Goal

The Government is working on the roll-out of large wind farms in the North Sea from 10 NM (Nautical Miles, 18.5 km) offshore. In some coastal towns residents are concerned about the visibility of the wind farms from the shore. By default, the wind turbines are delivered in white tones. ROM3D's desk study showed there are opportunities for wind turbines to reduce visibility through customized colouring and the application of patterns. RVO.nl wanted to investigate whether this influences the public's experience of the wind farms.

RVO.nl has developed three scale models of an 8 MW turbine, with one turbine in standard white colour and the other two with different colours and patterns (a "grey" turbine and a "black and white" turbine). By means of a previous experimental research, the visibility of these three turbines has been investigated with a test set up of the scale models on the beach and a small test group. The results of this first trial could not be generalised to the total Dutch population and to different days and weather conditions. This prompted the need for a larger scale quantitative research study to obtain reliable results about the visibility of the grey and white wind turbines that are representative of the Dutch population.

Background

For this research, in consultation with the decision makers of coastal communities, RVO.nl asked ROM3D to simulate five sea view scenarios:
1. Without wind farm (existing situation)
2. A wind farm with standard white turbines at 10 NM offshore
3. A wind farm with grey turbines at 10 NM offshore
4. A wind farm with a mix of white and grey turbines at 10 NM offshore: white and grey turbines at the horizon in four alternating sections (25% each).
5. A wind farm with a mix of white and grey turbines at 10 NM offshore: one section (50%) comprising grey turbines and one section (50%) comprising white turbines at the horizon.

ROM3D developed two variants for each scenario: one in sunny weather (all turbines are illuminated) and one in cloudy circumstances (all turbines are in the shade). The base picture - the sea view - is the same for all scenarios and variants. The 10 photographs are included in the report.

Method and design

The survey was conducted through an online questionnaire. The questionnaire included the photographs of the different scenarios. [1]

Set up questionnaire

Each respondent was asked to assess the five scenarios - both for cloudy and sunny conditions - by looking at the ten photos in random order. Per scenario, we have asked for them to rate the following:
- Attractiveness of the beach. Score between 0 (very unattractive) and 100 (very attractive)
- Visibility of the objects (wind turbines) at the horizon. Answer on a scale of 1 (very poorly visible) to 5 (very visible).

The perception and opinion about the different scenarios can be influenced by the level of knowledge in advance. Therefore, the questionnaire also made a distinction between conditions of information. Approximately half of the respondents received, as an addition to the eight photos on which wind turbines were visible, an explanation that there is a wind farm at the horizon that

generates energy.

Sampling and consultation
• A total of 1,113 Dutch people aged 18 to 70 participated in the research. Within this sample are the following, largely overlapping, subsamples:
1. Representative sample from the Dutch population (n = 1.014)
2. Sampling of non-coastal residents (n = 907)
3. Sampling of coastal residents, including boost [2] (n = 206)
• The results for the Netherlands are representative for education, age, gender, region, lifestyle (Mentality environments) and the interactions between them. The results for coastal residents are representative for age and gender.
• For all respondents, it is also known whether they are visiting the coast for one day or a longer stay. The distribution is given in the appendix.
• The internet consultation lasted from 3 July to 7 July 2017.

[2] In order to be able to make reliable statements, we recruited additional participants from coastal communities, so we have more than 200 respondents from this group.

Analysis
In order to make statements about the attractiveness of the beach in different circumstances, the analysis combined the results for a selection of the ten pictures. For example, pictures are combined for the following analyses:
• Attractiveness of the beach, without taking into account scenario and weather type: all 10 pictures (all scenario 1 to 5 photos).
• Attractiveness of the beach, with an offshore wind farm in general, without taking into account the weather type: 8 pictures (all scenario 2 to 5 photos) .
• Attractiveness of the beach, with an offshore wind farm in general, in sunny weather: all 4 photos with sunny weather for scenario 2 to 5.
• Attractiveness of the beach, with an offshore wind farm in general, in cloudy weather: all 4 photos with cloudy weather for scenario 2 to 5.
• Attractiveness of the beach in the 5 specific scenarios, without taking into account the weather type: all 10 pictures (by scenario 1 to 5, both sunny and cloudy condition photos side by side).

Conclusions

The Dutch people generally appreciate a wind farm with grey turbines better than scenarios with white or mixed wind farms

Comparing the scenarios, without taking into account the weather type, the Dutch people appreciate the scenario of a wind farm with all grey wind turbines generally better than the scenarios with white or mixed coloured turbines. The beach with a grey offshore wind farm is considered the most attractive and the least visible.

The two scenarios in which the wind farms are uniform in colour (completely white or grey) are better appreciated in terms of attractiveness and visibility than the two scenarios where the wind farms consist of mixed coloured wind turbines.

The Dutch people consider the scenario with no offshore wind farm (the existing situation) the most attractive of all five scenarios.

The grey park is better appreciated in sunny weather, the white park in cloudy weather

When analysing the results in more detail, the weather condition plays a major role. In sunny weather, the beach with the grey turbines offshore is found to be the most attractive and the wind farm with grey turbines the least visible. In cloudy weather, however, this changes: the Dutch people then consider the beach with the white turbines offshore the most attractive and the wind farm the least visible.

When differentiating between weather types, the appreciation of scenarios with mixed coloured wind farms also changes. In sunny weather, the two scenarios with an offshore wind farm consisting of white and grey wind turbines are considered more attractive compared to an even white offshore wind farm. In cloudy weather, the two scenarios with a mixed coloured farm are considered more attractive compared to an even grey offshore wind farm.

Information seems to play a part in the perceived visibility of the wind farms, but not in the attractiveness

Mentioning the existence of an offshore wind farm at the horizon does not seem to play a role in the attractiveness of wind farms in the different scenarios. However, the wind turbines are considered less visible in cases where they are referred to as "wind turbines" instead of "objects" at the horizon.

Coastal residents generally also consider the grey wind farm as less visible, but in this instance they do not consider the beach to be more or less attractive compared to the white wind farm.

Coastal residents have a slightly different opinion than the average Dutch people. If not taking into account the weather type, they do not distinguish between the scenarios of an offshore wind farm with white or grey turbines in terms of attractiveness of the beach. For this reason, there is no added value in having a grey offshore wind farm. However, like the Dutch people in total, they consider the grey wind farm slightly less visible. Obviously, for coastal residents this slightly less visibility does not lead to a demonstrable more attractive beach. However, when not taking into account the weather type, like the average Dutch people they consider the scenarios with a single-color wind farm (white or grey) to be more attractive than the scenarios with mixed coloured wind farms.

Preferences coastal residents in sunny and cloudy weather are similar to the preferences of the general Dutch public

When taking into account the weather type, like the Dutch people in general, the coastal residents consider in sunny weather the beach with a grey offshore wind farm more attractive and less visible than the beach with a white offshore wind farm. In cloudy weather the opinion is the opposite: the beach with a white offshore wind farm is more attractive and less visible than a grey offshore wind farm.

In sunny weather, coastal residents consider beaches with a mixed coloured wind farm as evenly unattractive as with the white offshore wind farm, but the turbines are slightly less visible. In cloudy weather, the same applies: the beaches with mixed coloured wind farms are more or less similar to the evenly grey park, but in the perception of coastal residents, they are slightly less visible.

All in all, coastal residents evaluate the grey wind farm the best in sunny weather and the white wind farm in cloudy weather.

Summary results Dutch population

Comparison between scenarios

• In general - so not taking into account the weather circumstances or the amount of information provided in advance - the Dutch people consider the beach with grey offshore wind turbines more attractive than scenarios with another type of wind farm. The beach under this scenario is considered slightly more attractive compared to a beach scenario where white offshore wind turbines are present (65.7 for grey turbines vs. 65.0 for white turbines)[3]. For the Dutch people, the offshore wind farm with grey turbines is also the least visible (2.5 vs. 2.6 for white turbines).

• A wind farm in one color (white or grey) is better appreciated by the average Dutch person in terms of attractiveness and visibility than a mixed coloured offshore wind farm.

• The Dutch people also appreciate the scenario without an offshore wind farm, with this ranking as the most attractive of all scenarios (71.4).

[3] If this summary discusses differences (vs.), they are generally tested based on a paired-samples T test and found to be significant (p <.05). If another comparison is made, this is indicated by *.

The influence of weather conditions

• In considering the type of weather, weather condition plays a major role. In sunny weather the grey wind turbines are considered the most attractive (68.9 vs. 60.8 for white turbines) and the least visible (2.0 vs. 3.6 for white turbines).

• In cloudy weather, however, the white turbines are the most attractive (69.1 vs. 62.4 for grey turbines) and the least visible (1.6 vs. 3.0 for grey turbines).

• The appreciation of mixed coloured wind farms also depends on the weather: in sunny weather, Dutch people prefer the mixed coloured wind farm scenarios above the scenario with only white turbines. In cloudy weather, they also consider the mixed coloured wind farms more attractive and less visible than the scenario with single grey turbines.

The role of information in advance

• The information content plays a role in the perceived visibility of the offshore wind turbines. If it is pointed out that there are "objects" at the horizon, wind farms (regardless of composition) are perceived to be more visible than if it has been notified that at the horizon wind farms can be seen that generate energy. *

• This is striking and cannot be explained well. In any case, it does not seem to indicate socially-friendly answers, because we would probably also find such a difference in the question of the attractiveness of the beach, but that is not the case.

Possibly when knowing the objects are wind turbines, the visibility is expected to be high, but the actual visibility is less than expected.

Coastal residents

How do coastal residents experience the scenarios?

• Coastal residents differ on a few points from non-coastal residents. When not taking into account the weather type or information, they consider the white and grey offshore wind farm equally attractive (69.4 for white and 69.2 for grey turbines). The grey offshore wind farm is considered just slightly less visible than a white offshore wind farm (2.5 vs. 2.6 for white turbines).

• They also consider all scenarios with offshore wind farms generally more attractive than non-coastal residents (68.2 vs. 64.4 for non-coastal residents). In particular, they consider the scenario with a white offshore wind farm more attractive than non-coastal residents (69.4 vs. 65.1 for non-coastal residents). For all other scenarios, including beaches without wind farms, a similar difference in the sample is found, but this is statistically just not significant. [4]

• This last point (a generally more positive experience of the wind turbine scenarios than non-coastal residents) only arises if they are not told that the objects at the horizon are wind turbines. If respondents receive the explanation that there are "wind farms" at the horizon, "generating energy," coastal residents consider all scenarios as attractive as non-coastal residents. If the explanation is only "objects" at the horizon instead of "wind turbines", coastal residents consider all scenarios more attractive than non-coastal residents. Apparently, knowing the objects at the horizon are wind turbines adversely affect their appreciation of the beach.

[4] These comparisons were tested on the basis of an independent-samples T test and found to be significant (p <.05).

The influence of weather type among coastal residents

• In sunny weather, coastal residents consider the beach in the scenario with an evenly grey wind farm more attractive and the turbines less visible than the situation with white turbines only (71.0 vs. 65.4 for attractiveness and 2.1 vs. 3.5 for visibility). In cloudy weather, the result is exactly the opposite (73.4 for white wind farm vs. 67.4 for grey wind farm for attraction and 1.7 vs. 2.9 for visibility).

• When we compare homogeneous wind farms (all white or all grey turbines) with mixed coloured ones, we see the following:

- In sunny weather, coastal residents also consider the grey wind farm more attractive and grey turbines less visible than in a mixed coloured wind farm with 50% white and 50% grey wind turbines or sections with 25% grey and white turbines. Mixed coloured wind farms score similar in sunny weather to white wind farms, in terms of attractiveness, but are experienced as slightly less visible than an evenly white wind farm.

- In cloudy weather, they consider the wind farm with white turbines more attractive and less visible than both mixed coloured wind farms. Mixed coloured wind farms score similarly to grey wind farms in cloudy weather, in terms of attractiveness, but are less visible according to coastal residents.

- When looking more in depth, the preferences of coastal residents generally correspond to those of the Dutch people in general: in sunny weather, a beach with a grey offshore wind farm is clearly preferred, in cloudy weather a beach with a white offshore wind farm is preferred.