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Attitudes towards Wind Power Development in Denmark

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Abstract

The present paper analyses the attitudes towards existing and future land-based turbines and off-shore wind farms. The analysis is carried out using a probit model to elicit systematic characteristics determining the attitude of the population. The analyses show that off-shore development is preferred to land based development, which indicates that the wind power development should be taken off-shore. But, the results also point out that the land-based opportunities for wind power development are not exhausted. On a more detailed level, the results denote that the attitude towards both land based and off-shore wind power vary with age of the respondents and experience with wind turbines. Younger respondents are more positive towards wind power than older respondents, pointing towards an increase in acceptance in the future. The attitude was also found to covariate negatively with the experiences and level of exposure to the impacts of wind turbines.

Keywords: Wind power development, land-based, off-shore, attitude, probit model

Preface

In the project ” Welfare Economic Valuation of the Externalities of Wind Power Production- an Evaluation of Economically Efficient Substitution Patterns between Locations” the external cost of land-based and off-shore wind power development are identified and valued in monetary terms. The estimated external cost can be applied in economic analysis in wind power planning, such as optimal location of land-based and off-shore wind turbines. The results from the project thus give the politicians and energy planners a broader foundation for efficient wind energy policy in the future. The present working paper is the second paper published in relation to the project. In the first paper “Economic valuation of the visual externalities of off-shore wind farms” the main focus is on eliciting the cost of visual disamenities of off-shore wind farms. The focus of the present working paper is however more holistic. In this paper, the attitudes towards land-based and off-shore wind power development are systematically analysed. The goal is both to verify if the Danish population overall is positive towards an increase in the wind power capacity on-land and off-shore, but also to identify significant determinants of attitudes.

Ph.d. Student Jacob Ladenburg have completed the present working paper and research assistant Jesper Tranberg, Søren Bøye Olsen, economist in Energy E2 Maria Skotte and Senior Researcher Brian Jakobsen have contributed with valuable comments.

Institute of Food and Resource Economics
Environmental Economics and Rural Development Division, January 2006

Alex Dubgaard
Research Director and Supervisor

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Executive Summary

Wind energy is a clean technology with regards to the emission of CO_2, SO_x, NO_x etc. However, the production of wind energy is not without impacts on the environment, such as visual impacts, noise, change in bird migration routes etc.

The negative impacts of wind power development are difficult to leave out of the equations in relation to the present wind power policy, where wind power capacity on-land and off-shore is planned to increase significantly in the future. Given the impacts and relatively large changes in the landscape that the future wind power development will cause, it is most relevant to elicit the attitudes towards wind power development in Denmark.

The analysis of attitudes is based on three samples consisting of 700 and 2x350 randomly selected persons, which were drawn from the Danish Civil Registration System. The sample of 700 respondents represents the Danish population, and will be referred to as the national sample (NA-sample). The two samples of 350 respondents each represent the population living in the area of the two existing commercial off-shore wind farms at Horns Rev (HR-sample) and Nysted (NY-sample). In a policy context, it is therefore interesting to see, if the attitude towards both existing and more off-shore wind farms differs between the respondents in the two samples.

The results of the analysis are in short presented below.

Land-based turbines

The attitudes towards existing and future land-based wind turbines are in general relative positive as only 10% and 25% of the respondents have negative attitudes, respectively. The relatively low number of negative respondents towards more land-based turbines denotes that the opportunities for land-based development are not exhausted. On a more detailed level, respondents older than 49 years are more negative. However, the negative attitude depends on the age and place of residence of the respondents. Respondents living in larger cities on Zealand and the southern islands are thus more positive.

Off-shore wind farms

The respondents in the three samples are on average very positive towards existing and more off-shore wind farms. Approximately 90 % have a positive/neutral attitude towards both existing and more off-shore wind farms, though the attitude varies between the three samples. The respondents in Nysted are thus more negative towards off-shore wind farms, while the respondents in Horns Rev are more positive. The determinants of choice vary between the samples. Across the three samples older respondents are more negative towards off-shore wind farms. In the national sample respondents who are members of an outdoor organisation and respondents who can see off-shore wind farms from their house and visit the beach frequently are more negative. In the two local samples older respondents are more negative towards off-shore wind farms. Respondents living along the coast at Horns Rev or who are Commercial Fishers in the Horns rev sample are also more negative towards off-shore wind farms.

Discussion

The attitude towards wind power clearly is a function of the age of the respondents, as younger respondents have more positive attitudes than older respondents. If the difference is generation dependent, this denotes that, everything else equal, the attitude in the future will be more positive.

The results indicate that off-shore wind farms are preferred to land-based turbines by the respondents. However the frame of the attitudinal questions does not include differences in wind power production costs. Had the respondents been informed about the potential differences in cost, it is believed that the respondents would change attitude towards the low cost alternative.

The development of wind turbines is rapid, as the size and capacity of the turbines are getting larger. If the respondents have based their attitude on the average turbine in the landscape, this indicates that the attitude might be more negative than the observed. This is particular evident in the case of land-based turbines, where the average size of the turbines are much smaller than new turbines.

1. Introduction

In order to fulfil the Kyoto protocol (UNFCCC, 1997) Denmark is committed to make significant reductions of greenhouse gas emissions. Besides different strategies to reduce the national CO_2 emission, such as CO_2 quota trading and flexible mechanisms, an increase in the national wind power capacity is considered to be an important component of the Danish CO_2 reduction strategy (Danish Ministry of Finance, 2003).

Wind turbines on-land are located in most parts of the country (Danish Energy Authority, 2005a). The scope for expanding the number of turbines on-land is therefore considered limited as this might have too large consequences for the surrounding landscape (Danish Energy Authority, 1996). The future land-based development is therefore expected to be carried out by replacing existing wind turbines with fewer but larger turbines (Danish Ministry of Economics and Business Affairs, 2004). The main potential increase in wind power production capacity is assumed to take place *off-shore* in the coastal zones.

Wind energy is a clean technology with regards to the emission of CO_2, SO_x, NO_x etc. However, the production of wind energy is not without negative impacts on the environment (European Wind Energy Association, 2005, Schleisner & Nielsen, 1997). More specifically, individual wind turbines or turbines located in a wind farm can have; visual impacts on the landscape (Alvarez-Farizo & Hanley, 2002, Manwell *et. al* , 2002, Schwahn, 2002), impacts with regards to noise disturbance (Manwell *et al.*, 2002, Schleisner *et al.*, 1997), impacts on birdlife (BirdLife, 2002, Manwell *et al.*, 2002) and other types of impacts on the ecological environment (Danish Energy Authority, 2003).

The attitude in the Danish population for future wind power development, as proposed by the government, can be both positive and negative. The public's acceptance of the proposed wind power policy is therefore expected to a certain extent to depend on the knowledge and view of the associated impacts.

Given the relatively large changes in the landscape, that the future wind power development will cause, it is highly relevant from a policy point of view to elicit the attitudes towards wind power development in Denmark.

Based on three samples the Danish populations' attitude towards existing and future land-based and off-shore wind power is analysed in the present paper.

2. Wind Power and Energy Policy in Denmark

In Denmark wind power to produce electricity has been utilised since 1891, where physicist Poul La Cour established his first power generating wind turbines at Ashøj Højskole (Danish Wind Turbine Owners' Association, 2003). It was from the beginning difficult for wind power to compete with power generated by fossil fuels. Nevertheless the number of wind turbines grew to the end of the First World War, where 250 wind turbines produced 3% of the Danish electricity consumption (Danish Wind Turbine Owners' Association, 2005). After the First World War the technology moved on, with several significant breakthroughs during the Second World War and in 1956-1957 (Danish Wind Turbine Owners' Association, 2005, Tranaes, 1997). However, due to low oil prices during the 1960's and up to the first energy crisis in 1973, wind power had difficulties competing as a commercial alternative to fossil power generation.

A breakthrough came in 1985 when the Minister of Energy made an agreement with the power companies to establish 100 MW wind capacity before the year 1991 (Danish Ministry of Energy, 1985). In 1990 the report "Energy 2000" set up a target to reduce Danish CO_2 emissions by 20% between 1988 and 2005. The most important instruments to meet the target were renewable energy, increased utilisation of natural gas and energy savings. In this relation 10% of Danish electricity consumption was planned to be covered by wind energy in 2005, and the consumption of renewable energy should be doubled before 2006 (Danish Energy Authority, 1990).

During the 1990s the focus on wind power development strengthened even further. In 1993 the expansion of the number wind turbines together with other renewable sources of energy was pushed forward by various subsidy schemes. In the energy plan (Energy 21) from 1996 for sustainable development the role of wind power to increase renewable energy was emphasised and put into a more formal structure of planning. The plan entailed specific targets for renewable energy to 12-14% of the energy consumption in 2005 and that the share of renewable energy in overall Danish energy consumption gradually should be increased by 1% a year up to 35% in 2030 (Danish Energy Authority, 1996). More specifically, it was the plan to increase the wind power capacity with 5500 MW, whereof 4000 MW should be located off-shore. In Energy 21, it was also recognised that the negative impacts of the turbines on the

surrounding environment limited the resources on-land for future development. The development on-land should therefore be limited to replacing small and older turbines with new, fewer and larger ones on-land.

Energy 21 was followed up by a plan for the future off-shore development in 1997, where a series of conclusions and recommendations for future off-shore development were put forward (Ministry of Environment and Energy, 1997). Only a half year later, the government assigned the energy companies to construct 750 MW of off-shore wind farms before the year 2008 (Danish Energy Authority, 2005c). In 2001 the construction of the world's first large scale off-shore wind farm at Horns Rev Off-shore was initiated. In 2002 Denmark ratified the Kyoto protocol. In the same year the EU ratified the Kyoto protocol and the construction of the second large scale off-shore wind farm at Nysted was started.

In 2002, the current government cancelled the assignment for the construction of three remaining off-shore wind farms, which was planned by the previous government. It was then argued, that the wind power development in the future should be seen from a more market based point of view, which preferably would increase the efficiency of meeting the CO_2 reduction requirements (Danish Ministry of Economics and Business Affairs, 2002).

Though the wind power development plan from 1997 is discharged, wind power development still has high priority. Presently the wind policy is characterised by the agreement between the Danish government and nearly all of the parties in the parliament on the establishment of 2x200 MW off-shore wind farms, which is now in tender. In the same agreement a continuous replacement of old land-based wind turbines with fewer but larger turbines is pushed forward with a subsidy scheme (Danish Ministry of Economics and Business Affairs, 2004).

To date the total wind power capacity in Denmark is approximately 3100 MW, where-off 423 are located off-shore. The wind power capacity covered 19% of the Danish electricity consumption in 2004.(Danish Energy Authority, 2005b)

3. Externalities of Wind Generated Power

As presented in the previous section, wind generated power is considered to be an important tool to reduce the CO_2 emissions in Denmark and to increase the production of sustainable energy. Besides the reduction in CO_2 emissions, wind generated power is also considered to be a clean technology with regards to emission of gases normally emitted from fossil generated power, such as NO_x and SO_x. However, even though there are no emissions during operations, wind power generation is associated with number negative impacts. Besides generated externalities during the construction of the turbines, the operation of the wind turbines has potential impacts on the environment, such as visual disamenities, noise or impacts on the environment. Depending on the location of either land-based or off-shore wind farms, both the volume of impacts and their level will vary.

In the present section the main potential impacts of wind power generation are presented and discussed in relation to how they potentially can influence people's attitude towards wind power generation in Denmark.

3.1. Noise Impacts

Noise or sound disturbance mainly origin from the friction between the wing blades and the wind. It is a potential negative impact from the operation of wind turbines. It is in general difficult to asses the level of noise impacts of wind farms, since the expected level of noise impacts is a function of various parameters such as the distance to people living in the area, location of buildings blocking the noise, wind direction, level of background noise, landscape elevation etc. (Pedersen, 2003, Schleisner *et al.*, 1997). Even though the exact level of sound from a given wind farm could be measured, the perceived impact of a given noise level is individual. Some people might perceive relatively low levels of sound from the turbines as unacceptable noise, while other persons might perceive the same level of sound as acceptable. The attitude toward wind power of the two persons would, every things else equal, be different even though they experience the same level of disturbance. The individual and subjective judgement of the experienced level of noise from a wind farm is expected to depend on the characteristics of the individual, such as the attitude towards wind power production in general but also the socio-economic characteristics of the individual, such as age, gender, etc. (Manwell *et al.*, 2002, Pedersen, 2003).

Off-shore wind farms are opposed to land-based turbines, located so that the noise from the turbines does not reach land. Noise impacts are therefore mostly related to land-based wind mills. In the environmental impact assessment studies done in relation to the planning of the two commercial off-shore wind farms at Horns Rev and Nysted, the noise effect above water was assessed to be negligible (Elsam & Electra Amba, 2000, SEAS, 2000).

3.2. Visual Impacts

Visual impacts are deemed to potentially have large effects on the surrounding landscape. Just as in the case of noise, the impact would vary from location to location, depending on the surrounding landscape (open fields, coastal area, forests etc.), distance to buildings, the point of view (from the top of a hill, flat land etc.) and most of all the attitude of the viewer towards intrusions in the landscape. Consequently the visual impact can be divided into three categories (Manwell *et al.*, 2002, Schwahn, 2002).

- The *visual burden*, is the size, shape, colour, number and other important physical characteristics of the turbines.
- The *objective impact* is the visual image of the wind turbine/farm within the line of sight of the turbine. The objective impact is a function of the landscape, number and type of buildings and other structures in the view and most of all the number of observers.
- The *perceived impact* is the individual subjective perception of the objective impact, and therefore depends on the individual attitude towards the change in the landscape, wind power in general as well as the characteristics of the individual.

As mentioned, the perceived impact is assumed to depend on the individual characteristics of the viewer. It would therefore be difficult a priori to verify which of two objective impacts from a land-based and off-shore farm, that might have the highest perceived impact on possible viewers. One person might prefer that the view of the coast is kept completely free from wind farms while another might prefer to have the undisturbed view of the rural landscape.

Off-shore, the visual impacts can to a certain extent be reduced by locating off-shore wind farms at a large distance from the shore, while the potential on-land is considered to be limited.

3.3. Impacts on Biodiversity

Potential impacts on biodiversity cover a broad range of impacts on different levels (BirdLife, 2002, Elsam & Electra Amba, 2000, SEAS, 2000). The different impacts can in broad terms be categorised as impacts on:

- Birds (collision risk, alteration of migration habits, reduction of available habitat and disturbance of breeding, nesting and foraging).
- The marine eco-system (fish stocks, mammal levels, change in species distributions or even change in the ecological environment).

Starting with the latter, the impact on the marine environment is only relevant in the case of off-shore development. In this relation it must be emphasised that the effects are *potential* impacts and they are in some cases even positive. The foundation of an off-shore turbine for example can function as an artificial reef, increasing the biodiversity in the surrounding area (BioConsult, 2005). However the increase in biodiversity can also change the biodiversity, which was initially in the area. Whether an impact on the biodiversity with regards to fish stocks and species distribution is perceived as a benefit or an externality is most probably quite individual.

The impact on birds is relevant both in the land-based and off-shore case, especially with regards to the risk of collisions. Again, some people might perceive bird collisions as a significant problem while others do not.

4. Previous Studies on the Attitudes towards Wind Power

To date several studies on people's attitude towards wind power have been carried out in Denmark and other EU countries. The focus in the studies is quite diverse as the studies examine the respondents' attitudes towards various aspects of wind power generation and development. It is therefore difficult to compare the results from the studies directly. The respondents' perception and attitudes towards wind energy are generally positive across the different studies (European Wind Energy Association, 2005).

Most of the studies conducted in Denmark dates back to the 1990's, see Danish Wind Turbine Owners' Association (2005). In a survey done by the analysis institute AIM in 1993 82% of the respondents (1.016) stated that they supported an increase in wind power and that 77% would be willing to pay a price premium of 10% for wind power.

With regard to the visual impact on the landscape 61% agreed that wind turbines are relatively neutral. In the study, the grouping of wind turbines was also addressed. 21% preferred single located turbines, 35% 2-8 turbines per location and 29% 10-50 turbines per location (Danish Wind Turbine Owners' Association, 2005). The same trend (or lack of trend) in preferences for the grouping of wind turbines was also observed in a study for reducing the visual externalities of off-shore wind farms (Ladenburg *et. al* , 2005). In the study, the respondents choose between alternative wind farm development schemes, which varied with regards to the number of turbines per farm, distance from the coast and the cost per household. The number of turbines turned out to be insignificant in two of the three samples, indicating high levels of heterogeneity in preferences.

The differences in preference with regards to the grouping of wind turbines are also supported in a local survey carried out in the Danish municipality Spøttrup in 1993. In the municipality 41 wind turbines were already operating and 10 new wind turbines had been approved. Of the respondents 46% would support an increasing in individual (not grouped) turbines, 32% would support more wind turbines in smaller groups (2-6) and 20% did not want more wind turbines in the municipality (Danish Wind Turbine Owners' Association, 2005).

In a more recent study carried out by the analysis institute Sonar in 2001 the same positive attitude was observed. In the study 68% of the respondents supported an increase in the number of wind turbines nationally, 18% believed that the present number was acceptable and 7% thought that there were too many wind turbines in Denmark (Danish Wind Turbine Owners' Association, 2005).

In general the previous studies in Denmark find positive attitudes towards wind power generation (Danish Wind Turbine Owners' Association, 2005). However, the scope of the studies is quite narrow. The studies thus generally focus on attitude towards land-based wind farms and on whether people are willing to pay a higher amount for wind energy. The studies however do not address the issue of land-based vs. off-shore wind power generation. The studies therefore only provide limited information in relation to the present policy situations as described in section 2, where the focus is on off-shore wind power.

Furthermore, the attitudes towards wind power and perhaps more importantly the source of the attitudes have never been analysed thoroughly and systematically. The

missing information on the attitudes has previously given the politician and energy planners little grounds to define wind energy policies on. There is therefore a strong need for more scientifically information concerning the attitude towards wind power development.

5. Study and Methodology

In section 3 the negative impacts of wind generated power were presented. As emphasised, individuals might respond differently to the same objective impacts of wind power. So depending on the individual evaluation of the impacts associated with wind power generation, the attitude towards land-based and off-shore wind power development can be different between individuals.

In this section the study of Danish individuals' attitudes towards wind power development is presented. This section is followed is followed by a presentation of the results of the study with regards to the attitudes towards land based and off-shore wind power in the subsequent section

5.1. Study

The study on Danish individuals' attitudes towards wind power was conducted in the period 2003-2004. The study is part of *The Danish Monitory Programme of Offshore Wind Farms*, which is a programme consisting of several studies on the environmental impact of off-shore wind farms. The programme is coordinated by the *Environmental Group*, and is a cooperation between Elsam Engineering, Energy E2, Danish Forest and Nature Agency, and the Danish Energy Authority and is evaluated by International Advisory Panel of Experts on Marine Ecology (IAPEME), see Dubgaard (2004) or Ladenburg *et al.* (2005).

In the study 700 and 2x350 randomly selected persons were drawn from the Danish Civil Registration System. The sample of 700 respondents represents the Danish population, and will be referred to as the national sample (NA-sample). The two samples of 350 respondents each represent the population living in relative vicinity of the two existing commercial off-shore wind farms at Horns Rev (HR-sample) and Nysted (NY-sample). Nysted off-shore wind farm is located relatively close (9-10 km) to the shore compared to the off-shore wind farm at Horns Rev (14-20 km). The experiences with off-shore wind farms are therefore different between the two local samples. In a

policy context, it is therefore interesting to see, if the attitude towards both existing and more off-shore wind farms differs between the respondents in the two samples.

The data on the attitudes was collected by mailing out a questionnaire, which the respondents completed and returned by post.

5.2. Methodology

The investigation of attitudes is divided into four separate analyses of attitudes towards wind power.

1. Existing land-based turbines, national sample only
2. Future land-based turbines, national sample only
3. Existing off-shore wind farms
4. Future off-shore wind farms

Within each category, the attitudes are analysed using two approaches:

1. A graphical presentation of the attitudes towards wind power.
2. Limited dependent variable (Probit) regression on the attitudes as a function of the characteristics of the respondents.

5.3. Graphical Presentation of the Attitude towards Wind Power Development

In the questionnaire the respondents stated their attitudes with regards to both existing number of land-based and off-shore wind farms and an increase in the number of turbines. The respondents stated their attitude on a 5+1 point scale, see below.

- *Very positive*
- *Mainly positive*
- *Neutral*
- *Mainly negative*
- *Very negative*
- *Do not know*

The analysis of the attitudes towards land-based turbines is based on the national sample. The analysis of attitudes towards off-shore wind turbines includes all three samples. It thereby becomes possible to verify if people from areas with off-shore wind farms (NY & HR-sample) have different attitudes compared to people who do not have had the same experiences (NA-sample).

5.4. Limited Dependent Variable Regression on the Attitudes towards Wind Power Development

The perceived attitude towards the impact of wind farms and wind power is assumed to be individual and as such a function of the characteristics of the individual, for example age, income or education. To identify possible systematic relations between attitude and the socioeconomic characteristics of the respondents, the individual attitude is regressed on the characteristics of the respondents. The attitude of the respondents is stated in discrete measures (1 to 6). An ordinary OLS regression model (Linear Probability Model) would consequently not be an appropriate model to use, since the variance would be discrete and heteroskedastic (Maddala, 1983). Consequently a limited dependent variable model is used.

In the present paper a binary probit model is applied[1], which as indicated by the name, requires that the dependent variable can take two values. The stated attitudes accordingly have to be defined as a binary variable. The 5 +1 point scale is therefore converted into binary scale (y = 1 or y = 0) reflecting whether the respondent has a positive/neutral attitude or a negative attitude towards land-based and off-shore wind power, see below.

- Very positive (y = 1)
- Mainly positive (y = 1)
- Neutral (y = 1)
- Mainly negative (y =0)
- Very negative (y = 0)
- Do not know (not included)

Where $y = 1$ denotes a positive outcome and $y = 0$ denotes a negative/zero outcome. It is recognised that the conversion of attitude into a binary variable reduces the level of information that can be extracted of the data. However, the aim of the analysis of systematic determinants of attitude is identify determinants of a negative attitude and not of the attitude in general. The conversion of the data therefore seems valid.

In the models the y is replaced with a continuous latent variable y^*. The latent variable y^* is assumed to be a function of a number of independent variables reflecting the atti-

[1] Alternatively a binary logit, ordered logit/probit or a multinomial models could have been applied, see Maddala (1983).

tude of the respondents. The independent variables can be divided into different categories such as:

- Socio-economic variables (gender, age, income, education etc).
- Geographical variables (zip code, region, size of the city, living close to a wind turbine etc.)
- Energy and wind power related variables (attitude to global warming, externalities of wind turbines, attitude to nuclear power etc.)

Representing these variables with the common vector x_i, y_i^* can be defined by

$$y_i^* = x_i\beta + \varepsilon_i, \mathrm{N}\left(0, \sigma^2\right)$$

Where y_i^* denotes the individual latent variables, x_i is the characteristics of individual i and ε_i is the individual specific error term, which is assumed to be normal distributed with a zero mean and a variance of σ^2.

The latent value y_i^* is mapped as y_i under the assuming that:

$$y_i = 1 \text{ if } y_i^* \geq 0$$
$$y_i = 0 \text{ if } y_i^* < 0$$

An interpretation of the mapping of y_i^* is given in the following. If the perceived utility (individual i) of for example existing land-based wind turbines, given the associated benefits and externalities, is 0 or larger, then the individual has a positive or neutral attitude towards existing wind turbines and vice versa[2].

Given the model specification of the latent variable:

$$E[y] = \Pr(y_i = 1) = \Pr(y_i^* \geq 0) = \Pr(x_i\beta + \varepsilon_i \geq 0) = \Pr(\varepsilon_i \geq -x_i\beta)$$

Normalising the final term with σ_ε and subtracting the mean (= 0) , the probability changes to

[2] In (Kuehn, 2005a, Kuehn, 2005b) two qualitative surveys,14-20 respondents living in the area in vicinity to Nysted and Horns Rev off-shore wind farms were interviewed. With reference to the interviews the respondents *actually* took into consideration both the positive and negatives sides of the off-shore wind farms when deciding whether they were against or in favour of the existing wind farms.

$$\Pr(\varepsilon_i \geq -x_i\beta) = \Pr(\frac{\varepsilon_i}{\sigma_\varepsilon} \geq \frac{-x_i\beta}{\sigma_\varepsilon}) = \Pr(\frac{\varepsilon_i}{\sigma_\varepsilon} \leq \frac{x_i\beta}{\sigma_\varepsilon}) = \Phi(x_i\beta)$$

Which is standard normal distributed. Applying maximum likelihood estimation, the loglikelihood becomes

$$LL(\beta) = \sum_{i=1}^{n}\left[y_i \cdot \ln\Phi(x_i\beta) + (1-y_i)\cdot(1-\ln\Phi(x_i\beta))\right]$$

Given the specification of a positive ($y_i = 1$) and a negative ($y_i = 0$) answer and the normal distributed error term, the limited dependent variable model is a probit model. The probit model estimates the impact of independent variables (x_i) of the respondents on the probability of having a positive-neutral attitude or a negative attitude towards existing land-based wind turbines.

The marginal effect $\left(\partial \Pr/\partial x_i\right)$ of the independent variables cannot directly be elicited from the estimated coefficients of the variables. The reason is that the latent variable function is not a linear function. Consequently the marginal effect of an independent variable is dependent on the value of the latent variable function. More specifically the marginal effect on the response probability is equal to:

$$\Delta\hat{P}\left(y = 1|x\right) \approx \left[\Phi\left(x_i\hat{\beta}\right)\hat{\beta}_i\right]\Delta x_i$$

Where x_i is a continuous or roughly continuous variable. The change in the probability of the response is individual and depends on $x_i\hat{\beta}$. The marginal effect is the product between the normal density function evaluated at the appropriate levels of all the independent variables $\Phi\left(x\hat{\beta}\right)$ times the change in the x_i variable ($\hat{\beta} \cdot \Delta x_i$). If x_i is a discrete variable the marginal effect is equal to the difference in the probability as the x_i goes from 0 to 1 (in the case of a dummy variable), see below:

$$\Delta\hat{P}\left(y = 1|x\right) \approx \Phi\left(x\hat{\beta} + x_i(1)\right) - \Phi\left(x\hat{\beta} + x_i(0)\right)$$

If x_i has a positive influence on the probability ($\beta_{x_i} > 0$) then $\Delta\hat{P}\left(y = 1|x\right) > 0$ and vice versa.

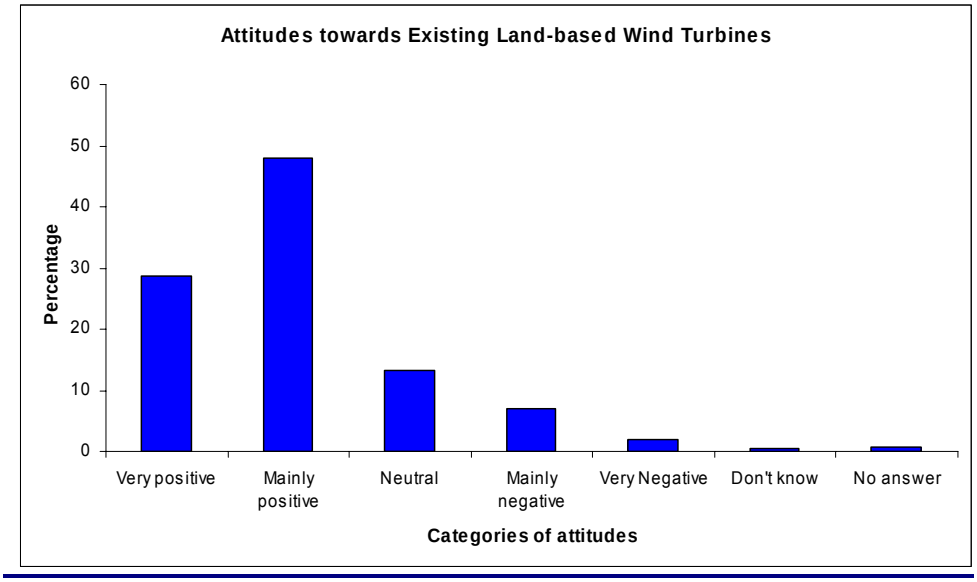
6. Attitudes towards Land-based Wind Turbines

In this section the attitudes toward existing and future land-based are analysed. The analysis is based on the stated attitude on a 5+1 scale (*very positive, mainly positive, neutral, mainly negative, very negative and do not know*).

6.1. Attitudes towards Existing Land-based Wind Turbines

In the present section the attitudes towards existing land-based wind power are explored based on the NA-sample. The effective sample consists of 362 respondents (>50% response rate). Referring to Ladenburg *et al.*(2005) the sample is over represented with regards to people with a higher education and household income level between 300-799.999 DKK. But as the probit regression will show, that does not seem to have an influence on the obtained attitudes with regards to the representativeness of the sample. In Figure 1, below, the attitudes are presented.

Figure 1. Attitudes towards Existing Land-based Wind Turbines



In Figure 1 there is a high acceptance of the existing land-based wind turbines. Less than 10% of the respondents have a negative attitude toward existing wind farms. Based on attitudes in Figure 1, the previous energy policy and wind power development, as presented in section 2, therefore seems to be supported by a large percentage of the population. However, Figure 1 does not give any information on the distribution of attitudes in relation to the characteristics of the respondents, such as age, gender or local/regional differences or for example whether the respondents live close to a wind farm. It would therefore not be correct to conclude that the population in general is in favour of the present wind power turbines, without taking into account potential systematic differences in attitude. For example, it could be that the respondent

with a negative attitude given the systematic differences are underrepresented in the sample and that the true attitude conditional on the model is more negative. Another example could be that all the negative answers were from respondents living very close to turbines or in an area, where the number of turbines is high. Consequently the wind power policy would only be accepted by the people living in the areas with no turbines and not accepted by people living where the turbines are located. This would denote that the wind power policy has a skewed distributional effect on people.

Before going to the probit model in the next section, it is worth noting that all the respondents with a negative attitude, also think that land-based wind turbines have a negative impact on the landscape. On the other hand not all respondents, who think that the wind turbines have a negative impact on the landscape, have a negative attitude towards the existing land-based turbines. This suggests that a large percentage of the respondents, who think that the existing wind turbines on-land have a negative impact on the landscape, nevertheless consider the overall impact of the existing turbines to be either positive or neutral.

6.2. Probit Model on the Attitudes towards Existing Land-based Wind Turbines

Given the specification of a positive ($y = 1$) and a negative ($y = 0$) answer, the probit model estimates the impact of independent variables (age, gender, income etc) of the respondents on the probability that the respondents have a positive-neutral attitude or a negative attitude towards existing land-based wind turbines. The model is presented below.

Table 1. Probit model for a positive or neutral attitude towards existing land-based wind turbines, NA-sample

Variables	β	σ	z	P<z
Age60+	-1.3397	0.3165	-4.23	<0.001
Age50-59	-0.6611	0.2777	-2.38	0.017
Gender_Age50-59	0.6387	0.4095	1.56	0.119
Jutland_Age60+	0.7543	0.2956	2.55	0.011
Age-Missing	-1.1080	0.3973	-2.79	0.005
Larger_Cities_Zealand	0.9825	0.4284	2.29	0.022
Constant	1.5555	0.1628	9.56	<0.001

No. Obs = 362, $\rho^2 = 0.1541$, Prob < χ^2 < 0.001

In Table 1 the probit model is presented. The first five independent variables in the model relate to the age of the respondents. The first two variables (Age60+ and Age50-59) represent the respondents older than 59 and between 50 and 59 respectively. Both variables are significant and have a negative sign, which indicates that respondents older than 49 years have a higher probability of a negative attitude compared to the younger respondents. The $\beta_{Age60+} < \beta Age_{50-59}$, why respondents older than 59 have a higher probability of a negative attitude, than respondents between 50 and 60. The difference in attitude is though not significant.

The age effect in the model is not uniquely defined across the sample. The third and fourth variable thus represent two subgroups of the respondents older than 49. The first subgroup variable (Gender_age50-59) represents female respondents between 50 and 59, but is only significant at 0.119 level. $\beta_{Gender\_Age5059} > 0$, which means that female respondents have a lower propensity for a negative attitude than males within the same age category. The overall effect of being a female respondent and between 50 and 59 years of age (-0,6611+0,6387=-0,0224) is still negative, but is not significantly different from zero. Female respondents (50-59 years) do therefore not have a significantly higher probability of a negative attitude than the respondents younger than 50 years. The other sub-group variable represents respondents older than 60 years and who live in Jutland. The variable is significant and is also positive, referring to a higher probability of a positive/neutral attitude than respondents older than 60 year and not living in Jutland. Again the overall effect is negative compared to respondents younger than 50 and is significantly different from zero.

The final age variable (Age_missing) controls for the respondents in the sample, who did not report their age in the questionnaire. The variable is quite significant and has a negative sign. Accordingly the respondents do have a higher propensity to have a negative attitude towards existing land-based turbines.

The last variable in the model (Larger_Cities_Zealand) represents respondents living in greater Copenhagen or in the larger cities on Zealand and the southern islands[3]. The variable is positive, why all other things equal these respondents have a higher probability to have a positive attitude than respondents not living in these cities. From a behavioural or economic point of view, this makes intuitively good sense, as the people living in the town centres most probably are less subjected to the externalities

[3] Lolland, Falster and Møn.

of land-based wind turbines. The constant term is positive and strongly significant, indicating the general propensity to a positive attitude in the sample.

It should be mentioned, that a broad range of characteristics and interactions between characteristics were initially included in the model derivation. Some variables which were expected to have a significant influence on the attitude of the respondents however turned out to be insignificant, when the age of the respondents was accounted for[4]. In this relation, it should also be noticed that variables such as; to what degree wind power should be used to reduce the CO_2 reductions, if there are too many wind turbines in the area and whether wind turbines have a negative impact on the landscape etc. potentially have a huge explanatory power if included in the model. The variables are though left out of the models in this paper, since they are endogenous. As previously mentioned, the explanatory power of the endogenous variables is nicely illustrated by the fact, that all the respondents who have a negative attitude, also think that wind turbines have a negative impact on the environment.

The presented model has a fit (pseudo rho) of $\rho^2 = 0.1541$, which is perceived to be good. Assuming that the independent variables in the models are uncorrelated with the unobserved differences in attitude among the respondents, the model gives a good description of the systematic difference in attitude across the respondents.

The overall probability for a positive attitude in Denmark, given the model, naturally depends on the true distribution of the independent variables. It has not been possible to obtain statistical data information within the age interval 20-65 years for all the variables in the model. A discussion of the predicted possibilities on national level of a positive attitude can therefore only be based on the independent variables of which statistics have been obtainable. In the present model, it has only been possible to obtain statistics with regards to the age variables.

Table 2. Sample and national frequencies of independent variables

	Sample frequencies	National frequencies*
Age60+	0.136	0.105
Age50-59	0.255	0.227
Gender_Age50-59	0.133	0.113
Jutland_Age60+	0.070	0.062

*(Statistics Denmark, 2005)

[4] A variable, controlling for if land-based turbines were visible form the home or summer house of the respondent, was initially significant ($\beta<0$), but became insignificant as soon the age variables was included.

As it can be seen in Table 2, the differences in the frequencies of the independent variables are not that large between the sample and the national levels. There seems to be an overrepresentation of people from the older part of the sample across the four variables. Without putting to much emphasis on the exact figures, it thus appears that the observed frequency of negative respondents in the sample is slightly overrepresented in the sample compared to the expected national level. However, due to the relatively small differences in the obtainable statistics, under the assumptions of a random sample, it seems reasonable to conclude that the generally very positive attitude towards the existing land-based turbines in the sample seems valid and that the population actually might be a little more positive than the respondents in the present survey.

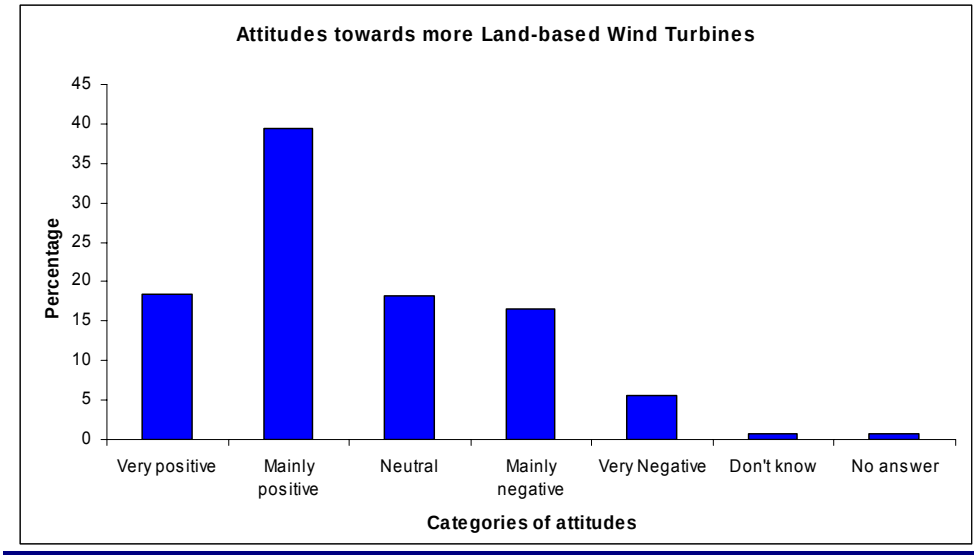
Comparing the marginal impact on the probability of a positive attitude of the β across the variables in the model is not straight forward. The marginal effect of a variable depends on the level of the other independent variables. The marginal effect of being older than 59 years (Age60+) is thus dependent on whether the respondent is from Jutland, living in a larger city on Zealand or none of the two.

In general the marginal effects on the probability of having a positive/neutral attitude are quite small. None of the variables can thus single handed explain a change in attitude from positive/neutral to negative. The variable with the larges marginal effect is Age60+. If the respondent is older than 59 years but does not live in Jutland or larger cities on Zealand, the marginal probability is -35.47% less than a person younger than 60 years. But given that the base probability (evaluated at the size of the coefficient of the constant) for a positive attitude is 94%, respondents, older than 59 have a possibility of a positive attitude larger than 50% (94%-35.47%>50%). For more information see appendix A.

6.3. Attitudes towards Increasing the Number of Land-based Wind Turbines

In the previous section the attitudes towards existing land-based wind turbines in the NA-sample were very positive. In the present section the attitudes towards increasing the number of land-based turbines are presented. In Figure 2, below, the attitudes expressed on the 5+1 scale (*very positive, mainly positive, neutral, mainly negative, very negative and do not know*) are presented.

Figure 2. Attitudes towards more Land-based Wind Turbines



Comparing the distribution of attitude in Figure 2 with the distribution in Figure 1, it is clear, that the respondents are, in general, more negative towards increasing the number of land-based wind turbines. Thus, a little less than 25% (opposed to 10%) of the respondents have negative attitudes towards more land-based wind turbines.

6.4. Probit Model on the Attitude towards More Land-based Wind Turbines

To identify possible determinant factors of the attitude, a probit model is elicited as in the previous section. The probit model is presented in Table 3.

Table 3. Probit model for a positive or neutral attitude towards increasing the number of land-based wind turbines

Variables	β	σ	z	P<z
Age50+	-0.6521	0.1967	-3.31	<0.001
Gender_Age50+	0.4431	0.2424	1.83	0.068
Age_missing	-0.7155	0.3729	-1.92	0.055
Larger_Cities_Zealand	0.5759	0.1920	3.00	0.003
Cities>60.000_Jutland	0.7999	0.3796	2.11	0.035
Constant	0.8827	0.1242	7.11	<0.001

No. Obs = 353, ρ^2 = 0.0834, Prob < χ^2 = 0.0154

The variables/characteristics of the respondents in Table 3 are relatively identical to variables in the model regarding attitudes towards existing wind turbines. The age of the respondents have a significant influence on the probabilities in the attitude model. The effect of age is represented by a single age main effect variable (Age50+) controlling for respondents that are 50 years or older. Comparing with the previous models, this means that respondents older than 59 years no longer have a higher probability for a negative attitude than respondents between 50 and 59. The β_{Age50+} is <0, why respondents older than 49 years have a higher probability of having a negative attitude than respondents younger than 50 years. Just as in the model for existing land-based wind turbines the attitude and age relation depends on the gender of the respondent. Female respondents above 49 years have a higher probability for a positive attitude than males in the same age category ($\beta_{Gender\_Age50+>0}$).The joint probability for having a positive attitude for a female respondent older than 49 years is consequently ($\beta_{Age50}+\beta_{Gender\_Age50+}$) = -0.1748. The joint effect is not significantly different from 0. Accordingly, female respondents older than 49 do not have a significantly higher probability for a negative attitude compared to respondents younger than 50 years.

The Age_missing variable is significant (just above 0.05) and negative, which could indicate that the respondents might be older of age. Respondents living in greater Copenhagen and larger cities on Zealand and the southern island are also more positive than the rest of the sample. A similar positive attitude towards more land-based wind turbines is also present among people living in the centre (zip code) in the larger cities in Jutland (Cities>60,000_Jutland[5]) with more than 60.000 inhabitants. Referring to the previous models, the difference in probability makes good sense from a behavioural/economic point of view, as these respondents are less subjective to the externalities than respondents living in smaller cities or in rural areas. It must be mentioned, that the attitude in many of the larger cities in Jutland with less than 60.000 inhabitants also is more positive, but the effect is not significant. Had the sample been larger and there subsequently would be more information from the smaller cities, a significant effect might have been detectable.

The constant in the model is positive and very significant, implying a systematic tendency to have a positive or neutral attitude towards more land-based wind turbines. The level of significance of the constant is though dependent on the specification of the model. If a quadratic term for the age variable is used the constant term becomes insignificant. A model with the age quadratic term has though a much lower fit.

[5] Aarhus, Aalborg, Esbjerg, Kolding and Randers.

The fit of the model is only 0.0834, which is not especially high compared to the previous model. As it will be apparent in the following models for off-shore wind farms, there is a decrease in the fit in the model when the attitude of future wind power development is modelled. The issue will be discussed more thoroughly in the end of the paper.

Just as in the analysis of the attitude towards existing wind turbines, it has not been possible to obtain national statistics with regards to all the independent variables in the model. The obtainable statistics are presented in Table 4.

Table 4. Sample and national frequencies of independent variables

	Sample frequencies	National frequencies*
Age50+	0.380	0.345
Gender_Age50+	0.193	0.173

*(Statistics Denmark, 2005)

In Tabel 4 the respondents older than 49 years (both males and females) are overrepresented in the sample compared to the national distribution. The differences are though quite small but point in the direction that given the model, the overall attitude towards more land-based wind farms is a little more positive than in the present survey. But this conclusion can only be made with regards to the two age variables for which national statistic are available. Given the model and depending on whether the respondents living in larger cities on Zealand or in Jutland, the conclusion could possibly be different.

Just as in the model on the attitude towards existing land-based turbines are the estimated marginal effect on having a negative attitude small. The largest marginal probability for a negative attitude is found for the respondents older than 49 and who do not live in either large cities on Zealand or in cities with more than 60,000 inhabitants in Jutland. The change I probability is -22.01%. All things equal, this mean that respondents older than 49 years have a 22% larger probability of negative attitude compared to respondents younger than 50 years. The probability for a positive attitude associated with the constant term is 81.13%, the male respondents older than 49 years therefore still have a positive probability for a positive attitude, see Appendix B.

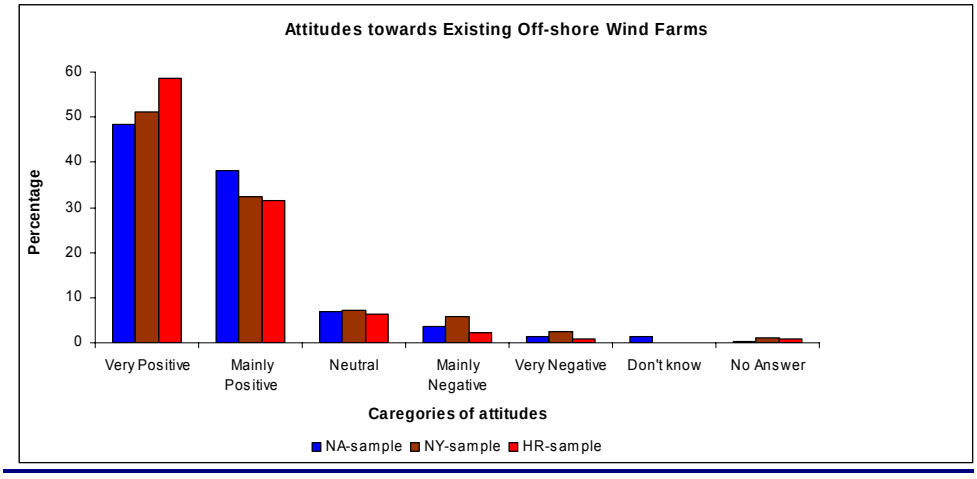
7. Attitude towards Off-shore Wind Farms

In the present chapter the respondents' attitudes towards existing off-shore wind farms and an increase in the numbers of off-shore wind farms are analysed across the three samples. The two local samples NY-sample and HR-sample are included to verify if the attitudes towards off-shore wind power depend on the experience with off-shore wind farms.

7.1. Attitudes towards Existing Off-shore Wind Farms

In Figure 3, below, the attitudes expressed on the 5+1 scale (*very positive, mainly positive, neutral, mainly negative, very negative and do not know*) are presented for the three samples. As mentioned in section 6.1, the number of respondents in the NA-sample is 362. In the NY- and HR-sample the number of respondents is 140 and 170 respectively.

Figure 3. Attitudes towards existing off-shore wind farms



As strongly indicated by the distribution of the answers Figure 3, the respondents in all three samples have a very positive perception of the existing off-shore wind farms. For the three samples more than 90% of the respondents find the wind farms either positive or neutral. The HR-sample contains respondents with the most positive attitude. Fewer than 5% of those respondents have a negative attitude. In the NY-sample

the number of respondents with a negative attitude is more than twice as high as the HR-sample. The differences in the attitude in Figure 3 most probably can be ascribed to the differences in location and visual externalities between the Horns Rev and Nysted off-shore wind farms. However with references to the probit models elicited in the previous sections, the difference in attitude could alternatively be explained by differences between samples in the characteristics of the respondents, such as age, which had a significant influence on the attitude in the previous models.

7.2. Probit Model on the Attitude towards Existing Off-shore Wind Farms, NA-sample

In this section the probit model for a positive attitude towards existing off-shore wind farms is presented. Compared to land-based turbines, the numbers of off-shore wind farms are much smaller and are located sparsely in the country[6]. It is therefore expected that the respondents in the NA-sample have relatively little experience with off-shore wind farms compared to land-based turbines. In Table 5 below the probit model for the NA-sample is presented.

Table 5 Probit model for a positive or neutral attitude towards existing off-shore wind farms (NA-sample)

Variables	β	σ	z	P<z
Age60	-0.7302	0.2956	-2.47	0.014
Age50-59	-0.4356	0.2760	-1.58	0.114
Age_missing	-0.9358	0.4748	-1.97	0.049
M.Out_Org	-0.6256	0.3196	-1.96	0.050
View_Beach_User	-0.7743	0.4639	-1.67	0.095
Constant	2.0442	0.1975	10.35	<0.001
No. Obs = 362, ρ^2 = 0.0891, Prob < χ^2 = 0.017				

In Table 5, above, the age of the respondents have a systematic influence on the probability of whether a respondent has a positive/neutral or negative attitude. Respondents older than 49 years thus have higher probability for a negative attitude, than respondents younger than 50 years.

[6] 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) (Danish Energy Authority, 2005b).

$\beta_{Age60} < \beta_{Age50\text{-}59}$, however they are not significantly different from each other. This means, that the respondents older than 59 years do not have significantly different attitudes towards existing off-shore wind farms than respondents of the age between 50 and 59. None of the two variables are though very significant, but they are jointly significant on a 0.05 level. The variable controlling for missing information of the age is also significant and negative.

Compared to the previous two probit models, there is no geographical/region specific variables in the model. It has consequently not been possible to identify significant systematic differences in the attitude across people living in large cities or not, as in the previous models. The change in probability for a positive or neutral attitude depends on other variables. Respondents who are members of an outdoor organisation (M.Out_Org) thus have a negative probability for a positive attitude. Referring to some of the potential impacts on especially bird life, a higher probability for a negative attitude makes intuitively good sense. Respondents who associate off-shore wind farms with a negative impacts on birdlife, would all things equal have a larger probability for a latent variable value lower than 0 ($y_i^* < 0$) and therefore a smaller probability for a positive or neutral attitude. The other significant variable (jointly significant on 0.05 level) is View_Beach_User. $\beta_{View\_Beach\_User} < 0$ and represents the respondents who visit the beach at least once a week and who can see off-shore wind farms from either their house or beach house. Respondents who can see off-shore wind farms from their house or summer house, but who do not visit the beach at least once per week, however do *not* have significant different attitude towards existing off-shore wind farms. Referring to the latent variable y^*, this means that only respondents with a relatively strong relationship, here defined by the view to off-shore wind farms and very frequent visits to the beach, associate the existing wind farms with a higher level of negative utility. Respondents with a less strong relationship (view to off-shore wind farms and less frequent visits or just different levels of frequency in visits) do not have significantly different probabilities for a positive or negative attitude everything else equal.

The constant term is positive and significant at level 0.0001 indicating that there is a strong systematic tendency in the sample to have a positive attitude towards the existing off-shore wind farms.

The fit of the model is 0.0891 and must be considered relatively small. However two statements must be put forward in this relation. First of all, the variance of the de-

pendent variable (y_i) is relatively small. Only 5.55% of the respondents has expressed a negative attitude towards existing off-shore wind farms. The sample size is 362, why the systematic difference in attitude is based on difference in the characteristics between 20 respondents (negative attitude) and 342 (positive attitude). Secondly, the experience with off-shore wind farms is most probably quite small among the respondents in the NA-sample, why systematic differences in attitude might be more blurred and consequently less significant in the models.

Again the older respondents are slightly overrepresented compared to the national level, see Tabel 2. This indicates that the observed attitude towards existing off-shore wind farms and given the elicited model might be slightly more negative than the general attitude in the population.

The marginal effects of the individual variables are very small, as the constant of the model is very large. As such, do neither of the variables account for a change in probability on more than 8 %, which support the overall positive attitude towards off-shore wind power. Even if the variables are combined, do the marginal change exceed 30%, see appendix C.

7.3. Probit Model on the Attitude towards Existing Off-shore Wind Farms, HR- and NY-sample

Presented in Figure 3, the respondents in the HR-sample are the most positive and NY the most negative towards existing off-shore wind farms between the three samples. In Table 6 below the elicited probit model for the joined data set of the HR – and NY-sample is presented.

Table 6. Probit model for a positive or neutral attitude towards existing off-shore wind farms (NY- and HR-sample)

Variables	β	σ	z	P<z
Age55+	-0.5731	0.2625	-2.18	0.029
Age45+_View_of.	-0.5867	0.3078	-1.91	0.057
C_Zip_Horns	-1.6507	0.6504	-2.54	0.011
Horn_Prof_Fisher	-1.9266	0.8631	-2.23	0.026
NY-sample	-0.9862	0.4145	-2.38	0.017
Constant	2.7735	0.4257	6.51	<0.001

No. Obs = 307. ρ^2 = 0.1849. Prob < χ^2 <0.001

In Table 6 the age of the respondents have a systematic effect on whether the respondent has a positive/neutral attitude or a negative one. The age attitude relation is represented by two variables; a variable controlling for whether the age of the respondent is 55 (Age55+) or older and a variable controlling for the respondents who are 45 or older and who can see off-shore wind farms from either their house/beach house (Age>44_View_offs.). Both variables are negative, which means that respondents older than 54 years have a higher probability of having a negative attitude than respondents younger than 55. However given the second variable, respondents older than 44 and who can see off-shore turbines from their home or summer house also have a higher probability of a negative attitude compared to the rest of the sample, everything else equal. Respondents who are 55 or older and have a view of the off-shore wind farms consequently have an even higher probability of a negative attitude ($\beta_{Age>54} + \beta_{Age>44\_View\_offs}$).

The other variables are related to the samples, from which the data origin (HR- and NY-sample). The variable Coast_Zip_Horns represents the respondents from the HR-sample, who live close to the shore orientated towards Horns Rev off-shore wind farm[7]. Though the variable only represents 2.6% of the joined sample, it is still significant on a 0.05 level. The coefficient is negative and relatively large, and denotes that the respondents living in those areas have a larger probability for a negative attitude than the rest of the sample. The other geographical variable is Horn_Prof_Fisher representing commercial fishers in the HR-sample. The coefficient is negative and large, which was expected due to the large oppression by the fishermen during the planning and construction phase of Horns Rev off-shore wind farm (Kuehn, 2005b). The commercial fishermen in the sample thus have a relatively high systematic probability of a negative attitude towards existing off-shore wind farms. But as with the C_Zip_Horns variable, only a small percentage of the sample is represented by the Horn_Prof_Fisher variable (1%). The final geographical variable is the Nysted variable controlling for the respondents in the NY-sample as opposed to the HR-sample[8]. The coefficient is negative why the respondents in the NY-sample have a more negative attitude compared to the HR-sample, all other things being equal. As mentioned previously, a valid explanation could be, that the wind farm at Nysted is closer to the coast than at Horns Rev. But, as presented in Kuehn (2005b), there has in general also

[7] In the HR-sample, the Horns Rev wind farm can only be seen from the west orientated shores on Fanø and Skallingen. People living in the coastal areas in Ho Bay, cannot see the wind farm.

[8] It was tested if the effect of Nysted could be expressed as an interaction with other explanatory variables, such as the two age variables in the presented model. However none of the constructed models was significant when the Nysted variable was taken into account.

been much more resistance towards the off-shore wind farm in Nysted compared to Horns Rev. This could also explain the overall more negative attitude in the NY-sample. In this relation, it must emphasised that the Horns Rev off-shore wind farm at the time the survey had been running for a longer period than the wind farm at Nysted. A possible explanation of some of the difference in attitude between the two samples could therefore be explained by the fact that the respondents in Horns Rev have had more time to get accustomed to the wind farm as time has passed! In two qualitative surveys (Kuehn, 2005b), 14-20 respondents were interviewed about their attitude towards the two wind farms. The interviews were carried out in two periods, before and after the construction of the wind farms. Kuehn argues that the difference in change in attitude most probably is credited to different expectations of the impact of the wind farm. In Horns Rev much of the negative attitude was associated the expectations concerning the wind farm's negative impact on the tourist level. The resistance in Nysted was on the other hand associated with landscape aesthetic issues.

The constant in the model is positive and significant, implying a systematic propensity to have a positive/neutral attitude. It is worth mentioning, that it was tested whether the subscription of the local papers "Jydske Vestkysten" in the HR-sample and "Lolland-Falster Folketidende" (LFF) in the NY-sample had an influence on the attitude of the respondents. The reason is that especially the LFF paper during the planning and construction phase of the off-shore wind farm at Nysted expressed a very negative attitude towards the wind farm (Kuehn 2005a, Kuehn 2005b). In the analysis the respondents subscribing for the local papers did not however have different (negative or positive) attitudes than respondents who did not subscribe the local papers.

The fit of the models is surprisingly good giving the small variance in the dependent variable and indicates relatively systematic and well defined preferences for existing off-shore wind farms.

It has not been possible to obtain data on the national levels of the frequencies of the independent variables in the areas where the two local samples are obtained. It is therefore difficult to verify if the observed attitudes are representative of the population living in the sample area.

Compared to the other models, the marginal effects on the probability of having a negative attitude are considerable. Especially the effect of being a commercial fisher is noteworthy in combination with the age variables (Age55+ and Age45_View_offs),

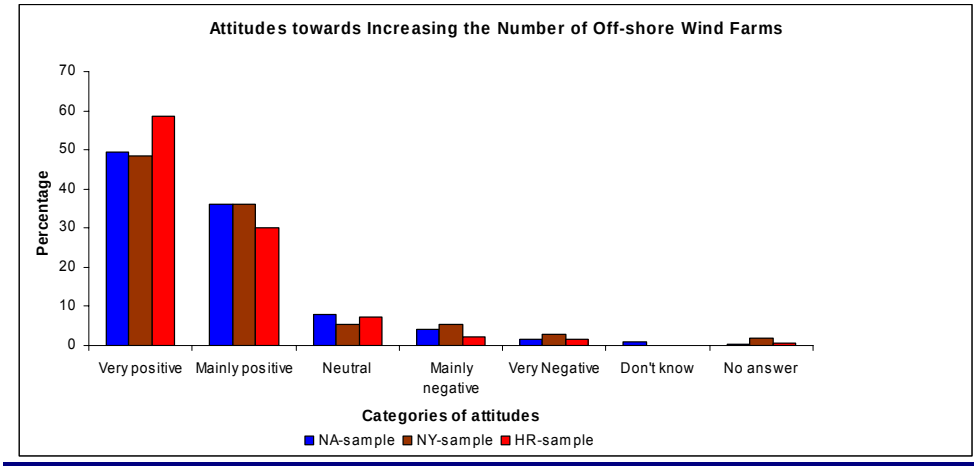
see Appendix D. However, the marginal probabilities are still relatively strongly influenced by the constant term, which is associated with a 99.72% probability of a positive/neutral attitude.

7.4. Attitudes towards Increasing the Number of Off-shore Wind Farms

The respondents in all three samples are in general very positive towards the existing off-shore wind farms in Denmark. In this section the respondents' attitudes towards increasing the number of off-shore wind farms are presented. The arguments put forward in the previous section with regards to the difference in attitude between the HR and NY-sample are also valid in this case.

In Figure 4 the attitudes of the three samples are presented, see below.

Figure 4. Attitudes towards establishment of new off-shore wind farms



The stated attitudes in Figure 4 are very similar to the attitude towards existing wind turbines presented in Figure 3. The only obvious difference is that fewer of the respondents from the NY-sample are *very positive* or *neutral* and more are *mainly positive*. However it is not possible to deduce from the figure if the change is significant. The overall attitude is thus very positive across the three samples. Approximately 9, 6 and 4% of the NY-, NA- and HR-samples respectively have a negative attitude.

7.5. Probit Model on the Attitude towards Increasing the Numbers of Off-shore Wind Farms, NA-sample

The elicited probit model identifying systematic differences in the attitude of the respondents in the NA- sample is presented in Table 7, below.

Table 7. Probit model for a positive or neutral attitude towards increasing the number of off-shore wind farms (NA-sample)

Variables	β	σ	z	P<z
Age_missing	-0.6971	0.4491	-1.55	0.121
Age55+	-0.4815	0.2305	-2.09	0.037
M.Out_Org	-0.5054	0.3145	-1.61	0.108
Constant	1.8343	0.1509	12.16	<0.001

No. Obs = 369, ρ^2 = 0. 0.0505, Prob < χ^2 = 0.0434

The probit model in Table 7 is relatively weak, as the joint significance of the variables is only 0.0434, thus barely significant on a 5% level. The fit of the model is also very low, just above 0.05. The model only contains three variables in the model the constant term exclusive. Age_missing is jointly significant with the other variables and the coefficient is negative. The other variable is Age55+, which represents the respondents older than 54 years. The variable is significant and as in the previous models older respondents have a higher probability for a negative attitude, as $\beta_{Age55+} < 0$. Members of an outdoor organisation are represented by the M.Out_Org variable and have a negative propensity for a positive attitude towards more off-shore wind farms. Though the effect is not as significant in the model for the existing off-shore wind farms, the estimated coefficients are almost identical across the two models. This indicates that respondents who are members of an outdoor organisation in general have a higher propensity for a negative attitude towards off-shore wind power. The constant term is positive and very significant.

Comparing the probit models for a positive attitude towards existing and more off-shore wind farms the two age variables (Age60+ and Age50_59) in the first model is represented by a single variable (Age55+). But as mentioned in relation to Table 6 the coefficients of Age60+ Age50_59 are not significantly different from each other. The collapsing into a single variable in the model for the attitude toward more wind farms is thus not surprising. The two models also differ with regards to the variable View_Beach_User, which is not significant in the model for more off-shore wind farms. It could have been expected that the respondents who visit the beach very frequently and who can see off-shore wind farms from either their house or summer

house also would have a smaller probability for a positive attitude for more off-shore wind farms. A possible reason for the insignificance could be that the exact location of the future wind farms is not known. If the respondents represented by View_Beach_User think that future wind farms are placed at locations where they do not have an impact on the view and the use of the beach, the respondents should be less motivated for a negative attitude.

The model is as mentioned relatively weak, which is illustrated in the estimated marginal effects, none of the estimated marginal effects thus exceed 11%, see Appendix E.

7.6. Probit Model on the Attitude towards More Off-shore Wind Farms, HR and NY-sample

The respondents in both the NY and HR- sample are in general positive towards the existing off-shore wind farms, though the respondents in the NY sample have a less positive attitude. A probit model for the attitude of the respondents in the NY and HR samples is presented in Table 8.

Table 8. Probit model for a positive or neutral attitude towards more off-shore wind farms (NY and HR sample)

Variables	β	σ	z	P<z
Age40+	-0.7308	0.4418	-1.65	0.098
Age40+_View_Offs.	-0.5624	0.2975	-1.89	0.059
Coast_Zip_Horns	-1.4713	0.6147	-2.39	0.017
Horn_Prof_Fisher	-1.6187	0.8047	-2.01	0.044
Nysted-sample	-0.6215	0.3298	-1.88	0.059
Constant	2.7802	0.4916	5.66	<0.001

No. Obs = 307, $\rho^2 = 0.1544$, Prob < χ^2 <0.001

In the probit model on the positive attitude towards more off-shore wind farms in Table 8, the attitudes of the respondents are represented by two age related variables. The first age related variable (Age40+) represents respondents that are 40 years or older. The β is negative and denotes that the respondents older than 39 years have a higher probability of negative attitude than the respondents younger than 40 years everything else being equal. The respondents who can see an off-shore wind farm from either the house or summer house furthermore also have higher probability of a

negative attitude. These respondents are represented by the Age40+_View_Offs variable, which has a negative coefficient. Both variables are though only significant on a 0.10 level[9].

The other variables in the model are identical to the model for existing off-shore wind farms. The variables Coast_Zip_Horns and Horn_Prof_Fisher thus represent the relevant subsamples in the HR-sample. Both variables are significant and are associated with a relatively large negative coefficient. Respondents living in the areas with a potential view to the Horns Rev off-shore wind farm and commercial fishers in the HR-sample therefore have a higher propensity for a negative attitude. The last variable in the model is Nysted, representing the respondents in the NY-sample. The variable is negative and significant as in the previous model.

When comparing the models for existing and more off-shore wind farms, it is rather evident that the models are identical with regards to the variables representing the respondents. Without going too much into details, the size of the coefficients is also rather identical (however not directly comparable). There seems to be a trend in the small observable differences. The coefficients of the geographical variables are all smaller in the model for future wind farms, which makes sense in relation to the latent variable. Assuming that the future wind farms are located in other areas or at least further away from the coast then the value of the latent variable (y_i^*) is expected to be higher for future wind farms than for existing wind farms.

Compared to the probit model on the attitude towards existing off-shore wind farms, the marginal effects are quite identical. The marginal effects are though slightly smaller in the present model. Almost all two way combinations of the different variables changes the probability with less than 50%, see Appendix F.

Again it has not been possible to obtain data on the national level of the frequencies of the independent variables in the areas where the two local samples are obtained.

[9] The variable specifications, Age55+ and Age45+_View_offs, which were used in the model on the attitude towards existing off-shore wind farms, are also significant in the present model. The variable definition used in the present model however improves the fit of the model significantly.

8. Discussions

As presented in the previous chapters the general attitude towards the existing and additional wind turbines/farms on-land or off-shore are quite positive among the respondents in the national sample and the two local samples (Nysted and Horns Rev). In the present section the results are discussed in relation to the validity and interpretation of the results, their relevance and use in policy relations.

8.1. Explanatory Power of the Models

The fit of the models are in general acceptable. But the fits of the national probit models for more land-based turbines and off-shore turbines are considered to be low. However it is necessary to see the model fits in relation to the variation in the dependent variable. As illustrated in the previous chapter the overall attitude towards more land-based turbines and off-shore wind farms is in general positive or neutral. This means that the expected probability of $y_i = 1$ is large and well above 0.5. The variation in the data set with regards to the dependent variable is therefore small, which makes it difficult to find significant determinants for the stated attitudes. The small model fits are therefore somewhat anticipated.

Besides the small variance in the dependent variable, the low fit in the models concerning future wind power development could be explained by that it might be more difficult to relate to future wind power facilities. The expressed attitude might therefore have become more "noisy" compared to the attitude towards existing wind power facilities. Consequently, the models have less systematic variance in attitude among the respondents.

Finally, concerning the models for off-shore wind power, and to a certain extent related to the section above, the respondents in the NA-sample have relative few experiences with off-shore wind power. It is therefore possible that many of the respondents have stated attitude towards existing and more off-shore wind farms based on beliefs of the expected benefits and externalities rather than personal experiences (mainly the externalities). Consequently it might be more difficult to identify characteristics of the respondents, which have a significant influence of the probability of a positive attitude towards off-shore wind turbines.

However, though the fits of the models are relatively low, the observed independent variables and their impact on the propensity of a positive or neutral attitude are still

valid and give an impression of the systematic differences in attitude among the respondents and the Danish population.

8.2. Attitudes in Previous Studies

The attitudes towards land-based wind power obtained in the present study nicely correspond with the attitudes identified in previous studies conducted in Denmark. In the most recent survey done by Sonar in 2001, 68% of the respondents supported an increase in the number of wind turbines nationally and 18% found the present number of turbines acceptable, see Danish Wind Turbine Owners' Association (2005). In Table 9, below, the results from the present and two previous studies are compared.

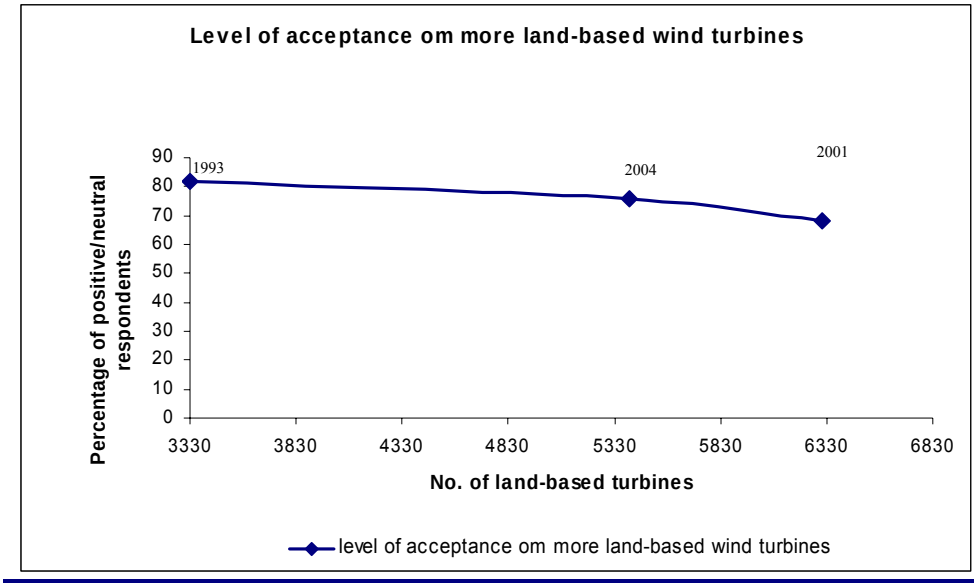
Table 9. Comparison of surveys

	Present Survey		Sonar 2001		AIM 1993
Level of turbines	Existing land-based turbines	More land-based turbines	Existing land-based turbines	More land-based turbines	More land-based turbines
Attitude					
Positive/neutral	90%	76%	86%	68%	82%
Negative	10%	24%	14%	32%	18%
No. Turbine at the time of the survey (approximately)*	----------5400----------			6310	3330
Average Effect (kW)*	----------580----------			395	140

*The number of turbines and the average effect is estimated based on Danish Energy Authority (2005a)

In Table 9 the attitudes across the different surveys cannot be directly compared. The reason is that the range of the ages of the respondents sampled in the Sonar and AIM studies have not been obtainable. Nevertheless it seems like, the attitude in the three surveys are relatively matching. Between 86% and 90% of the respondents in the present - and the Sonar survey thus have a positive or a neutral attitude towards the existing number of turbines in Denmark. In relation to the attitude towards more wind turbines, the results are though somewhat different between the studies. In AIM (1993) 82% of the respondents have a positive attitude towards increasing the wind power capacity, which is a relatively high number compared to the two other surveys. But as presented in the two lower rows the number of turbines installed and the average effect/turbine are much smaller in 1993 than in 2001 and 2004. The higher level of acceptance of more wind power in 1993 thus seems valid. In this relation is it worth mentioning, that there is a small trend in the attitude towards wind power. Everything else equal, the attitude towards existing and more turbines becomes more negative the higher the number of turbines installed. This relation is illustrated in Figure 5, below.

Figure 5. Attitude towards an increase in land-based turbines



In Figure 5, the relationship between the number of turbines and the attitude towards more turbines is non-linear. As so, the attitude exponentially becomes more negative as the number turbines increases. The illustrated relation is though only based on three surveys and does not take into account the differences in size/effect of the turbines, why the comments above regarding the attitude and the number of turbines must be viewed with some care.

8.3. Age: State Dependent or Generation Dependent

Across the elicited choice models, the age of the respondents have a significant influence on the propensity to have a positive/neutral attitude towards land-based and offshore wind turbines. From a policy point of view, this characteristic of the attitude of the respondents is quite interesting, since it could indicate that coming generations are more positive towards wind turbines than the present older generations. The essential question in this relation is though, whether observed differences in attitude are age or generation dependent?

In the first case, people in average become more and more negative towards wind turbines as they get older. The distribution of the attitude towards wind turbines, everything else being equal, would consequently not be different in for example 10 or 20

years. In this case, the attitude could be defined as a "true" function of the age of the respondents. That preferences change with age is not particular spectacular, as preferences for many goods and services change as the individuals get older, such as preferences for music, cars, housing etc.

In the latter case the observed attitude is not a "true" function of the age of the respondents but a function of the generation of the respondents. That is, that the average attitude stays fixed within each generation even though the respondents within the generation age. If the attitude is generation dependent, then the distribution of the attitudes would be different in 10 or 20 years as the younger generation substitutes the older generations. The central question in this relation is, which attitude do the coming generations have for wind power development? One of the arguments for increasing the wind power capacity is the concerns about the sustainability of the present power generation especially with regards to global warming. If the present younger generation (<20 years) and future generations are more concerned about the issue of sustainable power generation and global warming they might similarly be in favour of wind power as the younger respondents in the sample.

In this case, the attitude towards for example more land-based turbines (has the highest level of opponents) might become more positive in the future though the number of turbines installed increases. But on the other hand the presence of substitute turbines sites (off-shore) or new technology in the future could have a negative influence on the attitude towards land-based wind power development.

It would have been interesting to verify, if the observed age attitude relation also existing the previous surveys conducted in Denmark. However, neither of the surveys reports such a relation.

8.4. Attitude and Costs

As presented in the previous sections, the respondents are more positive towards increasing the wind power capacity off-shore opposed to on-land. This points towards that the future wind power development primarily should be taken off-shore. In the attitudinal questions however, the respondents have not been informed about the cost associated with on-land and off-shore development, respectively. The attitude stated must therefore be characterised as a "free choice" as the respondents do not necessarily consider the costs when stating their attitudes. The stated attitudes therefore do not

entail the trade-off between preferable wind power development sites and possible differences in cost.

The changes in consumer/respondent attitude/preference as a function of whether or not the stated attitude was associated with cost have been analysed in a study concerning the Danish people's preferences for forest characteristics (Aakerlund, 2000). In the study the respondent ranked alternative forest characteristic compositions (four types of tree species). Initially the respondents ranked 5 alternative forest compositions. Afterwards the respondents ranked the same alternatives, but where the alternatives were associated with an annual cost per household. As expected the attractiveness of the different alternatives decreased as the cost increased. The attractiveness of the proposed forest characteristic compositions was thus a function of the cost that the household should pay for the alternatives.

In the present case, it is difficult set up a precise estimate of cost of producing wind power, as the production cost varies with the size of the turbine, location (on-land), wind regimes, distance to the shore and depth of the water (off-shore), clustering of turbines, type of foundation etc. (Morthorst, 1997, Morthorst, 2004). The stated attitudes are though expected to be different if the respondents were informed about the cost associated with wind power development on-land and off-shore. If an increase in wind power capacity is associated with higher consumer cost, the consumers/respondents might be less in favour of increasing the wind power capacity in Denmark. Similarly differences in cost between on-land and off-shore wind power development could also change the attitude. If the net cost for off-shore development is higher compared to on-land, the respondents might have had a less positive attitude towards off-shore development as oppose to on-land and vice versa.

8.5. Policy Related Results

From an energy policy point of view the stated attitudes and the probit models in the survey are very interesting, as they might give a good indication of the support to the present government's wind power policy.

Land-based Turbines

Starting with the land-based wind power development it is as mentioned the government's policy to increase the wind power capacity on-land by replacing existing small turbines with fewer but considerable larger turbines. Given that 75% of the respondents have a none-negative attitude towards existing and more land-based wind tur-

bines, it could be argued that the present policy is also supported by the respondents in the survey. However, there are certain limitations in the survey, which would make it inappropriate to directly conclude as above without a number of aspects being discussed.

First of all, in Denmark wind turbines of various type and size/height are located in the landscape. In the present survey the size of the future wind turbines was not addressed in the question regarding the expansion of the number of turbines on-land. It is therefore difficult to verify if the respondents' attitude towards an expansion in the number of land turbines was based on the expectation of the new and large turbines or on the perceived size of the present turbines in the landscape. This is quite important as the new turbines are much larger than most of the existing turbines. Nearly 45% of the existing turbines have a capacity of less than 600 kW, which is the capacity of the smallest turbine sold on the market[10] (Siemens Power Generation, 2005, Vestas, 2005). A new turbine will therefore given its size have a much larger visual impact on the landscape than the average existing turbine. If the respondents have based their attitude on the average size of the present wind turbines, it is likely that more respondents would have opposed to more land-based turbines given the size of the new turbines.

Secondly, the present survey does not focus on the issue of replacing small turbines with larger ones. As presented it is the plan to replace approximately 900 turbines (max 450 kW) with 150-200 turbines (2 MW). This will reduce the overall number of turbines in the landscape. A typical 450 kW turbine is just above 50 m and a 2 MW turbine is typically 100 m to the tip of the blades. A 2 MW turbine is thus almost twice the size of a 450 kW turbine.

The replacement will have opposite effects on the landscape, as the impact of many small turbines will be replaced by the impact of few but larger turbines. Based on the data in the present survey, it would though be difficult to infer if the respondents would be positive/neutral or negative towards replacing many and small turbines with few and very large turbines.

The first point discussed indicates that the number of positive respondents in the present survey might be overrepresented, as the respondents possibly might not have

[10] The average size of the turbines installed on-land since 2002 is just above 1,200 kW (Danish Energy Authority, 2005a).

taken into account the size of the new turbines. However, referring to Table 9 and Figure 5, it seems likely, that it is the number of turbines rather than the size of the individual turbines that has an influence on the attitude of the respondents. Taking into account the weak relation between attitude and number of turbines, this indicates that the respondents might be at least as positive or even more positive towards increasing the on-land-based capacity by replacing many smaller turbines with fewer larger ones, and thereby reducing the total number of turbines as proposed by the government.

Given that the replacement policy will have a smaller impact on the landscape than the impact associated with an increase in turbines, but with no replacement of smaller turbines, the government's replacement policy seems to be supported by a majority of the respondents. However in this conclusion it must be kept in mind that the support might be smaller, if some of the respondents have misjudged the size of the future land-based turbines.

Off-shore wind turbines

In 2003 the Danish Government and most of the parties in the Danish Parliament agreed to establish 2x200 MW off-shore wind farms. The two off-shore wind farm projects are now in tender. Given that the respondents in all three surveys are very positive towards the establishment of more off-shore wind farms, there seem to be a high degree of support of the government's plan. The very high level of positive/neutral respondents even in the two local samples, who have experience with the two existing off-shore wind farms, the present survey strongly indicates that the future wind power development will have the strongest support off-shore.

9. Conclusion

In the present survey the Danish population attitude towards wind power was presented. The results show that the Danish population towards land-based turbines and off-shore wind farms is positive and very positive, respectively. The survey also find that the respondents in general are more negative towards more land-based turbines opposed to more off-shore development, which all other tings being equal indicates that the future wind power development should be located off-shore. However, based on the attitudes, the grounds for future on-land development do *not* seem exhausted.

On a more specific level the attitude towards wind power is found to be correlated with the characteristics of the respondents, such as age (negatively), gender, experience with off-shore wind farms, if the respondents and membership of outdoor organisations. The relations that older respondents have a more negative attitude and that respondents living in urban areas are more positive towards land-based turbines are quite interesting. The age relation indicates a higher support of-shore wind farms in the future, while the urban area relation points towards, that land-based development is acceptable, as long the density of turbines is kept on a low level in vicinity to larger cities.

Conclusively, the results verify the results from previous surveys, that the population in general supports the previous expansions of the wind power capacity in Denmark. Based on the attitude towards future wind power development, the results indicate that the wind policy of the present government seems to be strongly supported by the respondents.

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Appendix A

Table: Marginal probability of a positive or neutral attitude towards existing land-based turbines

	Age60+=1	Age50-59=1	Larger_Cities_Zealand = 1
Constant	-0.3547	-0.1256	0.0543
Age60+=1	0	-	0.2992
Age50-59=1	-	0	0.1553
Jutland_Age60+ = 1	-0.1555	-	-
Larger._Cities_Zealand = 1	-0.1098	-0.0247	0

(-) denotes non-feasible combinations of characteristics of the respondents

Appendix B

Table: Marginal probability for a positive or neutral attitude towards more land-based turbines

	Age50+(male)	Larger_Cities_Zealand	Cities>60.000_Jutland
Constant (Prob=0.8113)	-0.2201	0.1164	0.1425
Age50+	0	0.1988	0.2574
Larger_Cities_Zealand	-0.1376	0	-
Cities>60.000_Jutland	-0.1052	-	0

(-) denotes non-feasible combinations of characteristics of the respondents

Appendix C

Table: Marginal probabilities for a positive or neutral attitude towards existing offs-shore wind farms

	Age60 = 1	Age50-59 = 1	M.Out_Org = 1	V_B_OV = 1
Constant (prob=0.9795)	-0.0740	-0.0334	-0.0575	-0.0816
Age60 = 1	0	-	-0.1512	-0.2003
Age50-59 = 1	-	0	-0.1090	-0.1482
M.Out_Org = 1	-0.1676	-0.0848	0	-0.1817
V_B_OV = 1	-0.1927	-0.1000	-0.1576	0
M.Out_Org and V_B_OV = 1	-0.2745	-0.1577	-	-

(-) denotes non-feasible combinations of characteristics of the respondents

Appendix D

Table 10. Marginal probabilities for a positive or neutral attitude for existing off-shore wind farms (HR and NY- sample)

	Age55+	Age45+_View_offs	C_Zip_Horns	Horns_P_Fisher	NY-sample
Constant (Prob=0.9972)	-0.0111	-0.0116	-0.1280	-0.1958	-0.0342
Age55+	0	-0.0394	-0.2774	-0.3782	-0.0984
Age45+_View_offs	-0.0389	0	-0.2816	-0.3830	-0.1006
C_Zip_Horns	-0.1605	-0.1652	0	-0.6585	-
Horns_Prof_Fisher	-0.1936	-0.1988	-0.5907	0	-
NY-sample	-0.0754	-0.0780	-	-	0

(-) denotes non-feasible combinations of characteristics of the respondents

Appendix E

Table 11. Marginal probabilities for a positive or neutral attitude for existing off-shore wind farms

	Age54+	M.Out_Org
Constant (prob=96.67)	-0.0548	-0.0586
Age55+	0	-0.1064
M.Out_Org	-0.1064	0

(-) denotes non-feasible combinations of characteristics of the respondents

Appendix F

Table 12. Marginal probabilities for a positive or neutral attitude for more off-shore wind farms (HR and NY- sample)

	Age>39	Age>39_View_offs	Coast_Zip_Horns	Horn_Prof_Fisher	Nysted-sample
Constant (prob=99.73%)	-0.0175	-0.0106	-0.0926	-0.1200	-0.0127
Age40+	0.0000	-0.0483	-0.2614	-0.3131	-0.0564
Age40+_View_offs.	-0.0552	0.0000	-0.2144	-0.2613	-0.0419
Coast_Zip_Horns	-0.1863	-0.1324	0	-0.5264	-
Horn_Prof_Fisher	-0.2106	-0.1518	-0.5264	0	-
Nysted-sample	-0.0612	-0.0398	-	-	0

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