant, why it is not possible to determine/verify the exact influence of farm size variables on the respondents' choices. As mentioned previously, there is an interaction effect between the price variable and the respondents' gender. This means that men and women attach different weight to the price attribute. That is, the marginal utility of price differs between genders. These results and properties of the B-model are presented in more details in the section below.

Difference in WTP between genders

In the model, the variable P_SEX is significant and has a negative sign. This means that female respondents have a larger marginal disutility of the price (-0.00061 – 0.00132 = -0.00193), and subsequently are more sensitive to the price than the male respondents (-0.00132). Given that the WTPs are estimated by dividing the marginal utilities of the characteristic of wind farms by the marginal utility of the income, see 4.1.7, this implies that, all else equal, women are found to have a lower WTP than men, see Table 16.

Table 16: Differences in WTP (DKK/household/year) between female and male respondents, B-model , NA sample

	DIST 12	DIST 18	DIST 50
WTP Females	271.78	578.99	740.75
WTP Males	396.70	845.11	1081.22

From Table 16 it is clear that women have lower WTP than men. The difference is approximately 32 per cent[22]. It should be mentioned that the differences in marginal disutility of price, all else equal, only seem to be present in the B-model and R-model. This will be further commented on in the presentation of the two other models.

WTP of the basic model

As seen above the relation between price and gender affect the total WTP, which requires that the WTP presented in Table 15 must be adjusted. This is done by calculating a weighted average WTP, where the differences in utility/WTP and the distribution of men and women in the sample is accounted for. The weighted average WTP is presented in Table 17.

Table 17: Average WTP (DKK/household/year), B-model, NA sample

	DIST 12	DIST 18	DIST 50
WTP	331.74	706.73	904.17

As presented in Table 17 the average willingness to pay for moving the wind farms from 8 km to a distance of 12 km and 18 km from the coast is 331.74 DKK and 706.73 DKK/household/year. The WTP for moving the wind farms from 8 km to 50 km is 904.17 DKK. This result reveals that the respondents have a relatively large WTP for moving the

[22] The difference in WTP is equal to the difference in the gender specific PRICE coefficients: [(-0,00132-0,00061)-(-0,00132)]/(-0,00132-0,00061) =0,32 or 32 per cent in difference.

wind farms from 12 km to 18 km (706.73-331.74=374.98 DKK) compared to moving them from 18 km to 50 km (904.17-706.73=197.45 DKK).

7.1.2 Certain choice model (C-model)

As described earlier, the C-model refers to a model where, respondents stating (on a scale from 0-10) that they were less sure than 7 in their choices are excluded from the underlying dataset. On this basis the C-model was deducted, see Table 18, based on information from 254 respondents. The Pseudo rho is of 0.2827 and is thus considered good.

Table 18: C-model, NA sample

Variable	Coefficient	Std. Error	Z-value	Significance*
DIST12	0.781293	0.156961	4.98	***
DIST18	1.586346	0.173414	9.15	***
DIST50	1.888195	0.191035	9.88	***
SIZEM	-0.09961	0.131766	-0.76	NS
SIZEL	-0.21729	0.124704	-1.74	NS (0.081)
PRICE	-0.00163	0.000148	-10.99	***

Log likelihood = -378.7245 Pseudo R2 = 0.2827

* Level of significance: NS> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

As seen in Table 18 the distance and price variables (DIST12, DIST18, DIST50 and PRICE) are very significant, just as in the B-model. Similar to the B-model the size variables (SIZEM and SIZEL) are insignificant with negative coefficients, which indicate that medium and large wind farms are associated with disutility compared to small farms. In this model the difference in marginal utility of price between genders is no longer significant, meaning that men and women do not have significantly different marginal disutility of price.

WTP of the Certain Choice Model

In Table 19 below the WTP, obtained by the C-model, for moving the wind farms away from the coast are presented.

Table 19: Average WTP (DKK/household/year), C-model, NA sample

	DIST12	DIST18	DIST50
WTP	479.47	973.52	1158.76

The WTP ranges from 479 to 1,158 DKK/household/year depending on the distance to the coast. It is interesting to see that the exclusion of uncertain respondents implies that the difference in WTP between moving the wind farms to 12 km and 18 km has become more pronounced than in the B-model. In the B-model the difference in the WTP is 375 DKK, whereas in the C-model, the differences is (973.52-479.47 DKK) 494.05 DKK. The WTP for moving the wind farms from 8 km to 18 km is thus nearly 100 per cent larger than moving them from 8 km to 12 km. On the other hand, the difference in WTP between moving the wind farm from 18 km to 50 km is found to be quite low, i.e. (1,158.76-973.52 DKK) 185.18 DKK. The latter suggests that respondents in the C-model are close to being indifferent between having the wind farms at 18 km or 50 km. From a policy point of view, this is quite interesting. If people are more or less indifferent to having the view of the wind farms at a distance of 18 km compared to 50 km (cannot be seen from the coast), the wind farms should from a welfare-economic view be placed at a distance of 18 km, as this is likely to be the cheapest option. The more specific policy related consequences of the elicited WTPs in the three samples will be discussed more thoroughly in Chapter 9.

7.1.3 Rational choice model (R-model)

The R-model is a sub-model of the C-model. In the R-model, the respondents from the C-model who have given inconsistent answers in the questions in 7.4a-d are excluded from the sample. This results in a sample of 162 respondents. There are seven variables in the model and in addition to the main effect variables; the interaction effect between gender and price is also significant. The pseudo rho is of 0.3575 and is thus considered to be very good (Bateman et al. 2002) see Table 20.

Table 20: R-model DKK/household/year, NA sample

Variable	Coefficient	Std. Error	Z-value	Significance*
DIST12	0.832223	0.208716	3.99	***
DIST18	1.78349	0.234113	7.62	***
DIST50	2.126664	0.252834	8.41	***
SIZEM	-0.10931	0.178143	-0.61	NS
SIZEL	-0.28684	0.165082	-1.74	NS(0.082)
P_SEX	-0.00079	0.00039	-2.02	*
PRICE	-0.00166	0.000251	-6.6	***

Log likelihood = -215.97997 Pseudo R2 = 0.3575

* Level of significance: NS> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

In Table 20 the distance and price variables (DIST12, DIST18, DIST50, and PRICE) are seen to be very significant, just as in the previous two models. Again, the size variables (SIZEM and SIZEL[23]) are insignificant with negative coefficients indicating a disutility of medium and large wind farms. The difference in coefficients of the three distance variables is quite identical to the difference in the C-model. This implies that there is a large difference in utility, moving the wind farms from 12 km to 18 km from the coast, but a small difference moving the wind farms from 18 to 50 km.

Difference in WTP between genders

In the model, the variable P_SEX is (only just) significant and has a negative coefficient. As mentioned in section 7.1.1, in the R-model, females are found to have a lower WTP than males, all else equal. The differences in WTP between the two genders are shown in Table 21

Table 21: Differences in WTP (DKK/household/year) between female and male respondents, R-model, NA sample

	DIST12	DIST18	DIST50
WTP Females	340.59	729.89	870.34
WTP Males	502.49	1076.86	1284.06

In short, the WTPs in Table 21 differ with approximately 32 per cent[24] between genders. These differences are almost identical to the differences in the B-model (32 per cent). The difference in WTP between distances is though, as explained above, quite different from the B-model.

[23] As in the A and B-model, SIZEL is almost significant (0,082 level of significance)

[24] The difference in WTP is equal to the difference in the gender-specific PRICE coefficients: [(-0,00166-0,00079)-(-0,00166)]/(-0,00166-0,00079) = 0,32 or 32 per cent

WTP in the Rational Choice Model

As for the B-model, the relation between price and gender affect the WTP in the model. In Table 22 the weighted average WTPs are presented.

Table 22: Average WTP (DKK/household/year), B-model, NA sample

	DIST12	DIST18	DIST50
WTP	418.30	896.43	1,068.92

The WTPs in Table 22 are only slightly lower than in the C-model but higher than those obtained in the B-model. Due to the relatively small difference in the coefficients of DIST18 and DIST50, the difference in the WTP for moving the wind farm 18 km and 50 km from the coast is equally small and amounts to (1,068.92-896.43 DKK) 172.50 DKK, respectively.

7.1.4 Comparisons of WTP estimates across models

In section 7.1.1 to 7.1.3 the three models and the elicited WTPs for moving the wind farms to larger distances from the coast are presented for the NA sample. The models are nearly identical with respect to explanatory variables, though the B-model and R-model have some heterogeneity with regard to the price variables. In Figure 31,, below, the WTPs from the three models are presented.

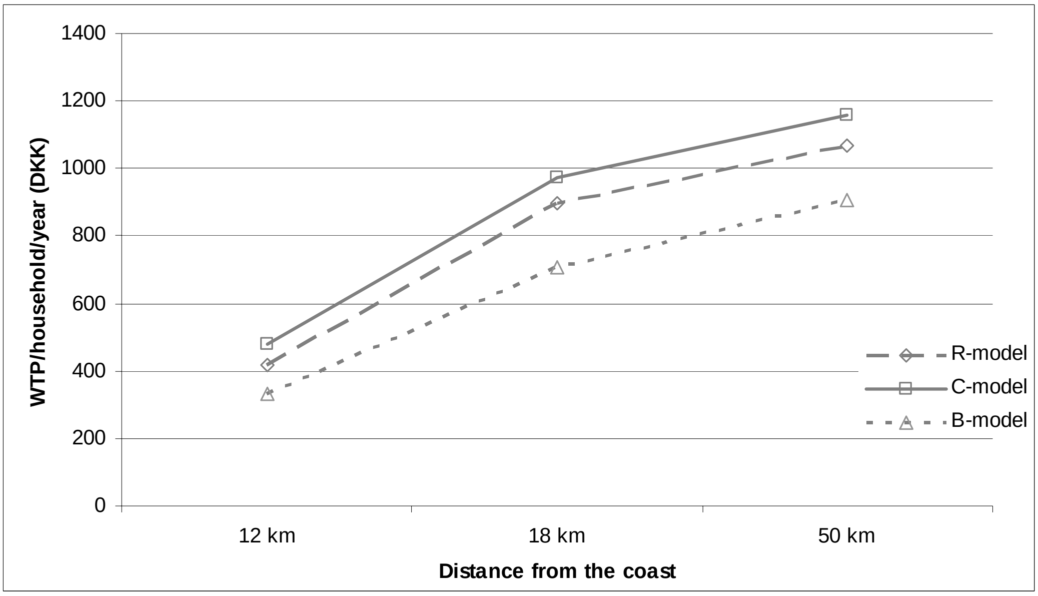


Figure 31: Comparisons of WTPs in the B-model, C-model and R-model

As seen in Figure 31,, the WTP differs between the three models. Especially the WTPs in the B-model deviate from the two other models by being considerably lower. The largest difference is found at 18 km where the WTP in the B-model is 266.79 DKK lower than in the C-model. In the NA sample, the B-model gives the lowest level for WTP for moving the wind farms out from the coast. However, as it will be apparent in the presentation of the models in the two other samples, the B-model only gives the lowest WTP in the NA sample. In Figure 32 an approximation of the marginal WTP/km above 8 km is presented.

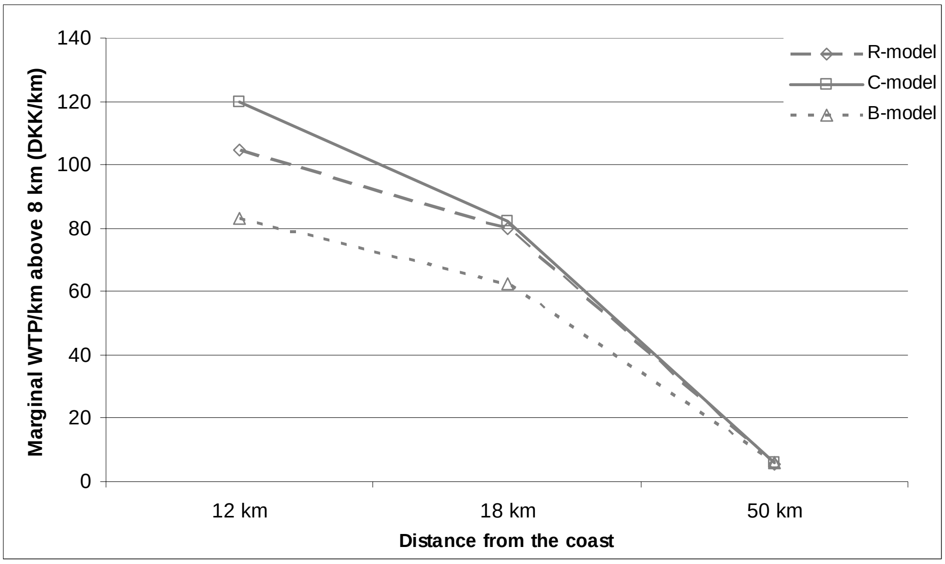


Figure 32: Marginal WTP/km above 8 km.

In Figure 32 it is quite evident that the marginal WTP/km above 8 km is decreasing for all three models. This implies that respondents' WTP for moving the wind farms one km further away from the coast is smaller if the wind farm is located at i.e. 18 km, compared to 12 km. As an example, the marginal WTP between 8 and 12 km and 12 and 18 km in the B-model is 83 DKK/km and 62 DKK/km, respectively. Stated differently, it is more important to move a wind farm from 12 km to 13 km than from 18 km to 19 km. This decreasing marginal utility is also what is expected according to economic theory. The marginal WTP illustrated in Figure 32 thus validates the choice models presented. The validation of the three surveys is presented and discussed more thoroughly in Chapter 9.

7.2 Nysted Sample

In the Nysted sample (NY sample), the questionnaire was mailed to 350 respondents, who were randomly drawn from the population living in the three municipalities adjacent to the Nysted Off-shore Wind Farms, and 170 useful questionnaires were returned. As for the NA sample, the three models, Basis-model (B-model), Certain choice-model (C-model), and the Rational choice-model (R-model) are presented and commented on in the following three subsections. A comparisons and discussion of the three models will be made in the end of the section.

A large part of the discussion made in the previous section will also apply to the results in the HR sample. Therefore, the subsequent presentation and discussion will be based on the previous section in an attempt to avoid repetitions. A comparison and discussion of the three models will be made in the end of the section.

7.2.1 B-model

The B-model is based on the full dataset and thus consists of 170 respondents. The model derived contains seven variables. These variables are the six main effect variables (DIST12, DIST18 DIST50, SIZEM SIZEL and PRICE) and one interaction variable between price and gender (P_SEX). The B-model for the NY sample has the lowest Pseudo R2 of all the nine models estimated, however, it is above the mentioned pseudo critical rho level of 0.10 (Bateman. 2002), see Table 23.

Table 23: Choice Model, B-model, NY sample

Variable	Coefficient	Std. Error	Z-value	Significance*
DIST12	0.53260	0.17176	3.10	**
DIST18	0.59434	0.17086	3.48	***
DIST50	0.97804	0.17980	5.44	***
SIZEM	0.09228	0.14537	0.63	NS
SIZEL	0.10507	0.13729	0.77	NS
P_SEX	-0.00062	0.00030	-2.08	*
PRICE	-0.00062	0.00019	-3.29	**

Log likelihood = -303.13208 Pseudo R2 = 0.1098

* Level of significance: NS> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

In Table 23, the size of the coefficients of the variables representing the distance from the coast (DIST12, DIST18 and DIST50) confirms the hypothesis that utility increases with increasing distance from the coast, though the difference between DIST12 and DIST18 appear to be insignificant. The latter is confirmed in a Wald test of whether or not the coefficients are significantly different. This means that the respondents reveal no significant difference in their preferences when it comes to the choice between moving the wind farm from 8 km to either 12 or 18 km. The disclosed preferences for moving the wind farms to the distance of 50 km are found to be quite strong. Thus, the coefficient of the DIST50 variable is almost twice the size of the coefficients of DIST12 and DIST18.

The size of the wind farm is not found to be significant for the choice of the respondents. Furthermore, the sign of the coefficients (positive) of the SIZEM and SIZEL variables indicates that on average, respondents associate medium sized and large wind farms with higher utility than small wind farms. A possible explanation for this could be that respondents have preferences for fewer but larger wind farms, compared to many small farms. It must be emphasised that the coefficients are not significant, why no effect of the farm size variables on the choice of the respondents could be estimated.

In Table 23 it is seen that the variable representing the interaction between price and gender of respondents is found to be significant. More specifically, it is found that female respondents associate a larger marginal disutility with the price than male respondents.

Difference in WTP between genders

The more specific differences in WTP between the genders are shown in Table 24.

Table 24: WTP (DKK/household/year) between female and male respondents, B-model, NY sample

	DIST12	DIST18	DIST50
WTP Females	431.04	481.01	791.55
WTP Males	858.34	957.84	1576.21

It appears from Table 24 that female respondents´ WTP is close to being 50 per cent[25] lower than that of male respondents. As will be seen in the following subsections, this interaction effect is only found to be significant in the B-model. Compared to the B-model of the NA

[25] The difference in WTP is equal to the difference in the gender-specific PRICE coefficients: [(-0,00062-0,00062)-(-0,00062)]/(-0,00062-0,00062) = 0,50 or 50 per cent

sample this result is nevertheless quite interesting as, it seems that the female respondents in Nysted, are relatively more sensitive to price changes than female respondents in the NA sample.

WTP of the basic model

The significant interaction between price and gender affect the total WTP. In Table 25 below the weighted average WTP of moving wind farms further away from the coast is presented.

Table 25: Average WTP (DKK/household/year), B-model, NY sample.

	DIST12	DIST18	DIST50
WTP	666	743	1,223.12

In Table 25, the average WTP for increasing the distance from 8 km to either 12 km or 18 km is 666 and 743 DKK/household/year, respectively. The WTP associated with moving the wind farm from 8 km to 50 km is 1,223.12 DKK/household/year. As mentioned, the coefficients representing the DIST12 and DIST18 variables are not significant from each other. Consequently, the difference of WTPs from moving the wind farms from 8 km to 12 km and from 8 km to 18 km is not significantly different (77 DKK/household/year). This means that respondents in the NY sample are unwilling to pay a significantly higher amount for moving the wind farms from 12 km to 18 km. The difference in WTP between having the wind farms at either 12 km or 18 km compared to 50 km is though almost 480 DKK, and must be considered quite significant. The respondents are thus willing to pay almost 65 per cent more to have the wind farms out of sight, compared to having them at 12 or 18 km from the coast. The price premium indicates that respondents in the NY sample have quite strong preferences for having future wind farms located out of sight.

7.2.2 C-model

The C-model of the NY sample is based on the choices of 113 respondents and six main effect variables, but no interaction variables are found to be significant. The farm size variables (SIZEM and SIZEL) are both found to be insignificant, whereas the other four main effect variables (DIST12, DIST18, DIST50 and PRICE) are quite significant (< 0.01). The Pseudo rho for the model is 0.1279 and is thus well above the critical value of 0.10, see Table 26.

Table 26: Choice Model, C-model, NY sample

Variable	Coefficient	Std. Error	Z-value	Significance*
DIST12	0.600464	0.209420	2.87	**
DIST18	0.687716	0.209205	3.29	***
DIST50	1.204202	0.224457	5.36	***
SIZEM	-0.039350	0.169692	-0.23	NS
SIZEL	-0.018280	0.181277	-0.10	NS
PRIZE	-0.000980	0.000187	-5.25	***

Log likelihood = -204.47987 Pseudo R2 = 0.1279

* Level of significance: NS> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

In Table 26 it is seen that the coefficients representing the DIST12 and DIST18 variables are once again almost identical. This is confirmed in a Wald test, where the coefficients are proven not to be significantly different from each other. Consequently, the respondents in the

C-model are indifferent between having the wind farms located at either 12 km or 18 km from the shore. Once again, the coefficient for the DIST50 variable is also significantly different from DIST12 and DIST18, implying that respondents hold significantly stronger preferences for having wind farms located 50 km from shore, compared to either 12 or 18 km.

In Table 26, the sign of the coefficients representing medium and large sized wind farms are both seen to be negative. This observation suggests that on average respondents in the C-model prefer a relatively large number of small wind farms with few wind turbines in relation to fewer but larger wind farms (more turbines). But just as in the B-model, the relative difference in preferences for medium and large wind farms is insignificant, implying that in practise respondents are indifferent,. In the C-model there is no difference between genders in the marginal utility associated with price.

WTP of the C-model
The WTPs estimated in the C-model for the NY sample for moving the wind farms further than 8 km away from the coast are presented in **Table 27** below.

Table 27: Average WTP (DKK/household/year), C-model, NY sample

	DIST12	DIST18	DIST50
WTP	612.91	701.97	1,229.15

The WTPs in **Table 27** are seen to range from 613 to 1,229 DKK. The difference in preference between increasing the distance to either 12 or 18 km is seen to be quite small (89 DKK), which is not all that surprising, considering that the two distance variables are found not to be significantly different from each other. The WTP for moving the wind farm from 12 km or 18 km to 50 km is seen to be between 616 and 527 DKK.

7.2.3 Rational Choice Model

There are 73 respondents in the R-model which contains the six main effect variables in interaction variables. The variables relating to the size of wind farms (SIZEM and SIZEL) are both found to be insignificant. The four other main effect variables are significant. It should, though, be noticed that the variables DIST12 and DIST18 are only significant at the 0.05 level, and are therefore just within the limits of significance. This indicates that in the dataset underlying this model there is relatively more variance in the exhibited preferences than is the case for the datasets underlying the B and C-models. The fit of the model (pseudo rho) is just above the acceptable level of 0.10, see Table 28.

Table 28: Choice Model, R-model, NY sample

Variable	Coefficient	Std. Error	Z-value	Significance*
DIST12	0.63525	0.25438	2.50	*
DIST18	0.63062	0.25604	2.46	*
DIST50	1.25808	0.28035	4.49	***
SIZEL	0.03426	0.20814	0.16	NS
SIZEM	0.07267	0.22126	0.33	NS
PRICE	-0.00085	0.00023	-3.72	***

Log likelihood = -134.9006 Pseudo R2 = 0.1174
* Level of significance: NS> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

With reference to Table 28, the coefficients of the DIST12 and DIST18 variables appear to be more or less identical, as was the case in the B- and C-model. A Wald test cannot reject the hypothesis of equal coefficients, why no significant difference between respondents´ preferences for moving the wind farms to either 12 km or 18 km can be established. The coefficient for moving the wind farm to 50 is significantly different from the coefficients of DIST12 and DIST18, in fact, it is almost twice as high.

Again, the preferences of wind-farm sizes are insignificant, although medium and large wind farms appear to be preferred to small wind farms. However, it must be emphasised that the variables are insignificant, implying that in practise respondents exhibit indifference with relation to farm size.

Just as in the C-model, no difference in the marginal utility of price between genders can be established in the R-model.

WTP of the R- model
The WTPs for moving wind farms further away from the coast than 8 km are presented in Table 29 below.

Table 29: Average WTP (DKK/household/year), R-model, NY sample

	DIST12	DIST18	DIST50
WTP	747.27	741.82	1,479.92

The respondents in the R-model seem to have rather strong preferences for moving the wind farms from 8 to 50 km. Thus, the WTP is estimated to be 1,480 DKK, which is the highest across samples and models, see chapter 9. The preferences for having the wind farms at 12 or 18 km are, as mentioned, almost identical, and in relation to the WTP, these are consequently also nearly identical. The difference between DIST12 and DIST18 is below 6 DKK (747-742) and is according to a Wald test considered to be insignificant, implying that respondents are indifferent between having the wind farms at 12 or 18 km away from the coast.

7.2.4 Comparison of WTP estimates across models

The WTPs obtained in the three models for the NY sample are compared in Figure 33. The models are identical with exception of the B-model where the variable P_SEX were found to be significant.

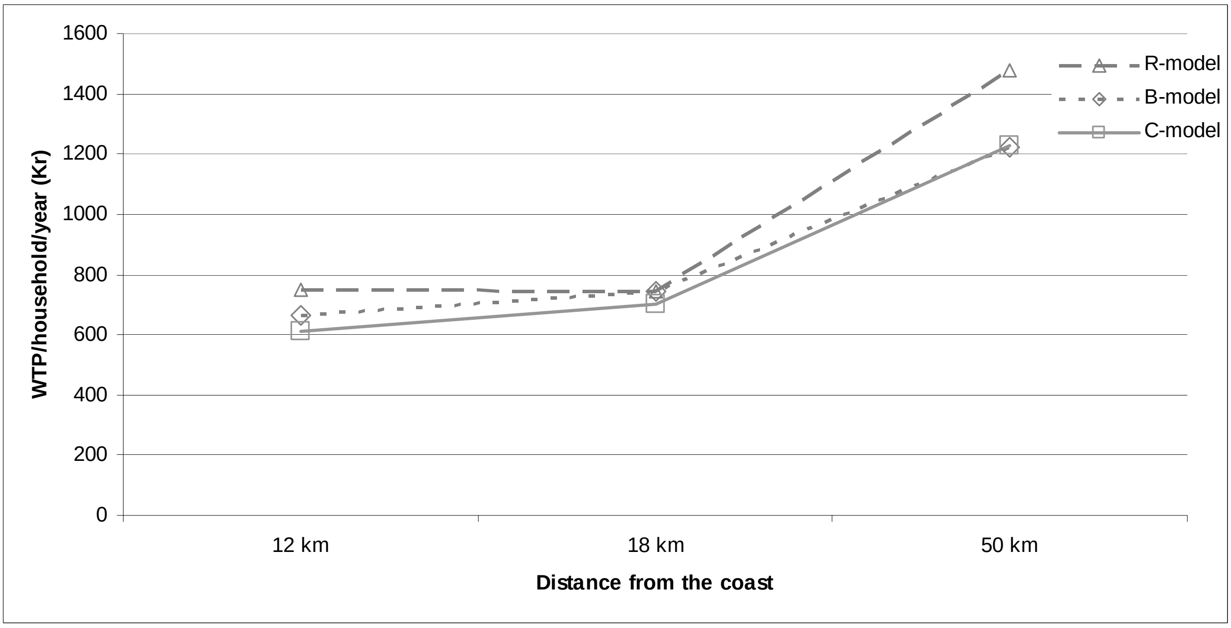


Figure 33: Comparison of WTPs across models, NY sample

As illustrated in Figure 33, the WTP between the three models differs, while the WTPs follow the same trend across models. The trend being that respondents are indifferent to having the wind farm placed at 8 km or 12 km or between 8 km and 18 km. Also the highest WTP in all three models is as expected at a distance of 50 km. The actual WTP varies between 1222 and 1480 DKK. Besides the trend of increasing WTP as a function of distance, Figure 33 also reveals that the WTP between models in general is increasing, as the uncertain respondents and respondents failing the consistency test are removed from the sample. However, it is beyond the scope of this study to test whether or not these differences in WTP across models are significantly different.

In Figure 34 below, the marginal WTPs/km for moving the wind farms further out than 8 km are presented.

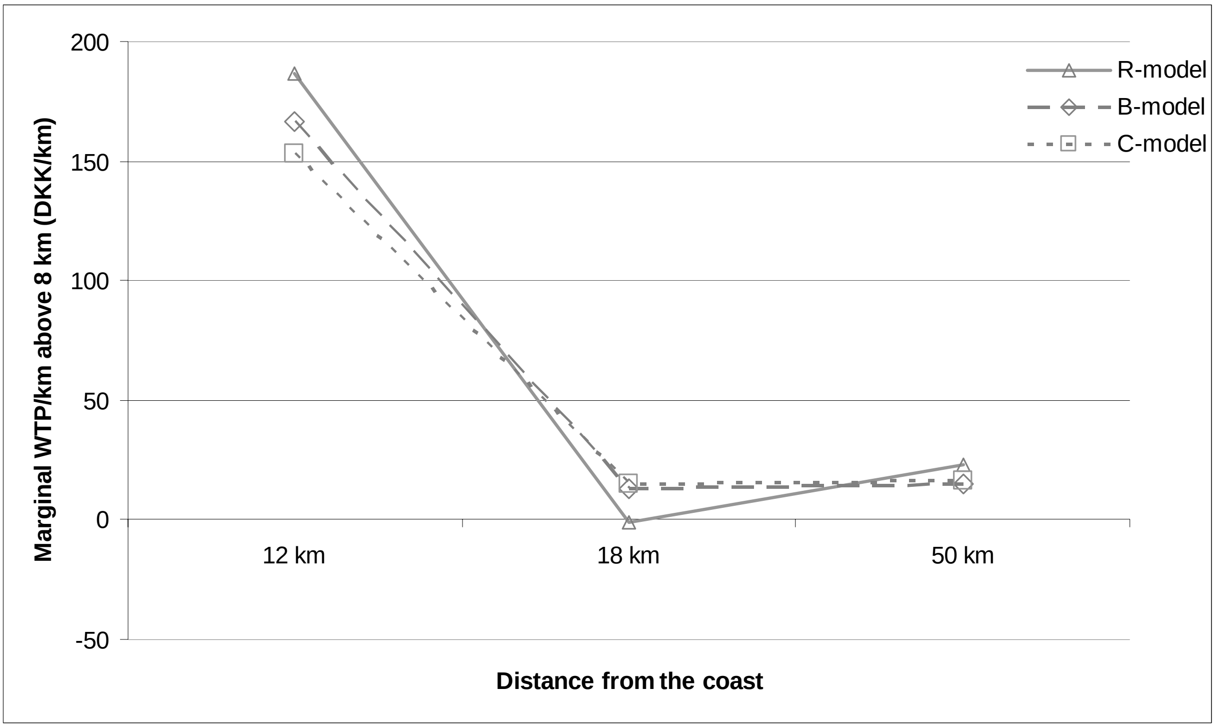


Figure 34: Marginal WTP/km for moving wind farms above 8 km from the coast.

As illustrated in Figure 34 the marginal WTP is as expected to be decreasing as a function of distance from the coast. It is worth noting that the marginal WTP/km between 12 and 18 km is close to zero in the R-model. This illustrates that the respondents in the R sample are indeed indifferent between having the wind mills at 12 or 18 km from the coast. Overall the marginal WTP roughly decreases from 150-180 DKK/km (8 to 12 km) to almost 0 DKK/km (12-18 km), and to about 20 DKK/km (18-50 km).

7.3 Horns Rev Sample

As for the NY- , the HR questionnaire was mailed to 350 respondents. The respondents were randomly drawn from the population living in the municipalities adjacent to the Horns Rev off-shore wind farm. The number of useful questionnaires returned was 140. As for the previous two samples, three models; the Basis model (B-model), the Certain Choice model (C-model), and the Rational Choice model (R-model) are presented and discussed briefly in the following three subsections.

A large part of discussions made in the previous section also applies to the results from the Horns Rev sample. Therefore, the subsequent presentation and discussion will be based on the previous section in an attempt to avoid repetitions. A comparison and discussion of the three models will be made at the end of the section.

7.3.1 Basic Model

The B-model of the HR sample is based on a dataset containing answers from 140 respondents. The derived model consists of six main effect variables (DIST12 DIST18 DIST0 SIZEM SIZEL and PRICE) and one interaction variable (EO_SL) representing the effect arising from the interaction between members of an environmental organisation (EO) and large wind farms (SIZEL). The pseudo-rho for the model is 0.2640 indicating that the fit of the models is good, see Table 30.

Table 30: Choice Model, B-model, HR sample.

Variable	Coefficient	Std. Error	Z-value	Significance*
DIST12	0.53619	0.20340	2.64	**
DIST18	1.31903	0.22072	5.98	***
DIST50	1.21138	0.25924	4.67	***
SIZEM	0.17092	0.17958	0.95	NS
SIZEL	0.06458	0.17527	0.37	NS
EO_SL	1.08607	0.44981	2.41	**
PRICE	-0.00205	0.00024	-8.64	***

Log likelihood = -212.22736 Pseudo R2 = 0.2640
* Level of significance: NS> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

As seen in Table 30, all three distance variables (DIST12, DIST18, and DIST50) are significant. The coefficients have the expected signs, and for DIST12 and DIST18 they are as hypothesised increasing as a function of the distance from the coast. However, the numerical size of the DIST50 (1.21138) coefficient is smaller than the DIST18 (1.31903) coefficient. This suggests that respondents prefer wind farms to be located at 18 km, compared to 50 km. A Wald test on whether the coefficients are significantly different from each other does, however, not reject the hypothesis of equal coefficients (Prob > chi2 =0.6162). Consequently, it appears that respondents are indifferent between whether the wind farms are located 18 km or 50 km away from the coast.

None of the two main effect variables relating to the size of the wind farms (SIZEM and SIZEL) are significant. But the interaction effect between a large wind farm (SIZEL) and membership of an environmental organisation (EO) is found to be a significant determinant of choice in the C-model. More specifically; respondents in the dataset underlying the C-model who claim membership of an environmental organisation are found to prefer large size wind farms over small or medium sized farms, compared to other respondents who are indifferent between small, medium and large wind farm. This could be interpreted as if the members of environmental organisations want to avoid a high number of wind farms by consolidate the farms in few areas.

In none of the three models of the HR sample are men and women found to have significantly different marginal disutility of prices. The variable P_SEX is therefore not present in either of the models.

WTP of the B-model
The WTPs for moving wind farms further away from the coast than 8 km and for increasing farm size from 49 to 100 or 144 mills per park are presented in Table 31 below.

Table 31: Average WTP (DKK/household/year), B-model, HR sample.

	DIST12	DIST18	DIST50	EO_SL
WTP	261.40	643.05	590.05	529.48 (53)

In the B-model the WTPs range between 261 and 643 DKK/household/year when considering increasing the distance between the wind farms and the coast from 8 km to 12 km and from 8 km to 18 km respectively. As already mentioned, the respondents do not hold significantly different preferences for having the wind farms at 18 km or at 50 km. Consequently the WTP does not differ either, and the WTP for moving the wind farms to either 18 km or 50 km therefore lies within 590 and 643 DKK/household/year.

As already mentioned, respondents who are members of an environmental organisation were found to have significantly stronger preferences for large wind farms, compared to small and medium sized. Thus, respondents are found to have a WTP of 529 DKK/household/year for substituting small and medium sized wind farms with large ones. There are only 14 respondents (10 per cent) in the sample who claim membership of an environmental organisation. The weighted average WTP can therefore be estimated to 53 DKK/household/year.

7.3.2 Certain Choice Model

The Certain choice model (C-model) for the Horns Rev sample is based on a dataset containing 100 respondents. The model consists of the six main effect variables (DIST12, DIST18, DIST50, SIZEM, SIZEL and PRICE). Contrary to the B-model, no interaction effects were found to be significant. The pseudo-rho of the model is 0.2667 which suggests that the fit of the model is good, see Table 32.

Table 32: Choice Model, C-model, HR sample.

Variable	Coefficient	Std. Error	Z-value	Significance*
DIST12	0.632037	0.244919	2.58	*
DIST18	1.460186	0.268526	5.44	***
DIST50	1.355857	0.316733	4.28	***
SIZEM	0.145963	0.210813	0.69	NS
SIZEL	0.398736	0.206099	1.93	*
PRICE	-0.00202	0.000285	-7.1	***

Log likelihood = -151.47332 Pseudo R2 = 0.2667
* Level of significance: NS> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

The composition of the C-model, which is displayed in Table 32, is not much different from the B-model. All three variables representing the distance of the wind farms from the coast are significant and with the expected signs. Just as in the B-model, respondents are found to be indifferent between having the wind farms located 18 km or 50 km from the coast (Wald test insignificant). In the C-model, the variable representing the interaction between membership of an environmental organisation and the farm size variables (SIZEL) is no longer significant. This means that no interaction effect (EO_SL) is present in the model. The variable SIZEL, on the other hand, is significant on a 0.05 level. This means, that the respondents included in the C-model are characterised by having significantly stronger preferences for large wind farms, compared to small and medium sized. However, the SIZEM variable was not significant.

WTP of the C-model model
The WTPs for moving the wind farms further away from the coast than 8 km and for increasing farm size are presented in Table 33 below.

Table 33: Average WTP (DKK/household/year), B-model, HR sample

	DIST12	DIST18	DIST50	SIZEL
WTP	312	722	670	197

The estimated WTP for moving the wind farms from 8 to 12, 18 or 50 km re, respectively, can be read from Table 32. The range of the WTPs is between 312 and 722 DKK/household/year for moving the wind farms from 8 to 12 km and from 8 to 18 km, respectively. As is the case of the B-model, the difference in WTP between 18 and 50 km is not significant. This means that the same considerations, as discussed in the B-model, can be applied to this model, and that the WTP for moving the wind farms to 18 or 50 km is between 670 and 722 DKK/household/year.

As mentioned, the SIZEL variable is found to be significant in the C-model. Specifically the WTP for substituting small and medium sized wind farms with large wind farms is found to be 197 DKK/household/year.

7.3.3 R-model

The exclusion of both inconsistent and insecure respondents from the dataset leaves 67 respondents available for estimation of the R-model. With regards to the variables which are found to have a significant influence on the choices of the respondents, the R-model is identical to the C-model. Consequently, the three distance variables (DIST12 DIST18 and DIST50), the variable representing large wind farms (SIZEL), and the price variable PRICE) are significant. As in the B-model and C-model, a pseudo rho of 0.2820 indicates that the fit of the model is very good, see Table 34.

Table 34: Choice Model, R-model, HR sample.

Variable	Coefficient	Std. Error	Z-value	Significance*
DIST12	0.64523	0.30774	2.10	*
DIST18	1.50267	0.33208	4.53	***
DIST50	1.43678	0.41236	3.48	***
SIZEM	0.38921	0.26978	1.44	NS
SIZEL	0.53631	0.25882	2.07	*
PRICE	-0.00205	0.00036	-5.73	***

Log likelihood = -99.042086 Pseudo R2 = 0.2820

* Level of significance: NS> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

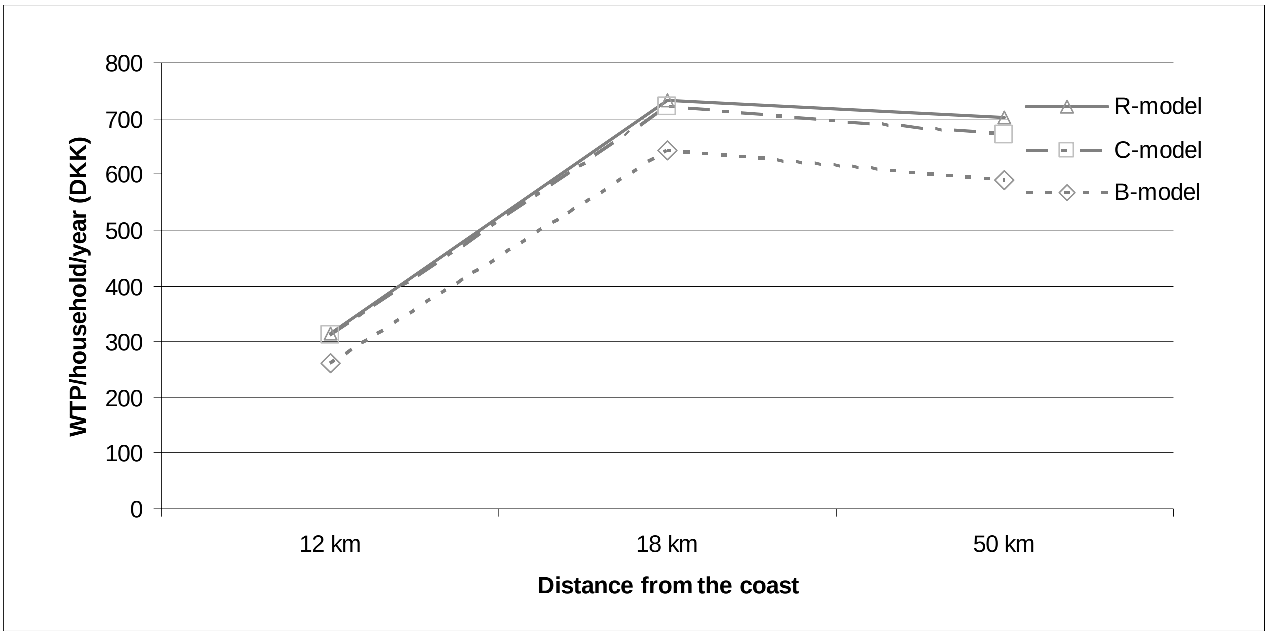
In Table 34, the coefficients for the distance variables are increasing as a function of the distance, although the respondents are found not to hold significantly different preferences for having the wind farms at 18 or 50 km away from the coast. With regard to the coefficient of the SIZEL variable, the sign is positive, implying that respondents prefer larger wind farms over small or medium sized farms.

WTP of the R model
The WTPs presented in Table 34 are quite identical to the ones from the C-model. It is nevertheless worth to notice that the coefficient representing DIST18 and DIST50 are relatively more identical, than in the C-model. This is also confirmed in the Wald test of equal coefficients[26]. Respondents are found to be willing to pay 314, 733 and 701 DKK/household/year for moving the wind farms from 8 to 12, 18, and 50 km, respectively. But referring to the Wald test, the coefficient of DIST18 and DIST50 are not significantly different, why it cannot be rejected that the coefficients and subsequently WTPs are identical. This means that the WTP for moving the wind farms to 18 or 50 km are between 701 and 733 DKK.

Concerning the WTP for substituting smaller and medium sized wind farms with large wind farms the WTP is 261 DKK/household/year.

7.3.4 Comparison of the WTP estimates across models

The three models in the Horns Rev sample turned out to be relatively identical as they contained almost the same significant variables. The only exception is in the B-model, where a relation between the respondents' membership and their preferences for one of the farm size variables (the EO_SL variable) was found to be significant. The WTPs for the three models are compared in Figure 35 and are commented in the following sections.



[26] The Wald test for equal coefficients in the R-model is the least significant of the Wald test in the three choice models.

Figure 35: WTP/household/year for moving the wind farms from 8 km

As seen from Figure 35, the WTPs differ between the three models while they generally follow the same trend with regard to changes in WTP associated with moving the wind farms from 8 to 12 km, 18 km and 50 km, respectively.

In all three models, the respondents turned out to be indifferent to having the wind farms at 18 and 50 km. In Figure 35 where the WTP obtained from the three models are compared it can be seen that the WTPs for moving the wind farms from 8 to 12 km are between 294 and 314 DKK, thus only a difference of 20 DKK (7 per cent). This difference is relatively higher between the three models, when looking at the WTP for moving the wind farms from 8 km to 18 km. Here the maximum difference is thus (733-643 DKK) 90 DKK (12 per cent). The difference between models increases further when considering moving the wind farms out of sight (50 km), as the maximum difference now reaches (701-590 DKK) 111 DKK (16 per cent). In all three cases the maximum WTP is obtained in the R-model while the lowest is found in the B-model. Consequently, it appears that preferences for moving the wind farms further away from the coast gets stronger as uncertain respondents and respondents failing the rationality tests are excluded. When studying Figure 35 one might get the expression that the marginal WTP (WTP/km) increases as the distance is increased from 12 to 18 km. However as is it presented in Figure 36 this is not the case.

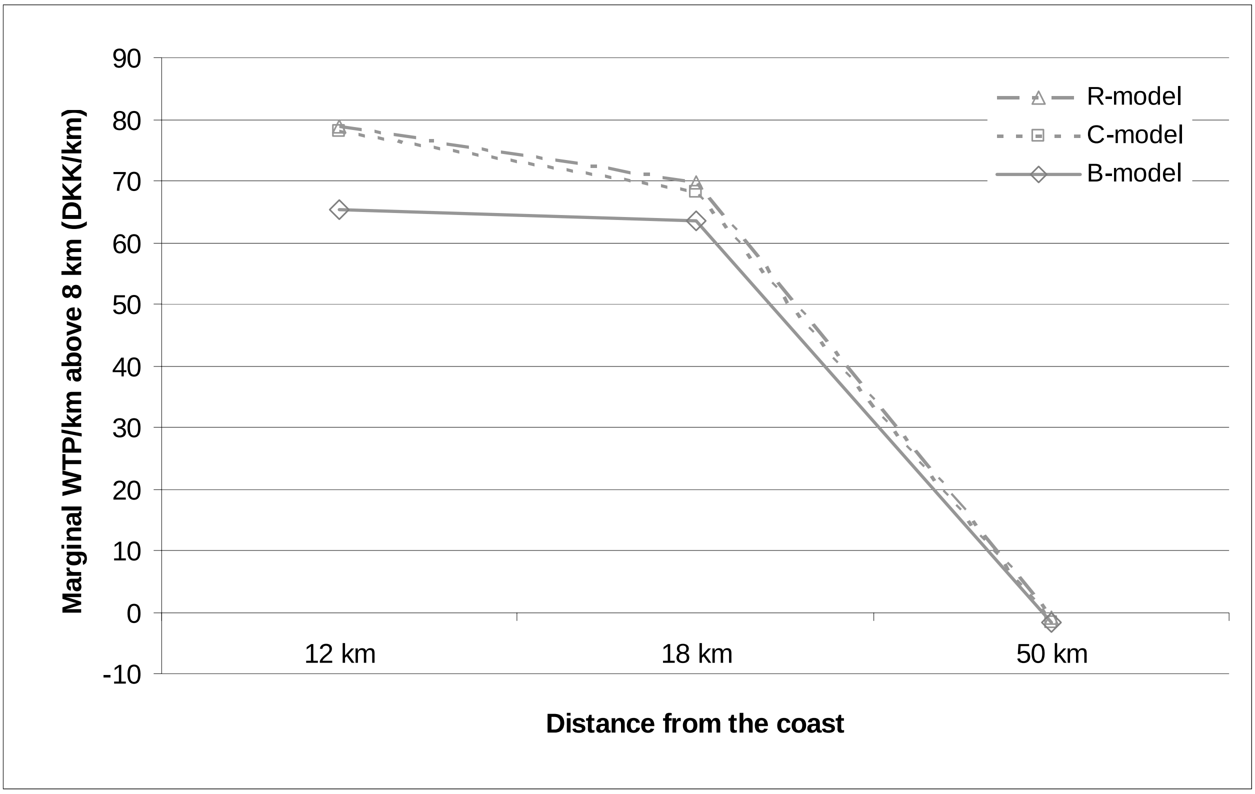


Figure 36: Marginal WTP/km moving wind farms above 8 km from the coast.

As illustrated in Figure 36, the marginal WTP and thereby the marginal utility associated with moving the wind farm one additionally km away from the coast is decreasing as a function to the distance of the coast. It is worth noticing that the marginal WTP between 18 km and 50 km is almost zero. This illustrates the fact that the marginal utilities (the coefficients) of moving the wind farms to a distance of either 18 or 50 km away from the coast are not significantly different from each other.

7.4 Heterogeneity in Preferences and WTP

In the previous three chapters the choice models for the three samples (NA sample, HR sample and NY sample) were presented and discussed in relation to the explanatory variables which were found to have a significant influence on the choices of the respondents. It turned out that it was the main effects of the characteristics of the wind farms that significantly influenced the choices. Thus, the results of the present study indicate that WTP for locating wind farms further away from the coast does not differ significantly between socio-economic groups. However, there may still be significant differences in respondents' preferences – even if these differences are not explained by socioeconomic variables or other individual characteristics sampled in the survey.

Returning to the attitude questions discussed in Section 6.3.3, it is evident that approximately half of the respondents prefer that off-shore wind farms should be kept out of sight, whereas the other half of the respondents are more or less indifferent[27]. All other things equal, this indicates that the respondents in the first group obtain a greater utility improvement from having wind farms located further away from the coast, compared to the latter group. Using this information as an explanatory variable in the estimation of respondents' overall WTP would not be correct due to the problems associated with endogenous variables[28].

However, this information can be used to analyse differences in the *strength* of the preferences with respect to wind farm visibility among subgroups of the respondents. The general preferences regarding visibility were indicated in the answers to question 7.4a – as explained in Section 6.3.3. In the following we will investigate how strong these preferences are measured in terms of the magnitudes of WTP for changes in visibility among different subgroups. Given that the aim is to illustrate possible heterogeneity, only the basic models (B-models) for each sample will be discussed.

7.4.1 Heterogeneity in the Danish sample (NA sample)

In the NA sample, 57 per cent of the respondents stated that they want off-shore wind farms out of sight and 43 per cent said they were to some extent indifferent. In Table 35 and Table 36, choice models incorporating this information are presented. In Table 35, a model solely based on respondents stating that off-shore wind farms should be placed out of sight is presented. In Table 36 a model based on the other half of the sample stating that off-shore wind farms should not necessarily be placed out of sight is discussed. Since the focus is on heterogeneity in preferences for moving the wind farms away from the coast, only the relevant variables (DIST12, DIST18 and DIST50) will be commented on.

Table 35: Heterogeneity model NA sample, sub sample preferring no visual impacts.

Variable	Coefficient	Std. Error	Z-value	Significance*	"WTP"
DIST12	0.8256	0.1787	4.62	***	567.70
DIST18	1.6669	0.1965	8.48	***	1,146.30
DIST50	2.5685	0.2345	10.95	***	1,766.28
SIZEM	-0.2798	0.1555	-1.80	NS (0.072)	

[27] The answers are to question 7.4a in the questionnaire.

[28] Endogenous variables are an econometric problem, which refers to the fact that an independent variable included in the model is correlated with the error term. The dependent variable, however, is observed for all observations in the data (Wooldridge 2003). The issue of endogenity is also discussed in Fosgereau and Bjørner 2004.

SIZEL	-0.4322	0.1468	-2.94	*
P_SEX	-0.0002	0.0003	-0.53	NS
PRICE	-0.0015	0.0002	-6.61	***

Log likelihood = -293.85361 Pseudo R2 = 0.3555

* Level of significance: ns> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

Table 36: Heterogeneity model NA sample, sub sample indifferent with respect to visual impacts.

Variable	Coefficient	Std. Error	Z-value	Significance*	”WTP”
DIST12	0.3748	0.1908	1.96	*	260.22
DIST18	0.4258	0.1882	2.26	*	295.59
DIST50	0.1594	0.2021	0.79	NS	*110.65*
SIZEM	0.3847	0.1615	2.38	*	
SIZEL	0.1502	0.1536	0.98	NS	
P_SEX	-0.0010	0.0004	-2.49	*	
PRICE	-0.0014	0.0003	-5.41	***	

Log likelihood = -243.88393 Pseudo R2 = 0.2347

* Level of significance: ns> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

It appears upon comparison of Table 35 and Table 36 that the preferences in terms of WTP for moving off-shore wind farms further away from the coast are significantly different between the two groups. In spite of the fact that the estimated WTPs should be interpreted with some caution[29], there is no doubt that the respondents represented in Table 36 have much stronger preferences (measured in terms of WTP) for moving the off-shore wind farms further away from the coast than the respondents in Table 36. It also turns out that the respondents in Table 36 are practically indifferent between having the wind farms at 12 or at 18 km (no significant difference in WTP between these two distances). In contrast, Table 35 shows that the respondents here are willing to pay twice as much for increasing the distance to 18 km compared to 12 km.

Another large difference between the two groups of respondents is the respective WTPs for moving the wind farms to a distance of 50 km from the coast. For the group of respondents in Table 35, WTP for this distance is 1,766 DKK, while WTP for this distance is only 111 DKK for the group in table Table 36 (the estimate is not significant). This leads to the conclusion that the respondents in this group are actually indifferent between having the wind farms at 8 km or 50 km off the coast.

Summing up the analysis of heterogeneous preferences in the NA sample, it appears that the preferences for moving off-shore wind farms further away from the coast vary significantly between respondents. The heterogeneity in NA sample can be represented by:

- A group of respondents who are willing to pay quite large amounts for moving the off-shore wind farms as far away from the coast as possible.
- A group of respondents who are willing to pay significantly smaller amounts for moving the off-shore wind farms 12 and 18 km away from the coast, but who are indifferent between having the wind farms at 8 or 50 km.

[29] Because of the problem of endogenous variables, see start of the section.

7.4.2 Heterogeneity in the Horns Rev sample (HR sample)

As for the NA sample, two models for the HR sample are elicited. In the HR sample, 46 per cent of the respondents stated that off-shore wind farms should be located so they were not visible from the coast. The choice model for this group of respondents is presented in Table 37. The remaining respondents (54 per cent) disagreed that off-shore wind farms should be located so they were not visual from the coast. The choice model for this group is presented in Table 38.

Table 37: Heterogeneity model HR sample, no visual impact preferred.

Variable	Coefficient	Std. Error	Z-value	Significance*	"WTP"
DIST12	1.3657	0.3298	4.14	***	717.07
DIST18	2.3126	0.4067	5.69	***	1,214.30
DIST50	2.6868	0.5231	5.14	***	1,410.75
SIZEM	0.0969	0.2907	0.33	NS	
SIZEL	0.3689	0.2856	1.29	NS	
PRICE	-0.0019	0.0004	-5.08	***	

Log likelihood = -91.715203 Pseudo R2 = 0.3555

* Level of significance: ns> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

Table 38: Heterogeneity model HR sample, sub sample indifferent with respect to visual impacts.

Variable	Coefficient	Std. Error	Z-value	Significance*	"WTP"
DIST12	-0.0751	0.3001	-0.25	NS	*-31.65*
DIST18	0.5216	0.2900	1.80	NS (0.072)	*219.81*
DIST50	0.1967	0.3289	0.60	NS	*82.90*
SIZEM	0.3820	0.2557	1.49	NS	
SIZEL	0.1326	0.2357	0.56	NS	
PRICE	-0.0024	0.0004	-6.76	***	

Log likelihood = -105.43244 Pseudo R2 = 0.2825

* Level of significance: ns> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

Comparing the choice models in Table 37 and Table 38, the conclusion from the previous section on heterogeneity appears to be even more valid here. In Table 37, the respondents express very high, increasing, and significant WTP levels for moving the off-shore wind farms further away from the coast. In Table 38, in contrast, WTPs for moving the off-shore wind farms further away from the coast are not significant. This means that these respondents are indifferent as to whether the wind farms are located at 8, 12, 18 or 50 km. The heterogeneity in the HR sample can thus be represented by:

- A group of respondents who are willing to pay quite large amounts for moving the off-shore wind farms increasingly far away from the coast.
- A group of respondents who are indifferent between whether the wind farms are located at 8, 12, 18 or 50 km and consequently are unwilling to pay any significant amount to increase the distance between the farms and the coast.

7.4.3 *Heterogeneity in the Nysted sample (NY sample)*

The final sample is the NY sample. In the NY sample, 43 per cent of the respondents stated that they want off-shore wind farms out of sight and 57 per cent that they were more or less indifferent.

The choice model for each group is presented in the Table 39 and Table 40.

Table 39: Heterogeneity model NY sample, no visual impact preferred.

Variable	Coefficient	Std. Error	Z-value	Significance*	"WTP"
DIST12	0.9379	0.3094	3.03	**	1,376.43
DIST18	1.7525	0.3247	5.40	***	2,571.94
DIST50	2.7748	0.3904	7.11	***	4,072.15
SIZEM	0.1016	0.2714	0.37	NS	
SIZEL	0.0995	0.2502	0.40	NS	
PRICE	-0.0007	0.0003	-2.64	**	

Log likelihood = -104.66688 Pseudo R2 = 0.3311
* Level of significance: ns> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

Table 40: Heterogeneity model NY sample, sub sample indifferent with respect to visual impacts.

Variable	Coefficient	Std. Error	Z-value	Significance*	"WTP"
DIST12	0.40833	0.23482	1.74	NS (0.082)	*316.19*
DIST18	-0.11989	0.22947	-0.52	NS	*-92.84*
DIST50	-0.23543	0.23552	-1.00	NS	*-182.31*
SIZEM	0.16786	0.19663	0.85	NS	
SIZEL	0.22500	0.19528	1.15	NS	
PRICE	-0.00129	0.00023	-5.67	***	

Log likelihood = -157.06735 Pseudo R2 = 0.1409
* Level of significance: ns> 0.05; * < 0.05; **< 0.01 and *** < 0.001.

In Table 39 and Table 40, a very clear difference in preferences between the two groups is again apparent. Respondents, who agree that off-shore wind farms should be located so they are not visible from the coast, display even higher WTPs for increasing the distance than those of the HR sample. Again, the other group is indifferent between having the off-shore wind farms at 8, 12, 18 ore 50 km. The heterogeneity in the NY sample can be represented by the following two groups:

- A group of respondents who are willing to pay quite large amounts for moving the off-shore wind farms increasingly further away from the coast.
- A group of respondents who are indifferent between whether the wind farms are located at 8, 12, 18 and 50 km, and therefore unwilling to pay for an increased distance.

7.4.4 Heterogeneity in NA sample, HR sample and NY sample

As presented in the previous sections, the evidence of heterogeneity in preferences for moving off-shore wind farms away from the coast is quite clear in each of the three samples. Respondents stating that they prefer wind farms to be invisible from the coast have relatively high WTPs for moving the wind farms away from the coast. On the other hand, respondent who state that wind farms need not to be invisible from the coast have much lower WTPs for moving the wind farms away from the coast - or there is as in the HR and NY samples no (statistically significant) WTP at all. It is interesting to see that the respondents in the HR and NY samples, in the latter group, are indifferent as to whether the wind farms are located at 8, 12, 18 and 50 km from the coast. This indicates, that the experience they have from the existing wind farms have made them indifferent, compared to the DS, who have no or relatively little experience with off-shore wind farms.

8 Socio Economic Impacts of Wind Farms

The two off-shore wind farms investigated in this study are large-scale projects with measurable economic impacts in terms of income generation and employment. The wind farm at Horns Rev (owned and operated by the energy company Elsam) consists of 80, 2 MW wind turbines. The wind farm at Nysted (owned and operated by the energy company E2) consists of 72, 2.3 MW wind turbines. Investments amount to approximately two billion DKK[30] for each of the two wind farms. It has not been possible at this stage to obtain data which would facilitate cost-benefit analysis or other economic efficiency assessments of the projects. In the following we will present an overview of the employment effects associated with the construction, operation and maintenance of the wind farms.

8.1 Multiplier Effects

The establishment of a wind farm generates economic effects associated with the construction activities and the manufacturing of wind turbines, building materials and other inputs. These production activities have indirect effects in terms of demand for inputs of goods and services from other sectors in the economy – and the production of these inputs creates new demands for inputs and so on and so forth. Deliveries come from domestic production sectors as well as imports. The aggregate magnitude of these commodity and service flows can be calculated using *input-output multipliers* derived from an input-output table. Input-output multipliers capture the entire employment and import effects of deliveries to final use - in this case wind turbines, transmission networks and other types of wind farm infrastructure.

The production activities specified above are associated with income generation. Higher incomes lead to an increase in the demand for consumer goods, which in turn will increase employment and income in the consumer goods industries. These impacts are known as *income multiplier* effects. Of course an aggregate increase in employment and income will occur only if there is excess capacity in the economy. Otherwise the production and demand generated by the operation and construction of wind farms will crowd out other economic activities. It is disputed to what extent project assessments should attempt to incorporate multiplier effects. According to the Danish Ministry of Finance, multiplier effects should generally be omitted in project appraisals due to uncertainties about the business cycle and structural barriers in the economy (see Ministry of Finance, 1999). On the other hand, in areas with relatively high unemployment – such as one of the locations in this investigation – the establishment of a wind farm will probably have a positive net effect on the economic activity and employment level.

In the following we will focus on the direct and indirect (input-output multiplier) effects of the construction and operation of wind farms, whereas the income multiplier effects will be omitted. Clearly, the direct and indirect effects may also result in crowding out of other activities. However, here it is possible to identify a significant share of the employment effects at the local and regional levels. This means that it is easier to assess to what extent crowding out may occur.

[30] One Danish krone (DKK) is equal to app. €0.13

8.2 Data Sources and Assumptions

Investment expenditures: Figures for investment expenditures on different components and facilities were provided by the power companies owing and operating the two wind farms: Nysted Wind Farm (Boesen, 2004); Horns Rev Wind Farm (Bonefeld, 2004). The support structures for the Nysted wind farm and the Horns Rev wind farm are not included in the calculation since these were made in Poland and Holland, respectively (erection of the support structures has created some domestic employment, which has not been accounted for).

Producers of wind turbines: The suppliers of the wind turbines (Bonus Energy A/S and Vestas Wind Systems A/S) are located in Denmark.

Input-output multipliers: Employment and imports associated with the manufacturing of wind turbines, building materials and other inputs are calculated using input-output multipliers. The input-output multipliers used are derived from the 2001 input-output tables for Denmark (see Statistics Denmark, 2003).

Displacement of existing power production: The power generated by the two new wind farms could be expected to displace production and capacity at existing coal or gas fired power plants. However, there is no reason to believe that this will happen at a one to one scale. Great fluctuations are inherent in wind power generation, and back-up is needed, either in terms of coal/gas fired power plants and/or power imports. Assuming that displacement effects are negligible this study does not consider a reduction in employment in the conventional power sector.

Effect on tourism and fisheries: Offshore wind farms may have an effect on tourism – positive or negative. In the Nysted area, the negative influence on the sailing tourism has been discussed and resulted in the construction of a new entry to the harbour (Kuehn 2005a). In the Horns Rev area it was stated by the locals that the wind farm would have a negative effect on the tourism. However, the research of Kuehn (2005b) implies that the negative effects on tourism have not been the case. Studies from Scotland indicate that there is a positive, but small, tourist effect of large wind farms (Stevenson & Peasley 1995). There is evidence that the two new wind farms in this study also attract tourist. The wind farm visitor centre in Nysted expects 40,000 visitors per year. However, it is beyond the scope of this study to investigate the possible effects of the establishment of the wind farms on tourism. The wind farms' expected effect on commercial fisheries is reported in the EIA-rapports (SEAS 2000, Elsamprojekt 2000). It is concluded that the effects on fisheries is negligible – implying that within commercial fisheries there will be no employment effects worth mentioning.

8.3 Investments: Domestic Deliveries and Imports

To calculate the employment effects of the establishment of a wind farm, it is necessary to identify the domestic share of total deliveries of investment goods and services to the project. This calculation is based on input-output *import multipliers* showing the import content in deliveries to final use by individual sectors.

Table 41 and Table 42 present the breakdown of the investment and the production sectors used to calculate the domestic shares of the deliveries, and the import content is specified for the different components of the deliveries to the two wind farms. As can be seen, the aggregate import quotas amount to 42 and 47.6 percent, respectively, for the two wind farms – consequently leaving a domestic investment share of approximately 1.1 billion DKK for both the Nysted and Horns Rev wind farms. In comparison, the study by Munksgaard *et al.* (1995) found an import quota of 35 percent for Danish land-based wind farms. Off-shore wind farms have relatively large components of construction and project management costs which tend to keep the import share of total investment costs at a relatively low level - when these components are delivered by domestic producers.

Table 41: Breakdown of total investments on domestic deliveries and imports, Nysted Wind Farm

Investment components	Imports per cent	Stat. no.	Production sector
Wind turbines*			
Generator	41.9	310000	Mfr. of other electrical machinery and app.
Gear	31.0	292000	Mfr. of other general purpose machinery
Rotor	26.7	252400	Mfr. of other plastic products n.e.c.
Tower	26.2	281009	Mfr. of construct. mat. of metal
Brakes	31.0	292000	Mfr. of other general purpose machinery
Support structures**	100.0	450001	Construction of new buildings
Offshore Trafoplatform	14.5	450001	Construction of new buildings
Control (SCADA)	41.9	310000	Mfr. of other electrical machinery and app.
Offshore transformer	41.9	310000	Mfr. of other electrical machinery and app.
Offshore net	41.9	310000	Mfr. of other electrical machinery and app.
Offshore to land net	41.9	310000	Mfr. of other electrical machinery and app.
Onshore net	41.9	310000	Mfr. of other electrical machinery and app.
Other cost	17.7	45000	Construction
Total investment	**42.1**		

* The breakdown of wind turbines on components is based on Munksgaard *et al.,* 1995 and Rasmussen & Knetz, 1992.

Table 42: Breakdown of total investments on domestic deliveries and imports, Horns Rev Wind Farm. Please note that several import quotients are given by Elsam Engineering and not by national statistics.

Investment components	Imports per cent	Stat. no.	Production sector
Wind turbines*			
Generator	41.9	310000	Mfr. of other electrical machinery and app.
Gear	31.0	292000	Mfr. of other general purpose machinery
Rotor	26.7	252400	Mfr. of other plastic products n.e.c.
Tower	26.2	281009	Mfr. of construct. mat. of metal
Brakes	31.0	292000	Mfr. of other general purpose machinery
Support structures**	82.5	(450001)	Construction of new buildings
Offshore trafoplatform**	80.0	(450001)	Construction of new buildings
Offshore net**	80.0	(310000)	Mfr. of other electrical machinery and app.
Offshore to land net**	70.0	(310000)	Mfr. of other electrical machinery and app.
Onshore net**	55.0	(310000)	Mfr. of other electrical machinery and app.
Project management	5.9	742009	Consulting engineers
Environmental research**	5.0	(742009)	Consulting engineers
Other cost	17.7	45000	Construction
Total investment	**47.6**		

* The breakdown of wind turbines on components is based on Munksgaard *et al.,* 1995 and Rasmussen & Knetz, 1992.
** Import quotients given by Elsam Engineering (Bonefeld, 2004).

8.4 Investments: Employment Effects

The employment created by the establishment of the two wind farms has been calculated for direct effects and indirect effects, respectively. The *direct employment* effects were calculated using *employment quotients* (from the 2001 input-output tables). Employments quotients show the number of man years per million DKK of production in the sectors delivering goods and services to projects. To produce these deliveries, the involved sectors demand inputs from other sectors in the economy. This creates *indirect employment* effects, which are calculated using input-output *employment multipliers*.

8.4.1 Direct employment effects

The direct employment generated by the establishment of the Nysted wind farm is shown in Table 43. For the Nysted wind farm, the direct employment effects in the sectors producing the different wind turbine components amount to 600 man years. Manufacturing and building activities related to transmission networks and constructions created employment equivalent to man years 602. In total, the calculated direct employment effects from the production of investment goods and services amount to 1202 man years.

Table 43: Direct employment effects from investment, Nysted Wind Farm

Investment breakdown	Employment quotient Man years/million DKK	Employment Man years	Production sector Stat. no.*
Wind turbines			
Generator	0.78	-	310000
Gear	1.17	-	292000
Rotor	1.23	-	252400
Tower	1.41	-	281009
Brakes	1.17	-	292000
Wind turbines		**600.3**	
Support structures#	1.12	-	450001
Offshore Trafoplatform	1.12	-	450001
Control (SCADA)	0.78	-	310000
Offshore transformer	1.12	-	450001
Offshore net	0.78	-	310000
Offshore to land net	0.78	-	310000
Onshore net	0.78	-	310000
Other costs	1.15	-	45000
Total for construction		**601.5**	
Total for investment	**1.1**	**1,201.7**	

* For sector specification, see table 1 and 2.

Support structures are not included in the calculation as turbines were manufactured in Poland.

Direct employment generated by the establishment of the Horns Rev wind farm is shown in Table 44. In the sectors producing the different wind turbine components, the direct employment effects amount to 870 man years. Manufacturing and building activities related to transmission networks and constructions created employment equivalent to man years 605. In total the calculated direct employment effects from the production of investment goods and services amount to 1275 man years for the Horns Rev investment.

Table 44: Direct employment effects from investment, Horns Rev Wind Farm

Investment breakdown	Employment quotient Man years/million DKK	Employment Man Years	Production sector Stat. no.*
Wind turbines			
Generator	0.78	-	310000
Gear	1.17	-	292000
Rotor	1.23	-	252400
Tower	1.41	-	281009
Brakes	1.17	-	292000
Wind turbines		**869.7**	
Support structures	1.12	-	450001
Offshore Trafoplatform	1.12	-	450001
Project management	1.42	-	742009
Environmental research	1.42	-	742009
Offshore net	0.78	-	310000
Offshore to land net	0.78	-	310000
Onshore net	0.78	-	310000
Other cost	1.15	-	45000
Total construction		**405.0**	
Total investment	**1.15**	**1,274.7**	

* For sector specification see table 1 and 2.

8.4.2 Indirect Employment Effects

Input-output multipliers are used to calculate the indirect employment effects created by the production of inputs to the above mentioned sectors making the direct deliveries of investment goods and services. The results are shown in Table 45 and Table 46 below. Most sectors in the economy are affected to some extent by this demand for inputs in terms of a multitude of goods and services. It is impossible to indicate these transactions in detail. In Table 45 and Table 46 the aggregate indirect employment effects are attributed to the sectors making the final deliveries to the projects (i.e. the production sectors in Table 41 and Table 42).

The indirect employment generated by the establishment of the Nysted wind farm is shown in Table 45. Input deliveries to the sectors producing the wind turbine components created employment effects amounting to 283 man years. Input deliveries to electrical equipment manufacturing and building activities created indirect employment effects equivalent to 549 man years. In total the calculated indirect employment effects amount to 832 man years for the Nysted wind farm.

Table 45: Indirect employment effects from investment, Nysted Wind Farm

Investment breakdown	Employment multiplier* Man years/million DKK	Employment Man Years	Production sector Stat. no.**
Wind turbines			
Generator	0.74	-	310000
Gear	0.72	-	292000
Rotor	0.51	-	252400
Tower	0.63	-	281009
Brakes	0.72	-	292000
Wind turbines		**282.7**	
Support structures#	0.94	-	450001
Offshore Trafoplatform	0.94	-	450001
Control (SCADA)	0.74	-	310000
Offshore transformer	1.51	-	450001
Offshore net	0.74	-	310000
Offshore to land net	0.74	-	310000
Onshore net	0.74	-	310000
Other costs	0.96	-	45000
Total construction		**549.3**	
Total investment	0.77	**831.9**	

* Indirect effect only.
** For sector specification see table 1 and 2.
# Support structures are not included in the calculation as they were manufactured in Poland.

The indirect employment generated by the establishment of the Horns Rev wind farm is shown in Table 46. Input deliveries to the sectors producing the wind turbine components created employment effects amounting to 418 man years. Input deliveries to electrical equipment manufacturing and building activities created indirect employment effect equivalent to 399 man years. In total the calculated indirect employment effects amount to 818 man years for the Horns Rev wind farm.

Table 46: Indirect employment effects from investment, Horns Rev Wind Farm

Investment breakdown	Employment multiplier* Man years/million DKK	Employment Man Years	Production sector Stat. no.**
Wind turbines			
Generator	0.74	-	310000
Gear	0.72	-	292000
Rotor	0.51	-	252400
Tower	0.63	-	281009
Brakes	0.72	-	292000
Wind turbines		**418.4**	
Foundation	0.94	-	450001
Offshore Trafoplatform	0.94	-	450001
Project management	0.77	-	742009
Environmental research	0.77	-	742009
Offshore net	0.74	-	310000
Offshore to land net	0.74	-	310000
Onshore net	0.74	-	310000
Other cost	0.96	-	45000
Total construction		**337.6**	
Total investment		**756.0**	

* Indirect effect only.

** For sector specification see table 1 and 2.

8.5 Operation and Maintenance

In addition to the investments there is a *flow* of activities related to operation and maintenance of the wind farms over the expected 20 year life time of the projects. Estimates in terms of expenditures are available only for the Horns Rev wind farm. The operator of the Nysted wind farm has provided an estimate of the number of man years required for the operation of the wind farm.

8.5.1 Expenditures on Maintenance and operation of the Horns Rev Wind Farm

Table 47 gives a breakdown of the expected expenditures on maintenance components, domestic deliveries, and imports for the Horns Rev wind farm. Total maintenance and operation costs over the entire life time of the wind farm are estimated at 1.1 billion DKK. Input-output import multipliers were used to calculate the domestic share of these deliveries, which amounts to 806 million DKK.

Table 47: Total expenditures on maintenance and operation over an expected 20-year life time, Horns Rev Wind Farm

Maintenance and operation	Imports per cent	Stat. no.	Production sector
Service	17.7	45000	Construction
Maintenance	17.7	45000	Construction
Transport	51.6	6009	Transport
Spare parts	31.0	292000	Mfr. of other general purpose machinery
Insurance	8.7	660300	Non-life insurance
Scrapping	14.2	450002	Repair and maintenance of buildings
Total	**29.3**		

8.5.2 Employment effects of operation and maintenance

Based on the expenditure figures in Table 47 above, employment estimates have been calculated using input-output employment multipliers.

Table 48: Accumulated employment effects from maintenance and operation over 20 years, Horns Rev wind farm

Maintenance and operation	Employment quotient Man years/million DKK	Employment Man Years	Production sector Stat. no.*
Direct employment			
Service	1.15	-	45000
Maintenance	1.15	-	45000
Transport	1.38	-	60000
Spare parts	1.17	-	292000
Insurance	1.05	-	660300
Scrapping	1.96	-	450002
Total		**1,031.1**	
Indirect employment			
Service	0.96	-	45000
Maintenance	0.96	-	45000
Transport	0.96	-	60000
Spare parts	0.72	-	292000
Insurance	0.61	-	660300
Scrapping	0.67	-	450002
Total		**696.6**	
Total employment		**1,727.7**	

* For sector specification see table 1 and 2.

As can be seen from Table 48 maintenance and operation of the Horns Rev wind farm is estimated to generate a total of 1031 man years of direct employment during the 20 years of expected operation and 697 man years of indirect employment. In total this amounts to 1728 man years when both direct and indirect employment effects are considered.

When it comes to operation activities, no cost or employment estimates are available for the Horns Rev wind farm. The operator of Nysted wind farm expects that operation activities here will create (direct) employment equal to 360 man years in total for the 20-year operation period.

8.6 Total and local employment effects

The total employment effects for the two wind farms are summarized in Table 49 below - detailed on activities associated with the investments and the operation and maintenance activities over the 20-year operation period. *Investment activities* created *direct* employment equal to 1275 and 1202 man years for Horns Rev and Nysted, respectively. The *indirect* employment generated by the investments was found to be 756 man years at Horns Rev and 832 man years for Nysted. In total direct and indirect employment generated by investment sums to 2,031 man years for the Horns Rev wind farm and 2034 man years the Nysted wind farm.

The *running activities* during the 20 years of operation also create employment. For the Horns Rev wind farm accumulated employment associated with *maintenance* and *operation* was calculated to be 1728 man years in total - distributed on 1031 man years in terms of direct employment and 697 man years in indirect employment. For the Nysted wind farm employment figures were provided by the operator, who expects that *operation activities* will create employment equal to 360 man years in total over the operation period. This is equivalent to a permanent staff of 18 employees, on average over the years.

Table 49: Total employment effects for Horns Rev and Nysted wind farms, man years

	Horns Rev			Nysted		
	Direct empl.	Indirect empl.	Total	Direct empl.	Indirect empl.	Total
Wind turbines	870	418		600	283	
Construction	405	338		602	549	
Total investment activities	1,275	756	**2,031**	1,202	832	**2,034**
Maintenance	1,031	697		na	na	
Operation				360	na	
Total running activities	1,031	697	**1,728**	360	na	**360**

The input-output model calculations do not provide a breakdown of employment effects on the local and national level. Overall we assume that the employment activities associated with the manufacturing of wind turbines are at the national level. Construction activities, on the other hand, will create a certain amount of employment at the local/regional level. According to an estimate made by Bonefeld (2004), two thirds of the employment generated by construction (of the Horns Rev wind farm) and 90 per cent of the maintenance activities have been/will be local. However, the breakdown of construction activities in the present input-output model calculations includes deliveries from e.g. electrical equipment manufacturers and consulting engineers. It is not possible to distinguish between on-site construction activities and the former type of deliveries.

The distinction, which can be made, is between direct and indirect employment effects. As a rough estimate we will assume that 50 per cent of the *direct* and 25 per cent of the *indirect* employment effects associated with "construction", as defined in the tables above, are local. This implies that the investments have created 438 (0.5*602+0.25*549) man years of employment in the Nysted area, while the establishment of Horns Rev wind farm has generated 287 (0.5*405+0.25*338) man years of local employment.

As far as the *maintenance* activities are concerned, we assume that 90 per cent of the direct and 50 per cent of the indirect employment effects are local. For *operation* activities alone the local share of the employment is assumed to be 100 per cent. Accordingly, at Nysted operation is assumed to create 360 man years of employment at the local level (equal to 18 man years on an annual basis). For the Horns Rev wind farm it is not possible to distinguish between maintenance and operation activities. A conservative estimate indicates that maintenance and operation over 20 years will create a total of 1277 man years of local employment - distributed on 928 (0.9*1.031) man years in terms of direct employment and 349 (0.5*697) man years of indirect employment.

To summarize: As indicated above, it has not been possible to obtain all relevant figures for both wind farms, and Nysted is somewhat atypical to normal Danish construction work in the sense that the support structures were imported. The Horns Rev wind farm is best documented in terms of cost data and probably the most typical where the origin of deliveries is concerned.

If we take the Horns Rev wind farm as a model, our calculations show that the establishment of an off-shore wind farm with 80, 2 MW turbines creates a total of around 2000 man years of domestic employment over the construction period. A tentative estimate indicates that up to one quarter of this will be at the local level.

Operation and maintenance over the 20-year life time of the park will create an additional 1700 man years of employment. It is expected that three quarters of this will be at the local level.

9 Discussion

In the *first part* of this chapter, the results relating to the choice models and the estimated WTPs for placing the wind farms at a greater distance from the coast are discussed. The discussion is based on a comparison between the three samples and is for simplicity only made within each of the three models (Basic model, Certain choice model and Rational choice model). The purpose of the discussion is twofold:

- Firstly to summarise the estimated WTPs and compare these across samples.
- Secondly, to link the WTP-results to the findings in the chapters on socio-economic characteristics of the respondents and the non-WTP questions also included in the questionnaire, chapter 5 and 6 respectively (section 9.5).

The design of the survey and a validation of the result are discussed in the *second part* of the chapter.

9.1 Models

The variables, which were found to have a significant influence on respondents´ choice, are nearly identical across the nine models in the three samples. This is to some degree surprising given the geographical and experiential differences between the samples (see chapter 6). Nevertheless, it can be considered somewhat reassuring as it indicates a high degree of model stability. However, it is more surprising that *very few* of the proposed interactions between the main effect variables (see Table 2) and the socio-economic characteristics of the respondents, have turned out to have a systematic and significant influence of respondents´ choices. As a consequence, the choice models are mainly characterised by the main effect variables, PRIZE, DIST12, DIST18, DIST50, SIZEM and SIZEL, where-off not all have proved to be equally significant.

Two interaction variables, however, were significant in four of the nine models. The *first* interaction variable is the P_SEX variable which is found to be significant in the B and C models of the NA sample and the B-model of the NY sample. These samples do show a gender-specific heterogeneity with regard to the influence of the price variable (PRICE). Even though females were found to have a 30 and 50 per cent lower WTP in the two samples, it does *not* point to the fact that females have different preferences for the location of the wind farms as such. Instead, the findings must be interpreted in the way that in the two samples females were more sensitive to price. The *second* interaction variable that turned out to be significant is the EO_SL which is significant in the B-model of the HR sample.

The presence of a difference in sensitivity to the price-variable between genders is interesting as it occurs in three of nine models. The effect is, however, not present in all nine models. It would therefore be an error to conclude that in general women are more price sensitive than men. However it could be argued that the women in the national survey seem to be more price sensitive than the men, given that the effect is present in both the B and R-models. It is not possible to explain the occurrence of the EO_SL variable besides what has already been attempted, and as it only occurs in one of nine models it can be reckoned as an interesting but not important finding.

The two wind farm size variable, SIZEM and SIZEL turned out to be insignificant in all three samples except one (HR sample, C-model). This is quite surprising as respondents were expected to have preferences for the size of the wind farms. The size variable can, however, be difficult to handle in relation to modelling the choices/preferences of the respondents. Some respondents might prefer larger wind farms so that the number of wind farms is kept low. This would mean that respondents would prefer large visual impacts at few locations compared to smaller visual impacts at more locations. The opposite could equally be the case, i.e. that some respondents would prefer small but many wind farms to large but fewer wind farms[31]. The presence of such heterogeneity in preferences might explain why the farm size variables are found to be insignificant. Such different preferences for wind farm size were presented and discussed in chapter 7, and support the above mentioned explanation. Even though the size variables were non-significant in the three samples, it is nevertheless quite interesting to have a brief look at the difference between the samples. In the NA sample on average the respondents had a negative "WTP" for both SIZEM and SIZEL. Implying that respondents seemed to prefer small wind farms to medium or large wind farms. In the NY and HR samples the respondents, on average, appeared to have the opposite preferences structures. Consequently, large wind farms were preferred to medium and small wind farms. The fact that the respondents already have some experience with the view of a wind farm in the HR and NY samples, might explain why their preferences might appear to be different from the preferences of the Danish population in general.

9.1.1 Fit of the models

As mentioned, the nine models are quite identical with regard to the significant independent variable. It could, therefore, be expected that the models performed somewhat identical with regard to the model fit (the pseudo R^2). As stated by Train (2003), it is, however, not possible to directly compare pseudo R^2 between models, based on different datasets. It is though interesting to see, that especially the B-model of the NY sample seems to fit the data less than the other B-models (see Table 50).

Statistical and empirical experience suggest that a pseudo R^2 higher than 0.10 is acceptable, and that the rate of explanation is really good when the pseudo rho is above 0,20 (Bateman *et al.* 2002). This means that all three models can be accepted regarding their abilities to predict the preferences of the respondents.

Table 50: Pseudo rho of the nine models.

	B-model	C-model	R-model
NA sample	0.2494	0.2827	0.3575
HR sample	0.2640	0.2667	0.2820
NY sample	0.1098	0.1279	0.1174

It is not straight forward to explain why the R^2 of the NY sample is smaller than it is the case for the NA and HR samples. One possible explanation could be that the respondents to a higher degree have made their choices with regard to possible omitted attributes in the model, and thereby introducing more randomness in the model (Ben-Akiwa & Lerman, 1985). Another and perhaps more simple explanation could be that the heterogeneity in preferences is larger in the NY sample than in the HR and NA samples, why the significance of the independent variables in the model is lower, in relative terms. It is interesting to see, that the pseudo rho value, as expected, increases as "uncertain" and irrational respondents are excluded from the sample (from B-model to C-model and C-model to R-model). This

[31] This difference in preference was also observed during the focus group interview

indicates that the models' ability to predict respondents´ choices increases along with the exclusion of respondents. Moreover, it verifies, that the "uncertain" respondent were indeed uncertain about their choices. This is not surprising as the exclusion of respondents being uncertain of their choices and/or respondents responding irrationally were expected to result in more predictable samples.

9.2 WTP Results (across samples)

In this section, the main emphasis is placed on comparing the WTPs across and between samples, but within models, starting by discussing the Basic Models derived from each sample. The more general discussion of models and the results between models is conducted in chapter 7.

9.2.1 Basic model

In Figure 1, the WTPs derived form the three B-Models are presented. The average WTP of all B-models is 420 DKK/household/year for moving the wind farms from 8 to 12 km, 698 DKK/household/year from 8 to 18 km, and 906 DKK/household/year for moving them from 8 to 50 km. As can be seen from Figure 1, the WTP of the NA sample turns out to be very close to this average, while that of the HR sample is below, and that of NY sample is way above the average.

Accordingly the NY sample holds the highest WTP and the HR sample the lowest WTP of all three samples. This result is interesting when comparing the socio-economic characteristics of the NY and HR samples. The NY sample has the respondents with the lowest income and educational levels, so a priori it would be expected that the NY sample would exhibit a lower WTP than, for example, the HR sample, see hypothesis Table 2. But, as mentioned, the difference in the income level variables was found not to be significant in any of the choice models, implying that the a priori expectations were not confirmed. A potentially valid explanation could be that the existing wind farm at NY is located much closer to the coast than the wind farm at HR, where the wind farm is hardly visible in most types of weather. Accordingly, the respondents from NY have more practical experience with the visual externalities than the respondents in the HR and NA samples. Thus, it seems reasonable to expect that the respondents in the NY sample have stronger preferences for moving the wind farm further away from the coast. This corresponds to the observations that the establishment of the NY wind farm has been surrounded by markedly grater public attention and opposition than was the case of the HR farm (see sociological studies by Kuehn, 2005a and 2005b).

The difference in the respondents' preferences across samples is clearly illustrated when comparing the WTPs for moving the wind farms from 8 to 12, 18, and 50 km, see Figure 37.

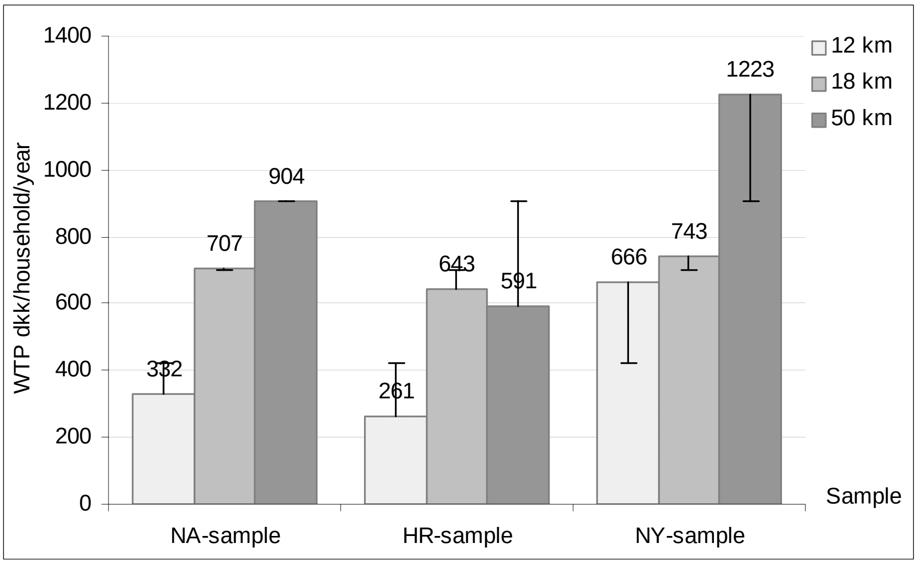


Figure 37: WTP in DKK/household/year for moving from 8 km to 12 18, and, 50 km when applying the basic model of the samples.

In Figure 37 the respondents from the NY sample are, as already mentioned, seen to have quite high WTPs for moving the wind farms from 8 to 12 km (666 DKK) and 8-50 km (1.223 DKK). These WTPs are between 30-100 per cent higher than those of the HR and NY samples. The validity of these observed differences is supported by the analysis presented in chapter 6 where it was shown that 87 per cent of the respondents in the HR sample stated that they were positive or neutral, when asked about their opinion on the appearance of wind farms in costal areas. In comparison, only 74 per cent of respondents in the NA sample and 72 per cent in the NY sample, declared that they were positive or neutral. On the other hand, the NY sample was also shown to exhibit the highest frequency of respondents, who did not agree that the wind farms should be placed out of sight. All else equal, this indicates a lower WTP for the NY sample than for the other samples. As shown in the endogenous models in the heterogeneity section, the respondents in the NY sample, who believe that wind farms should indeed be placed out of sight, turn out to hold very strong preferences for moving the wind farms to longer distances off the coast.

9.2.2 Certain Choice Model

The WTP obtained in the three C-models can be seen in Figure 38. The average WTP of the three models are 468 DKK/household/year for moving the wind farms from 8 to 12, 799 DKK/household/year when the wind farm is moved from 8 to 18 km, and 1,019 DKK/household/year when mowed from 8 to 50 km. These results are approximately 100 DKK/household/year higher for each of the three distances compared to the average result of the B-models. This increase in the WTP of the C-model is caused by the increase in WTP in the NA sample, where the WTP in the C-model is remarkably higher than in the B-model. It is not possible to identify any specific differences in the socio-economic composition of the C-model which may serve as an explanation of the stronger preferences.

However, a possible explanation could be that the number of respondents in the C-model for the NA sample, who states that wind farms should be placed at a distance where they are out of sight, are higher than in the B-model, see 9.2.4 for further discussion.

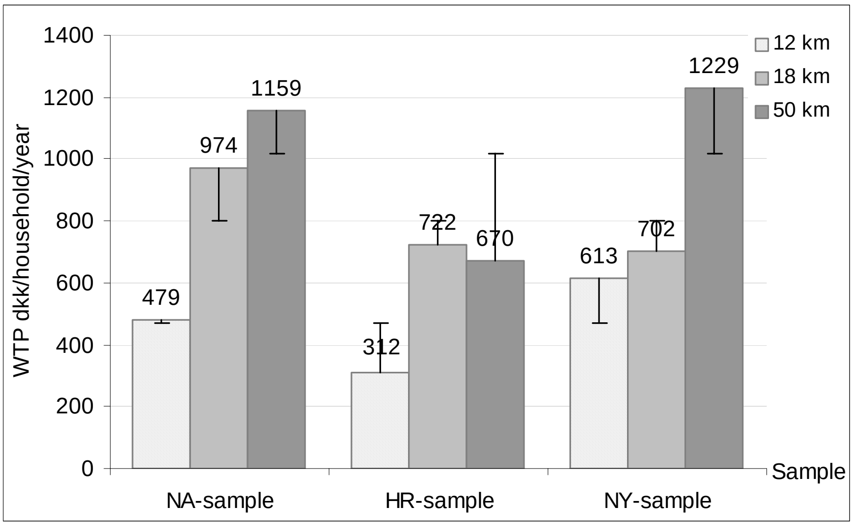


Figure 38: WTP in DKK/household/year for moving from 8 km to 12, 18, and, 50 km when applying the Certain Choice model of the samples.

As for the B-model it is surprising that the C-model of the NY sample returns so high WTPs. Again the reflections on the matter, which were made in the previous section, may apply as an explanation. The high WTP of the NA sample makes more sense seen from a socio-economic point of view as the respondents in the national sample in general have a higher income than in respondents in the other samples.

As a consequence of both the NA sample and the NY sample reaching quite high levels of WTP, the low WTP obtained in the HR sample becomes even more pronounced. As pointed out in the previous section and in Chapter 7, a possible explanation for the low WTP of the HR sample and for the fact that the respondents are indifferent between 18 and 50 km, can be linked to the features of the existing wind farm.

9.2.3 Rational Model

In Figure 39 the R-models are presented. The average WTP across the three samples is 493 DKK/household/year for moving the wind farms from 8 to 12 km, 791 DKK/household/year for moving them from 8 to 18, and 1083 DKK for moving them from 8 to 50 km. As mentioned previously, the respondents in the NY sample express a significantly higher WTP for moving the wind farm to 50 km, compared to the respondents in the NA sample and no at less those of the HR sample. The same explanation as considered in relation to the B-model may be applied again:

- Respondents in the NY sample may have generated very strong preferences for moving wind farm out of sight; the existing wind farm in their area is very visible.
- Distance issues have locally been a matter of considerable attention.

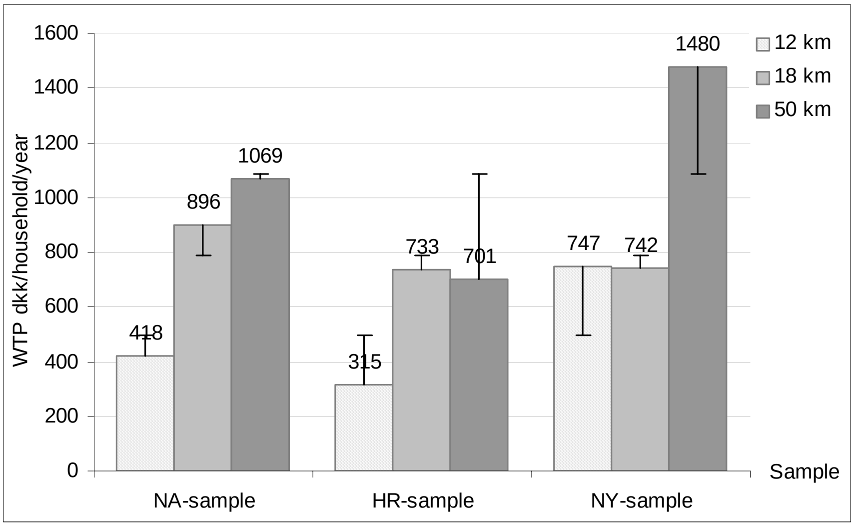


Figure 39: WTP in DKK/household/year for moving from 8 km to 12, 18, and, 50 km when applying the Rational model.

9.2.4 WTP across Models and Heterogeneity

As presented in the previous sections, the WTPs in each sample increase as uncertain and irrational respondents are excluded. It is difficult to determine why, since the distribution of the socio characteristics of the respondents does not change significantly when moving from the B to the C-model and the R-model, see 5.2. As discussed in 7.4, there seem to be strong heterogeneity in preferences with regard to whether the respondents state, that the wind farms should be located out of sight or within sight. One possible explanation could therefore be that the number of respondents who prefer that the wind farms are moved out of sight increases in the C and R-models compared to the B-model. However, a brief analysis could not confirm the suspicion. Thus only in the case of the NA sample did the frequency of respondents who prefer to have wind farms out of sight, increase when moving from the B to the R-model. For the HR and NY samples the frequency either decreases or remains constant across models.

9.3 Survey and design

The design and contents of the questionnaire could have included additional information, or the information could have been presented differently. A discussion of these matters is the focus of the following section.

9.3.1 Weather and Light Markers

The focus group expressed that the use of illustrations in the choice sets were of great importance in relation to making the choice sets realistic/understandable. However, the illustrations only depicted the wind farms on a clear day and in full daylight. This might not be fully representative as some months during the year contain up to 20 percent of “non visibility” days (DEA 1994). This is especially relevant in relation to the west coast of Denmark, where the weather seldom is as clear as in the pictures presented in the questionnaire. This might have caused the respondents to express stronger preferences for moving the wind farms further away from the coast and thereby express a higher WTP, than they would have done if illustrations with a lower visibility had been presented. It was not possible to include changing weather conditions in the questionnaire and therefore it is important to keep this fact in mind.

Just as important as potential changes in weather conditions is the fact that the wind farms also give rise to visual externalities during night time. This is due to markers (warning lights) set up to warn air and sea traffic in the area. The markings consist of red lights placed on top of each turbine plus a lantern beaming with a yellow light from the four corner turbines of each farm. The installed light markers are a part of the NY and HR demonstration projects and, especially at NY, they have been found to be obstructive. However, new and less visible light markers are expected to be the result of a forthcoming regulation (Nielsen 2005). In this study, however, none of these marking options were included as no illustrations of the wind farms at night were presented. Nevertheless, it may be noted that including the visual externalities caused by markers would most likely have resulted in a higher WTP for moving the wind farm to a far distance. However, the respondents from the NY and HR areas might already have been aware of the effects and included them in the expression of their preferences. This may in fact serve as an explanation for the high WTPs for moving the wind farm to 50 km in the Nysted sample.

Biodiversity

In the present study the focus was solely on the visual externalities of the off-shore wind farms. If other externalities were included in the study new results regarding respondents preferences for these externalities would of cause have been obtainable. In this connection one potentially important externality could be the effect on biodiversity. The effect of could thus have been included as an attribute in the questionnaire although it would have been difficult to present in a both meaningful and easy comprehensive way. However, biodiversity was not the focus of the study and therefore not included.

The decision to exclude possible effects on the biodiversity from the survey is generally supported by the respondents' answers to question 3.4 and 3.5 (see appendix 2). The answers to the questions reveal that most respondents' perceive the impact of off-shore wind farms on marine and bird life to be positive or neutral. This finding supports the hypothesis that the respondents' preferences for size and placement of the wind farms are not confounded with the respondents' perception of the interaction between wind farms and biodiversity.

9.3.2 Cognitive Burden

In choice experiments, the respondents are faced with a requirement of understanding the different attributes and their different levels. Furthermore, they are asked to choose between alternatives each holding different levels of attributes. This means that they are faced with a quite complex task. Exactly how complex the task is depends on the number of alternatives, the number and levels of the attributes, and the number of choice sets that the respondent is exposed to. Research by Mazotta & Opaluch (1995) has shown that respondents have difficulties evaluating more than 4 attributes. However, other researchers have found that there was no difference between using four or eight attributes (Hanley *et al.* 2002). Among other things, the limit of cause depends on the complexity of the definition of attributes. The present study uses four attributes which are all well defined although their definition requires reading some text. Nevertheless, it is expected that the cognitive burden of the choices were not too large. This is supported by the low variance of the WTP functions found in the study.

9.4 Validation of results

In the following section the validity of the results will be discussed by comparison to similar research and by discussing the results in the light of the hypotheses set up prior to the study.

International research on visual externalities of wind farms has so far not been the subject of much attention and the research has mostly been in connection to land-based wind farms. Furthermore, most research has not included economic valuation of the externalities. One of the studies that has been made on the subject is the Swedish “Valuing the Environmental Impacts of Wind Power, A Choice Experience Approach” from Lileå University by Ek (2002). Here, the environmental impact of three different placements of wind farms, farmland, mountains, and off shore, was investigated. The WTP results from this study are not directly comparable to the study at hand, as the visual externalities in the study by Ek (2002) are not singled out from the other environmental impacts. However, the research has some similarities to the present study.

The respondents in Ek (2002) were found to be indifferent between different sizes of off-shore wind farms. This corresponds fairly well with the results of the present study where a significant effect of the size of the wind farms was only present in the HR sample. Similarly, Ek (2002) could not identify any relation between respondents’ socio-economic characteristics and their attitudes towards the placement of wind farms.

A study of Alvarez-Farizo & Hanley (2002), using choice experiments, investigated the environmental impact of wind farms on a Spanish case area. The study was set up to reveal preferences for protecting the area from the establishment of a small land-based wind farm (8-12 mills), one of the attributes being the visual impact. The overall result of this study was that respondents were willing to pay the equivalent of 276 DKK per household for protection of the landscape (representing the visual externalities). This is a very low estimate compared to the ones from the present study, but as mentioned, the comparability between the studies is perceived to be small.

In section 7.4, we test the hypothesis, that respondents who expressed indifference to whether wind farms are placed out of view or not have a lower WTP than other respondents,. The hypothesis was accepted thus proving that respondents have been consistent when expressing their preferences.

The hypothesis, that the presence of wind farms in the local area would have an effect on respondents’ WTP, can also be put forward. It was expected that the WTP of the HR and NY samples were lower than for the rest of the population (NA sample) as the respondents had grown accustomed to the view. This turned out to be only partly true as the respondents of the NY sample revealed a very strong preference for moving the wind farm out of sight. As stated above, an explanation to this phenomenon might be the extensive influence from an extensive public focus on the wind farm. Another explanation could be that the wind farm in NY is placed much closer to the shore creating a stronger preference for moving it out of sight (50 km from the shore).

9.5 Attitudes towards wind farms and WTP

As discussed earlier, the general attitude towards off-shore wind farms appears to be quite positive. Thus, as already mentioned several times, a large proportion of respondents expressed that they were neutral regarding visual impact on the coastal landscape from off-shore wind farms. However, being neutral is not equivalent to not having preferences for the placing of wind farms further away from the coast. Instead, it indicates that the WTP is likely to be fairly low ,which might be confirmed by the fact that the HR sample is the most positive towards the off-shore wind farms while also having a significantly lower WTP than the other two samples. This correlation verifies to some extent the findings of the choice experiment. As touched upon earlier, the positive attitude among the HR respondents might be a consequence of the far distance at which the local wind farm is located (14 to 20 km). Also the level of information that the respondents might have on the issue at hand might be important in connection to the WTP. In this connection it may be noted that apparently the respondents in the HR area are better informed than the respondents in the other samples; at least they have a significantly lower “don’t know” rate in the questions asked.

In question 7.4a, respondents are asked if off-shore wind farms ought to be placed so they are not visible from the coast. If respondents disagree with this statement, they indicate that they are positive or indifferent when it comes to the view of offshore wind farms. The result to this question is surprising as 52 percent of the respondents agreed with the statement. This does not correspond to the large proportion of respondents who stated in question 3.3 that the visual impact of off-shore wind farms was neutral or positive. The explanation to this difference is not straight forward, and apparently the different formulation of the questions might have had an effect. The first question being built as a five-step scale from very positive to very negative, and the second question as a statement which required an agree/disagree statement.

Finally referring to the endogenous choice models in 7.4, the difference in preferences validates the elicited preferences in the non-endogenous choice models. Respondents who prefer to have the off-shore wind farms out of sight have much higher WTPs than others have the highest WTPs. These differences in preferences make good sense from an economic theory point of view.

9.6 Policy related issues

9.6.1 WTP for reducing the visual externalities per wind farm

The elicited preferences and the estimated WTPs in the three samples are based on a scenario of the future off-shore wind power development in Denmark. In the scenario approximately 3600 MW of off-shore wind power is expected to be established by the year 2030. It should therefore be kept in mind that the estimated WTPs are not the WTP for moving one wind farm further away from the shore, but the WTPs for moving 3600 MW wind farms away from the coast. Consequently the estimated WTPs cannot readily be used to evaluate a specific off-shore wind farm project. However the size of the wind farms in the models did, in general, not have a significant influence on the choice of the respondents. The value of reducing the visual externalities of a specific off-shore wind power project can therefore under certain assumptions be estimated as a function of the share of the 3600 MW that the specific wind farm will produce. These assumptions would be:

- The value of reducing visual externalities is independent of the size of the wind farm (supported by the choice models, where the SIZE variables apart from a few exceptions were insignificant).

- The value of a reduction of the visual externalities is constant across wind farms. This means that it is equally important that the second wind farm established is located at X km from the coast as it is that the first wind farm is established X km from the coast.

Given these assumptions are fulfilled, the value of reducing the visual externalities of e.g. a 200 MW wind farm (5MW turbines) would be equal to 200/3,600*WTP=1/18*WTP.

9.6.2 WTP and Turbine Size of the Turbine

In the present project, the wind turbines used in the scenario are 5 MW turbines. These turbines are presently in a test faze. Therefore it can not be expected that off-shore wind turbines will be of such capacity in the nearest future. Consequently, the elicited preferences and estimated WTPs could not directly represent off-shore wind farms with smaller turbines. Using the estimated WTPs would in this case not be correct since the visual externalities of smaller turbines are expected also to be smaller. However, an estimate of the benefits of reducing the visual externalities of a wind farm with smaller wind turbines could be obtained by adjusting the WTPs as a function of the distance. For example, the visual externalities of a 5MW wind farm at 12 and 18 km, respectively, might be equal (visually) to a 3 MW wind farm at 8 and 12 km, respectively. If so, the benefits from moving a 3 MW wind farm from 8 to 12 km would be equal to the benefits of moving a 5 MW wind farm from 12 to 18 km.

9.6.3 WTP and specific locations

In the scenario description in the questionnaire, the location of the future wind farms was not specified. It is, however, stated that protection of wild life, scenic landscape and protected areas will be taken into account. It is important to keep in mind that the present study only elicits preferences for the visual externalities. The visual externalities are therefore assumed to be independent of potential impact on wild life and of whether or not the wind farm is situated in a protected area. Consequently, the estimated values should be representative for wind farms in all locations, though other values related to wild life or protected areas might also be present, depending on the more exact location. With regard to scenic landscape, the visual externalities are likely to depend on the surrounding landscape. A wind farm in a narrow fjord might have a larger impact than one in the open sea. In that case, the estimated WTPs might be an underestimate of the true WTP. Similarly, a wind farm close to famous sight such as Møns Klint or Skagen could be expected to generate higher levels of visual externalities at a given distance from the coast, compared to one located off the beaten track.

10 Conclusion

The overall objective of the project has been twofold:

1) To elicit preferences for the visual externalities associated with off-shore wind farms and to derive WTPs associated with moving wind farms to greater distances from the coast. In this relation, a sub-purpose was to identify attitudes towards wind power and different future wind power development options. The Choice Experiments method was used, and a questionnaire was mailed to three different samples sample groups. A national sample (NA sample) was drawn randomly in order to elicit the preferences of the general population. To test how experience with existing off-shore wind farms might influence preferences, two additional samples were used. The two samples were drawn randomly from areas in the vicinity to the two existing off-shore wind farms at Nysted and Horns Rev. Consequently the survey includes an analysis of three different samples.

2) To analyse the socio-economic consequences experienced in the local regions Nysted and Horns Rev, in areas existing off-shore wind farms are located.

The concluding results in relation to respondents' preferences, WTPs, attitudes towards wind power development and socio-economic impacts are presented in the following sections.

10.1 Preferences for the visual externalities and elicited WTPs

In each sample, three choice models were identified; the Basis model (B-model), the Certain choice model (C-model) and the Rational choice model (R-model). However, the conclusions will mainly refer to the B-models, which are based on the complete samples. For further details on differences between models, see chapter 7.

10.1.1 National sample

The NA sample consists of 375 randomly sampled respondents from the Danish population. In Table 51 below the average WTPs for moving the future wind farms further away from the coast than 8 km are presented.

Table 51: Average WTP (DKK/household/year), B-model, NA sample

	DIST 12	DIST 18	DIST 50
WTP	331.74	706.73	904.17
Marginal WTP	83 DKK/km	63 DKK/km	6 DKK/km

In Table 51 it is seen that respondents in the NA sample are willing to pay 332, 707 and 904 DKK/household/year for moving the future wind farm from 8 to 12, 18 and 50 km, respectively. The WTP is thus an increasing function of the distance from the coast. Interpreted on a marginal scale, the MWTPs for moving future wind farms are; 83 DKK/household/year /km (from 8- 12 km), 63 DDK/household/year /km (12-18 km), and 6 DKK/household/year /km (18-50).

10.1.2 Nysted

The NY sample consists of 170 randomly sampled respondents in the three municipalities Holeby, Nysted and Sydfalster. In Table 52 below, the average WTPs for moving future wind farms (3600 MW) further away from the coast than 8 km are presented.

Table 52: Average WTP (DKK/household/year), B-model, NY sample.

	DIST12	DIST18	DIST50
WTP	666	743	1,223.12
Marginal WTP	167 DKK/km	13 DKK/km	15 DKK/km

In Table 52 it is seen that respondents in the NY sample are willing to pay 666, 743 and 1,223 DKK/household/year for moving the wind farms from 8 to 12, 18 and 50 km, respectively. Once again, the WTP is thus increasing with the distance from the coast. However, the difference in WTP between moving the wind farms to 12 and 18 km is relatively small, and based on a Wald-test it cannot be rejected that respondents are indifferent between having the wind farms at 12 or 18 km. Interpreting the derived WTP on a marginal scale, the WTPs for moving the wind farms are; 167 DKK/household/year/km (from 8- 12 km), 13 DDK/household/year/km (12-18 km) and 15 DKK/household/year/km (18-50).

10.1.3 Horns Rev

The HR sample consists of 140 randomly sampled respondents in the three municipalities Blåvandshuk, Esbjerg and Fanø. In Table 53 below, the average WTPs for moving the future wind farms (3,600 MW) further away from the coast than 8 km are presented.

Table 53: Average WTP (DKK/household/year), B-model, HR sample

	DIST12	DIST18	DIST50
WTP	261.40	643.05	590.05
Marginal WTP	65 DKK/km	64 DKK/km	-2 DKK/km

In Table 53 the respondents in the HR sample are seen to be willing to pay 261, 643 and 590 DKK/household/year for moving the future wind farms from 8 to 12, 18 and 50 km, respectively. The WTP for moving the wind farms from 8 - 50 km is less than that from 8-18 km, but it can not be rejected that the WTPs are identical. Consequently, the respondents in the HR sample appear to be indifferent between having the wind farms at 18 or 50 km. Interpreted on a marginal scale, the MWTPs for moving the wind farms are; 65 DKK/household/year/km (from 8- 12 km), 64 DDK/household/year/km (12-18 km) and -2 (0) DKK/household/year/km (18-50).

10.1.4 WTP across samples

The WTPs across the three samples (NA, NY and HR samples) are relatively different. In relation to the size of the expressed WTP, the samples can be ranked as follows:

1) Nysted sample
2) National sample
3) Horns Rev sample

The visual externalities of the Nysted off-shore wind farm are likely to be perceived higher than the externalities of the wind farm at Horns rev, since it is much closer to the coast. The NY and HR samples are, furthermore, relatively identical with regard to the socio-economics characteristics of the respondents. Consequently, there seems to be some evidence that the visual externalities of off-shore wind farms influence people's preferences for wind farms; a higher level of experienced visual externalities appears to result in higher WTPs, at least in a controlled evaluation study like the present.

10.2 Preferences for Wind Power Development in Denmark

In general, the respondents in the three samples appear to be quite positive towards wind power development.
As such, wind power and solar power are perceived to be the most important instruments to reduce the national CO_2 emissions. Respondents are found to be mainly positive towards existing wind turbines located on land. However, though mainly positive, the attitude is less positive with regard to an increase in the number of wind turbines on land. An alternative to land-based locations is to take the wind turbines off-shore and concentrate them in wind farms. In this relation, respondents across the three samples all appear very positive towards the existing off-shore wind farms. This means that the respondents from the HR and NY sample are indeed positive towards the two off-shore wind farms, located in their vicinity. The same positive attitude is also observed with regards to the establishment of new off-shore wind farms. Almost 80 per cent of the respondents are found to have a positive attitude towards the establishment of new off-shore wind farms. In this relation, it is worth mentioning that the respondents from HR are the most positive. With regard to the visual impacts associated with off-shore wind farms, the respondents in general express a neutral attitude, though with a little overweight of respondents considering the externalities as positive. The externalities are considered to be most positive by the respondents in the HR sample and least positive by the respondents in the NY sample.

10.3 Employment Effects

The employment effects associated with the establishment and running of wind farms have been calculated using input-output model data. The results are presented in chapter 8. Taking the Horns Rev wind farm as a "reference", the calculations show that the establishment of an off-shore wind farm with 80, 2 MW turbines creates a total of around 2000 man years of domestic employment over the construction period. A tentative estimate indicates that up to one quarter of this will be at the local level. Operation and maintenance over the 20-year life time of the park will create an additional 1700 man years of employment. It is expected that three quarters of this will be at the local level.

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Appendices

[See file *Appendices 1&2*]