Offshore Energy Strategic Environmental Assessment (SEA) Seascape Study

Identification of Seascape Units around the English coast and consideration of Seascape Buffer Zones

WORKING PAPER

WHITE consultants
with
Arup
CESA

Offshore Energy Strategic Environmental Assessment (SEA) Seascape Study

Identification of Seascape Units around the English coast and consideration of Seascape Buffer Zones

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White Consultants
18-19, Park Place
Cardiff
CF10 3DQ

Tel: 029 2064 0971
Email: sw@whiteconsultants.co.uk

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1 Introduction

1.1 Scope of Brief

White Consultants was commissioned in November 2008 on behalf of the Department of Energy and Climate Change to progress a Seascape Study to help inform decisions on further leasing for offshore wind farms, for which DECC is undertaking a Strategic Environmental Assessment (SEA). The consultant team included Arup and the Centre for Environmental and Spatial Analysis [CESA].

The objectives of the seascape study are to:

- Identify seascape units for England in a manner consistent with that already completed for Wales and Scotland but acknowledging, and benefiting from, any lessons learned.
- Guide appropriate seascape buffer zones for Round 3 (and subsequent rounds) of offshore wind farm leasing. The focus of the study is for fixed wind turbines in waters of 60m or less. The objective of the project is to provide a reasoned [evidence backed] advice on seascape buffer zones needed to reduce the potential visual impact of offshore wind farms to the point where an adverse effect would not be significant.

Our interpretation of the threshold of no significance is derived from a ‘worst case’ scenario in the DTI (2005) seascape and visual impact assessment guidance which states that moderate adverse effects could be judged as significant [although it is most likely they are not]. Taking a precautionary approach our research defines the point where the visual effect of an offshore windfarm development changes from one of moderate adverse significance to minor-moderate significance. In practice it is difficult to be precise because effects change depending on the size of the windfarm, the viewpoint, the viewer and weather conditions. Beyond this threshold, windfarms are still likely to be visible in clear conditions. The method, variable factors and findings are discussed in more detail in the report.

1.2 Purpose of this Report

This report is a working draft with the purpose of assisting decision-making on the coastal buffer distances of wind farms for the Offshore Energy SEA, which as part of the DECC’s draft plan considers a third and subsequent Rounds of offshore wind leasing.

The work carried out so far is derived from available information and from tasks carried out within the initial stages of the contract. Whilst this is useful it has not been verified by the project team through further detailed desk study and site work. The additional tasks that will be carried out to inform the draft report are:

- Verification of SVIA assessments through review of independent monitoring reports carried out for Round 1 windfarms once constructed where available.
- Verification of SVIA assessments through site visits to representative Round 1 and Round 2 windfarms.
- Use of additional data from other windfarms SVIAs as the information becomes available.
- Consideration of the effects of elevation on or near coasts.
- Consideration of the effects of designations on or near coasts.
- Consideration of cumulative effects of offshore windfarms.
- Consideration of other issues in relation to character of seascape units.
- Additional research into international approaches to windfarm planning particularly in relation to Denmark, Germany and the US.
- Additional research into the effects of lighting.

The overall effect of this necessary work may be that the preliminary conclusions set out below (for preliminary conclusions see section 8.6) may be changed as further evidence comes to light.

1.3 Structure of Report

The structure of this report is as follows:

- Chapter 2: Seascape Studies;
- Chapter 3: Round 2 SEA Environmental Report;
- Chapter 4: SVIAs review- magnitude of effect
- Chapter 5: Lighting:
- Chapter 6: The International Perspective;
- Chapter 7: Wireframe Analysis
- Chapter 8: Preliminary Conclusions.

2 Seascape Studies

A number of reports have been reviewed to inform the development of a methodology and evidential assessment for this study. The major relevant studies are discussed below including seascape guidance and national guidance on seascape sensitivity.

2.1 Seascape Guidance to date

2.1.1 INTERREG Guide to Best Practice in Seascape Assessment – Countryside Council for Wales (2001)

This report by Hill et al (2001), involving the Countryside Council for Wales, was the first to tackle the issue of how to assess seascape. It was the result of an 18 month collaborative research project between Welsh and Irish agencies. Seven pilot assessments were undertaken in addition to reports on historic and cultural matters, public perception and the extent of national seascape units.

The project defined seascape as including:

- Views from land to sea;
- Views from sea to land;
- Views along coastline; and
- The effect on landscape of the conjunction of sea and land.

Elements which are considered to be additional to those found in landscape assessment include the cultural significance of the coast, the coast as an interface between two fundamentally different environments, the dynamism of the sea, the visual qualities of the sea and horizon and the amenity uses of the sea and seashore.

A hierarchal approach to assessment based on seascape units is suggested. The levels are national, regional and local and each level nests within the other. Each unit has three components:

- The coastal dimensional – Intertidal areas and areas of land directly related to the marine environment.
- The marine component – 24km, 15km, and 2-3km offshore respectively for each level.
- The hinterland component – defined by zone of visual influence [ZVI] of the sea inland [up to 10km] with additional reference to landform and land cover.

These components are brought together and the relationship between them described. This comprises the essence of a given unit's seascape character. The guidance places emphasis on the use of field survey sheets to capture the visual qualities of a unit. The process of evaluation of a unit's quality, value and capacity to accommodate change is also explored.

2.1.2 An Assessment of the sensitivity and capacity of the Scottish seascape in relation to wind farms – Scottish Natural Heritage (2005)

This report for Scottish Natural Heritage by the University of Newcastle (2002) is focused on defining seascape character with a view to understanding its capacity for offshore wind farms. It uses a modified Hill et al (2001) methodology.

33 seascape units are defined at national level incorporating regional level aspects. The units are mapped and described focusing on the key characteristics, scale and openness, form, settlement, pattern and foci, lighting, movement, aspect, how the area is experienced, modification/remoteness/sense of naturalness and exposure. These headings are the key criteria for judging the sensitivity of the unit to wind turbines.

13 broad coastal types are described which incorporate physical characteristics and experiential qualities of the coast, sea and hinterland. These are derived from an analysis of existing character assessments. The overall method is based on the University of

Newcastle's previous projects relating to renewable energy in the Western Isles and in the North-east of England.

Intervisibility between sea and land is explored to assist in determining a sensitivity of any given seascape unit. Factors affecting visibility are considered including curvature of the earth, global visibility studies, meteorological effects on visibility in Scotland, illumination, object characteristics and the acuity of the human eye. Taking these into consideration the seaward limit of visual significance is set at 35km.

A specific scenario for a wind farm 8km offshore is used to act as the basis for assessing expected qualitative visual effects as this is the limit of perceived high visual impact, referring back to the DTI Round 2 SEA report by BMT Cordah (2003).

2.1.3 Guidance on the Assessment of the impact of offshore wind farms: Seascape and visual Impact Report – DTI (2005)

The purpose of the seascape assessment in this document DTI (2005) is to inform environmental impact assessment and therefore focuses at a detailed level. The document covers the recommended process of assessment, baseline studies required, sensitivity, predicting impacts and their magnitude, assessing significance and cumulative impacts.

Definition of a seascape unit is based broadly on the Hill et al (2005) approach for a regional scale unit which is considered appropriate for assessing offshore wind farms. The characteristics of a given unit are based on the landscape character of the hinterland, a description of the coast, patterns of coastal geometry, patterns of sea horizons etc. It is made clear that within one seascape unit there will more than one landscape character area.

A fieldwork stage is regarded as essential for this level of assessment. Principles of visual perception are discussed including clarity, harmony, current contrast, and scalability. Key views are regarded as an essential component of data collected using a 35km seaward limit of visual significance.

Consideration of magnitude of change identifies quantifiable parameters which include distance, number and proportion of turbines visible, proportion of field of view and navigational lighting. Less quantifiable parameters include arrangement of turbines, background, aspect and weather and prominence of other built features in the view.

It cites the Round 2 SEA Study (BMT Cordah, 2003) in terms of thresholds for significance but states that a proposal for a 100 turbine windfarm with 150m high turbines will have a different limit of visual significance to a proposal for 30 turbines 100m high. In order to inform decisions on magnitude of effect, it lists a series of factors [Figure 25, p75]. These include

Factors that tend to decrease apparent magnitude [sample]:

- Long-distances;
- Small proportion of horizon occupied;
- Small percentage of development visible;
- Integration through siting;
- Skylining;
- Low visibility;
- Absence of visual clues;
- Windfarm not focal point;
- Complex scene;
- Low contrast; and

- High elevation.

Factors that tend to increase apparent magnitude [sample]:

- Short distances;
- Large proportion of horizon occupied;
- Large percentage of development visible;
- Strong contrast due to poor siting or layout;
- Backgrounding;
- High visibility;
- Visual clues;
- Windfarm is focal point;
- Simple scene;
- High contrast;
- Low elevation; and
- Night-time lighting.

Useful definitions of magnitude of change are set out to assist consistency of approach.

The degree of significance is also tackled in terms of the relationship between magnitude of change and sensitivity of receptor. This indicates that major and major/moderate effects are significant. It is stated that effects of moderate significance are most likely to be not significant, but it is feasible that they could be judged as significant, depending on the particular circumstances arising.

Navigation lighting is considered very much a secondary visual effect due to the curvature of the earth, association with shipping and the presence of few receptors at night. The report does not, however, cover aviation lighting.

2.2 Seascape and Visual Assessments for Onshore Wind Energy

2.2.1 Visual Assessment of Wind farms: Best Practice – Scottish Natural Heritage (2002)

This report by the University of Newcastle (2002) was produced in order to investigate the visibility of existing wind farms, compare as-built visibility with estimates of visibility in ESs, and draw conclusions on appropriate distances for ZVI in different circumstances.

Based on survey work at eight sites in Scotland (Beinn An Tuirc, Beinn Ghlas, Deucheran Hill, Dun Law, Hagshaw Hill, Hare Hill, Novar and Windy Stadard), overall analysis concluded that all the issues surrounding magnitude, visualisation and significance are subject to complexity, controversy and uncertainty. It recommended that best practice requires that the bases for all judgements made are clear and explicit on a case-by-case basis.

The report also stressed the importance of recognising a clear visual size classification as opposed to solely recognising the distance. This point was taken further by reiterating that the size class should be correctly interpreted in representing the significance of effects. As a result of ESs that have been reviewed during the study, the report commented that "*We are not persuaded by the common declaration or assumption found in some of the ESs examined that a medium effect imposed on a medium sensitivity receptor is necessarily insignificant, nor that a small effect on a high sensitivity receptor is also insignificant*."

2.3 Issues affecting visual effects arising out of reports

The visual effects of a windfarm are influenced by the limits of visibility and by the perception of the significance of seeing the object. The first is an objective measurement, the second, subjective. Visual range, actual visibility and the effect of the curvature of the earth and visual contrast are objective issues discussed below.

2.3.1 Visual range

Theoretically, in very clear conditions, objects can be seen from great distances. A case of an object seen from 193km has been recorded in the USA (Colorado State University, 1999). This assumes a black object seen against a contrasting, light background. This is not usually the case with wind turbines at sea. The Hill et al study (2002) indicates that a pole 0.1m wide is potentially visible at 1km, and a 0.2m wide is visible at 2km. Turbines of 6m and 7m diameter at base are therefore potentially visible at 60km and 70km respectively.

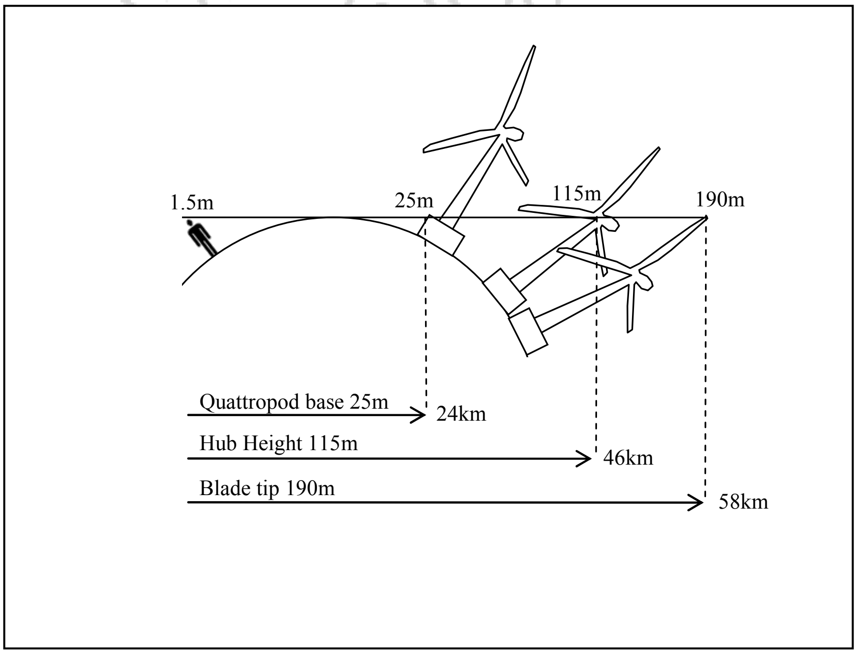
2.3.2 Actual visibility

Visibility is constrained by the clarity of the air/atmosphere and by the weather. In determining the limits of significance, it is considered appropriate to use a worst case scenario of clear visibility, so the latter is discounted. In terms of air clarity, a quoted global visibility study by Husar & Husar (1998) indicates that this differs across the UK, with Scotland generally experiencing greater clarity than Wales or England. On this basis, the SNH (2005) study suggests a limit of visibility of around 35km, with Wales being between 19km and 24km. The latter range could also apply to England and would be less in industrial or urban areas with greater particulate content in the atmosphere.

2.3.3 Effect of curvature of the earth and refraction in the atmosphere

The curvature of the earth limits the distance that objects can be seen. The horizon is around 6km when viewed at 1.5m above sea level and 32km at 60m above sea level [Hill et al, 2001, p8]. The effect on a 10MW turbine 190m high is shown in **Figure 2.1**. The refraction of light in the atmosphere bends light and therefore visibility is slightly increased.

Figure 2.1 – Effect of Curvature of the Earth on visibility of 10MW turbine



The distance at which elements of representative turbines used in this study's wireframes coincide with the horizon when viewed from 1.5m above sea level are set out in **Table 2.1**. This takes into consideration the effect of light refraction which tends to bend light and therefore slightly increase the distance at which objects are visible over the horizon.

Table 2.1 – Distances to Horizon at which wind turbine elements can be seen

Element and Height (m) above sea level	Distance (km)
3.6MW Hub Height 83	40
3.6MW Blade tip 137	50
5MW Hub Height 112	46
5MW Blade tip 175	56
Quattro-pod base 25	24
10MW Hub Height 115	46
10MW Blade tip 190	58

From this table it can be seen that the curvature of the earth only has an effect at long distances.

2.3.4 Visual contrast

At the horizon, the atmosphere is thickest and therefore, the number of particles visible greatest. These particles lighten the sky so it is lightest at the horizon and darkest overhead. Therefore in neutral lighting conditions, light grey or white turbines on the horizon provide a limited contrast to the light sky. In conditions of sunset behind a windfarm the turbines would be in silhouette and therefore in a high contrast situation. This would occur in west facing coasts. Sunrise would also give rise to contrast but would be seen by fewer people.

2.3.5 Perceptions of objects at distance

Numerous factors affect people's perception of windfarms at a distance. These include visibility factors mentioned above such as air clarity and weather and also the relationship of the development with the horizon, background, intervening screening, previous experience of wind farm developments, the occupation/interests of the individual receptor, other objects and activity. It is also influenced by the activity of the viewer- the most sensitive viewers being those who are moving slowly or are static and are there to enjoy the coast and sea views e.g. coastal path walkers and sightseers.

2.3.6 Discussion on visual issues

All the above factors modify visibility. It would appear that 35km is the maximum limit of visual significance and that within this distance there are further modifying factors. The precautionary approach to defining buffers is to consider the worst case scenario of clear conditions and sensitive receptors with clear views. This does not necessarily reflect the day to day reality of some less sensitive coasts. A range of buffers appears to be the most pragmatic way forward to reflect the complexity of the coast, the range of receptors and the scale of development.

3 Round 2 SEA Environmental Report

3.1 Approach to Seascape

3.1.1 Introduction

In April 2001 following a pre-qualification process, 18 companies were awarded agreements for leases by the Crown Estate (CE) in the first round (R1) of offshore wind farm sites around the UK. Each company was given a three-year period in which to obtain the necessary consents for a lease to be granted by the CE.

Round 1 was intended as a demonstration round, enabling each prospective developer to gain technological, economic and environmental expertise. Developers were limited to a 10km² area of seabed to be developed with a maximum of 30 turbines and an installed capacity of 20MW.

The DTI's consultation paper 'Future Offshore' (2002) sets out the Government's policy direction and commitment to take a more strategic approach to offshore wind farm development. To assist decision making on the design and terms of the competition the DTI commissioned a Strategic Environmental Assessment in line with the requirements of the 'SEA' Directive. Three areas were defined for assessment, some crossing territorial waters. Seascape was one aspect considered. Each of the three areas were analysed in some detail in order to set out constraints for each area.

3.1.2 Methodology

The assessment of seascape drew on the Hill et al (2001) CCW guidance applied within the constraints of a strategic desk based study. Seascape units were defined, characterised and attributed sensitivity. The potential for major, medium and minor effects were defined in distance bands based on CCW guidance and further work by Briggs (2003). This was based on information viewing land from the sea. The conclusions were that:

- Up to 10km away we can see field patterns, clusters of buildings, woodlands etc
- Up to 24km we can see broad colours and textures representing towns and forests etc and large man made structures such as power stations and turbines.
- Above 24km we struggle to see recognisable detail on land.

Based on this information low or no risk areas for offshore windfarms were identified by combining sensitivity with these likely visual impacts. Turbines were expected to be a maximum of 160m high to blade tip.

3.2 Conclusions

The resulting table of significance in the report was as follows (Extract from Round 2 SEA, BMT Cordah 2003):

Table 3.1 – Effects of proposed development for different seascape unit sensitivities

Seascape unit sensitivity	Significance of effect		
	Possible minor or no effect – Preferred Areas	Possible medium effects threshold	Possible major effects threshold
Low/no sensitivity	8km+ offshore	N/A*.	<8km offshore
Medium sensitivity	8km+ offshore	8-13km offshore	<8km offshore
High sensitivity	24km+ offshore	13-24km offshore	<13km offshore

[Note: it is considered that one box of the table is incorrect- medium sensitivity/preferred area should read 13km+, not 8km +]

The significance of effect is a product of sensitivity of seascape unit and magnitude of effect in accordance with GLVIA [2002] guidelines. The following magnitudes of effects were derived from CCW guidance and consultation (p5-1):

- Substantial/high effect: 0-8km
- Moderate/medium effect: 8-13km
- Minor/low effect: 13-24km
- Negligible effect: 24km+

In order to avoid significant effects the outer limits of each of these ranges were applied i.e. 8km the closest distance for low sensitivity coasts, 13km for medium sensitivity coasts and 24km for high sensitivity coasts.

3.3 Review of Limitations to Approach

3.3.1 Magnitude of Effects

The distances for magnitude of effects were derived from initial research by CCW and others without the benefit of assessment of windfarm proposals such as SVIAs or a review of constructed offshore windfarms. Completed SVIAs are examined in the next chapter to see if these distances are reflected in practice.

3.3.2 Threshold of Significance

The Stage 2 SEA (2003) report implies that effects of moderate significance are significant. This appears to be at odds with the DTI (2005) which indicates that major and major/moderate effects are significant. It further suggests that effects of moderate significance are most likely not to be significant, but could be significant depending on site specific circumstances. The precautionary approach is to treat them as significant, and this responds to this study brief's requirement to establish the minimum distance where there are no significant effects to shoreline observers.

4 Review of Seascape, Landscape and Visual Impact Assessments: Magnitude of Effects

This chapter considers the Seascape and Visual Impact Assessments (SVIAs) carried out as part of the Environmental Impact Assessment (EIA) for Round 1 and 2 wind farm developments. The majority of assessments [Round 2] have been obtained from the COWRIE website.

Figure 4.1 shows the location of the Round 1 and 2 proposals in relation to the proposed Crown Estate Round 3 areas. Given that this working paper also informs subsequent rounds of offshore wind leasing, the following applies to the entire UK coast.

4.1 Information Required for Analysis

4.1.1 Introduction

The main objective for analysing the Round 1 & 2 Seascape, Landscape and Visual Impact Assessments (SVIAs) is to identify the limits of visual significance of an offshore windfarm.

DTI (2005) guidance states that '*A viewpoint assessment should be carried out to identify and evaluate the potential effects on available views and visual amenity arising from the proposed offshore wind farm at specific representative locations in the study area*'. The conclusions on the degree of effect on these viewpoints will also inform the expected effect on seascape units. In order to meet the EIA requirements, the choice of viewpoints must go through consultation with the local authority, DTI and key stakeholders whilst also taking into consideration comments made during public consultation.

Predicting the likely significance of visual impacts (i.e. comparing the development against the original baseline) for each viewpoint is achieved by combining the *sensitivity* of the receptor or seascape unit that the viewpoint is located within and the *magnitude* of change. For the purposes of the brief, the magnitude of change is the key determinant as the sensitivity of receptors will be spatially variable. Nevertheless, the factors which define sensitivity are briefly discussed below so a rounded picture of how significance is derived can be fully understood.

4.1.2 Sensitivity of seascapes

The sensitivity criteria used for each seascape unit are derived (with minor modification) from the University of Newcastle Study (2002). These are as follows:

- Sense of scale;
- Openness/scale;
- Coastal and hinterland form;
- Settlement pattern;
- Seascape pattern and foci;
- Movement;
- Lighting;
- Aspect;
- Tranquillity/remoteness/wildness;
- Exposure; and
- How the seascape is experienced.

The value of a seascape unit is also considered as expressed by designations, public attitudes, associations, and other value criteria including landscape quality, rarity, and scenic quality. Taking account of a consensus view on value is encouraged.

4.1.3 Sensitivity of visual receptors

The sensitivity of a receptor is the degree to which a particular place, accessible to people, can accommodate change without detrimental effects on its visual amenity. Sensitivity will be dependent on the location and context of a viewpoint, the expectations, occupation and activity of the receptors and the importance of the view (GLVIA, 2002). It is worth noting that '*sensitivity is more dependent on the purpose of their [the receptor(s)] presence than as the receptors as individuals*' (University of Newcastle, 2002). Sensitive observers will therefore have higher expectations of the seascape quality.

4.1.4 Magnitude of Change

The magnitude of change to visual receptors is broadly assessed in a standardised way based on GLVIA and other guidance. There are a number of factors which influence magnitude of effect. These include the size and character of development, the distance of development from a viewpoint, the degree of change in a view, the degree of contrast or integration, the duration and nature of effect [e.g. temporary/permanent, moving/still], the angle of view of a receptor and the extent of area over which changes would be visible.

Inevitably there is some variation in how the magnitude of change is defined in both the Round 1 and Round 2 SVIAs reviewed. The majority tend to follow the definitions as suggested by the GLVIA and SNH as set out below in **Table 4.1.**

Table 4.1 – Magnitude of change: names, descriptors and definitions

Magnitude / size class	Other terms used	Name	Descriptors – appearance in central vision field	Definition
Very Large	High, very high substantial, very substantial,	Dominant	Commanding, controlling the view, foremost feature, prevailing, overriding	Proposed offshore wind farm causes very large alteration to key elements / features / characteristics of the baseline seascape or visual conditions (pre-development) such that there is a fundamental change.
Large	Medium-high, moderate - substantial	Prominent	Standing out, striking, sharp, unmistakeable, easily seen	Proposed offshore wind farm causes large alteration to key elements / features / characteristics of the baseline seascape or visual conditions (pre-development) such that there is an unmistakeable change.
Moderate	Medium	Conspicuous	Noticeable, distinct, catching the eye or attention, clearly visible, well defined	Proposed offshore wind farm causes moderate alteration to elements / features / characteristics of the baseline seascape or visual conditions (pre-development) such that there is a distinct change.
Small	Low, slight, minor	Apparent	Visible, evident, obvious, perceptible, discernible, recognisable	Proposed offshore wind farm causes small loss or alteration to elements / features / characteristics of the baseline seascape or visual conditions (pre-development) such that there is a perceptible change.
Very Small	Low, slight or minor-negligible	Inconspicuous	Lacking sharpness of definition, not obvious, indistinct, not clear, obscure, blurred, indefinite, subtle	Proposed offshore wind farm causes very small loss or alteration to elements / features / characteristics of the baseline seascape or visual conditions (pre-development) such that there is a distinguishable change.
Negligible		Faint	Weak, not legible, near limit of acuity of human eye	Proposed offshore wind farm causes negligible loss or alteration to elements / features / characteristics of the baseline seascape or visual conditions (pre-

				development) such that there is no legible change.

4.1.5 Combining magnitude with sensitivity to derive significance

The study brief asks for the definition of the minimum distance offshore turbines would need to be to achieve no significant effects to shoreline observers, day and night. The threshold for a significant effect is taken as one of **moderate** significance, as defined by the BMT Cordah Round 2 SEA report (2003). This can be derived from various combinations of sensitivity of receptor and magnitude of effect [see **Table 4.2** below].

Table 4.2 - Significance of effects

Landscape and visual sensitivity	Magnitude of change				
	Very large	**Large**	**Moderate**	**Small**	**Very small**
Very high	Major	Major	Major	Major/moderate	Moderate
High	Major	Major	Major/moderate	Moderate	Moderate/minor
Medium	Major	Major/moderate	Moderate	Moderate/minor	Minor
Low	Major/moderate	Moderate	Moderate/minor	Minor	Minus/none
Very low	Moderate	Moderate/minor	Minor	Minus/none	None

Note: Those boxes of significance of effects shaded orange are considered to be significant effects, those shaded yellow may be significant. Those which are not shaded are considered not to be significant.

Assessments may use other terms for magnitude. These are set out below in **Table 4.3** below:

Table 4.3 - Terms for Magnitude

Magnitude/size class	Other terms used for magnitude
Very Large	Very high or very substantial, high or substantial. [Assessments may not differentiate between very large and large]
Large	High or substantial, medium- high or moderate – substantial. [Assessments may not differentiate between very large and large]
Moderate	Medium
Small	Low, slight, minor
Very Small	Low [slight or minor]-negligible

For individual viewpoints in certain SVIAs the assessor may have decided that the above table does not apply and the effect may be considered significant or not significant depending on particular conditions. However, in general terms **Table 4.2** is considered a sound template.

For the purposes of this study it is considered sufficient to look at the magnitude of effect only for each viewpoint so that the sensitivity of individual receptors does not confuse the findings. A pragmatic range to consider for the purposes of the brief is low and moderate magnitudes of effect which combined with high and moderate sensitivity of receptors respectively result in effects of moderate significance. Receptors of low sensitivity exist on the coast, mainly in industrial or urbanised areas. However, the extent of these areas tends to be limited and adjacent receptors in rural areas are likely to be of at least moderate sensitivity. It is highly unlikely that there will be any locations where large offshore windfarms will only be subject to views from low sensitivity receptors. Therefore to avoid any significant effects, moderate adverse magnitude of effects is used as the closest range of turbine distances to viewpoint locations advisable.

The visual effects are set out for each windfarm SVIA below and summarised in the SVIA Tables in **Appendix C**. A mean ‘average distance’ of moderate or low adverse effects and a maximum average distance have been extracted from each assessment. Analysis of the results (Section 4.4 and 4.5) have been separated for 2/3.6MW and 5/6MW turbines as these are likely to give rise to different magnitudes of effect given their size and separation distances.

4.1.6 Reliability of SVIA evidence

The SVIAs had been carried out by a range of consultancies and individuals with a range of experience in judging effects of wind turbines offshore. Experience in this field is relatively limited although, no doubt, some assessors will have been able to draw on experience of onshore wind farm assessments, although different conditions and issues apply. No third-party reviews of the SVIAs have been made available or studied. The study team have also been unable at this stage to verify the accuracy of judgments by on-site visits. Therefore the results derived from this exercise have to be considered with some caution.

4.2 Round 1 Proposals

4.2.1 Kentish Flats

Kentish Flats consists of 30 4.3MW turbines each with an expected maximum capacity of 129MW, with each turbine at 140m (height to blade tip). The site will be arranged in a regular grid of five east-west rows, spacing between each turbine will be a minimum of 700m, but in the predominantly south-westerly wind direction, this spacing will be about 1200m.

The Kentish Flats Environmental Statement and Non-Technical Summary used for this analysis were extracted from the COWRIE Database.

12 viewpoints were chosen to represent the visual study area as part of the ES; basic viewpoint information can be found in **Appendix C1**. Detailed assessment information which considers the perceptual effects of Kentish Flats on each viewpoint receptor can be found in **Appendix C1**. Analysis of the relative maximum and average distances for viewpoint receptors with low or moderate magnitudes of change can be found in **Table 4.4**.

Table 4.4 – Analysis of Kentish Flats: Visual Impact Assessment

Maximum Distance where Low Magnitude of Effect occurred	26.9km
Average Distance where Low Magnitude of Effect occurred	21.1km
Maximum Distance where Medium Magnitude of Effect occurred	12.1km
Average Distance where Medium Magnitude of Effect occurred	11.2km

4.2.2 North Hoyle

North Hoyle Wind Farm has been in operation since November 2003. The wind farm consists of 30 turbines with a maximum capacity of 60MW. The wind turbine generators are 2MW Vestas and have a height to blade tip of 130m.

The North Hoyle Environmental Statement used for this analysis was extracted from the NPower Website.

12 viewpoints were chosen to represent the visual study area as part of the ES; basic viewpoint information can be found in **Appendix C1**. Detailed assessment information which considers the perceptual effects of North Hoyle on each viewpoint receptor can be found in **Appendix C1**. Analysis of the relative maximum and average distances for viewpoint receptors with low or moderate magnitudes of change can be found in **Table 4.5**.

Table 4.5 – Analysis of North Hoyle: Visual Impact Assessment

Maximum Distance where Low Magnitude of Effect occurred	21.8km
Average Distance where Low Magnitude of Effect occurred	18.28km
Maximum Distance where Medium Magnitude of Effect occurred	13.5km
Average Distance where Medium Magnitude of Effect occurred	11.17km

4.3 Round 2 Proposals

4.3.1 Gunfleet Sands 2

Gunfleet sands 2 is the second wind farm developed by GE Energy following Gunfleet Sands 1 located approximately 8.5-10km off the South East coastline. The development consists of 22 turbines spread across 7.5km² in two rows facing in a north-easterly to south-west direction. The site has a maximum capacity of 64MW with 3.6MW Wind Turbine Generators (WTG) which have a height to blade tip of 135m.

The Gunfleet Sands 2 Non-Technical Summary and Seascape and Visual Assessment used for this analysis were extracted from the COWRIE database.

8 viewpoints were chosen to represent the visual study area as part of the ES; basic viewpoint information can be found in **Appendix C2**. Detailed assessment information which considers the perceptual effects of Gunfleet Sands 2 on each viewpoint receptor can be found in **Appendix C2**. Analysis of the relative maximum and average distances for viewpoint receptors with low or moderate magnitudes of change can be found in **Table 4.6**.

Table 4.6 – Analysis of Gunfleet Sands 2: Visual Impact Assessment

Maximum Distance where Low Magnitude of Effect occurred	19.6km
Average Distance where Low Magnitude of Effect occurred	14.0km
Maximum Distance where Medium Magnitude of Effect occurred	*Moderate Magnitude of Change – N/A*
Average Distance where Medium Magnitude of Effect occurred	*Moderate Magnitude of Change – N/A*

4.3.2 Lincs

The proposed Lincs development is expected to consist of 83 turbines with a maximum capacity of 250MW covering an area of 35km². The turbines are to be orientated in a north-south direction and located in water depths of 8-18m, approximately 8km from the coast of Skegness.

The Lincs Seascape and Visual Impact Assessment and Non-Technical Environmental Statement used for this analysis were extracted from the COWRIE Database. The assessment was carried out assuming a worst-case scenario based upon 41 6MW turbines in a monopole structure with a maximum height of 170m above Mean Sea Level (MSL).

8 viewpoints were chosen to represent the visual study area as part of the ES; basic viewpoint information can be found in **Appendix C2**. Detailed assessment information which considers the perceptual effects of Lincs on each viewpoint receptor can be found in **Appendix C2**. Analysis of the relative maximum and average distances for viewpoint receptors with low or moderate magnitudes of change can be found in **Table 4.7**.

Table 4.7 – Analysis of Lincs: Visual Impact Assessment

Maximum Distance where Low Magnitude of Effect occurred	*Low Magnitude of Change - N/A*
Average Distance where Low Magnitude of Effect occurred	*Low Magnitude of Change - N/A*
Maximum Distance where Medium Magnitude of Effect occurred	8.3km
Average Distance where Medium Magnitude of Effect occurred	8.3km

4.3.3 London Array

The proposed London Array wind farm development is situated between the Kent and Essex Coastlines and will consist of 271 turbines covering an area of 245km² in water depths up to 23m.

In order to carry out the assessment, the London Array Landscape, Seascape Visual Assessment was extracted from the COWRIE website. The assessments assumed a worst case scenario using 7MW turbines and have a height to blade tip of 175m.

18 viewpoints were chosen to represent the visual study area as part of the ES; basic viewpoint information can be found in **Appendix C2**. Detailed assessment information which considers the perceptual effects of London Array on each viewpoint receptor can be found in **Appendix C2**. Analysis of the relative maximum and average distances for viewpoint receptors with low or moderate magnitudes of change can be found in **Table 4.8**.

Table 4.8 – Analysis of London Array: Visual Impact Assessment

Maximum Distance where Low Magnitude of Effect occurred	21.0km
Average Distance where Low Magnitude of Effect occurred	21.0km
Maximum Distance where Medium Magnitude of Effect occurred	*Moderate Magnitude of Change – N/A*
Average Distance where Medium Magnitude of Effect occurred	*Moderate Magnitude of Change – N/A*

4.3.4 Thanet

The proposed Thanet offshore wind farm is located off the South East coastline. The SVIA assumed 60 5MW monopole wind turbine generators, with a maximum capacity of 300MW and a height to blade tip of 150m. The total wind farm area is 35km².

In order to carry out the assessment, the Thanet Landscape, Seascape Visual Assessment was extracted from the COWRIE website.

10 viewpoints were chosen to represent the visual study area as part of the ES; basic viewpoint information can be found in **Appendix C2**. Detailed assessment information which considers the perceptual effects of Thanet on each viewpoint receptor can be found in **Appendix C2**. Analysis of the relative maximum and average distances for viewpoint receptors with low or moderate magnitudes of change can be found in **Table 4.9**.

Table 4.9 – Analysis of Thanet: Visual Impact Assessment

Maximum Distance where Low Magnitude of Effect occurred	27.7km
Average Distance where Low Magnitude of Effect occurred	21.6km
Maximum Distance where Medium Magnitude of Effect occurred	17.5km

Average Distance where Medium Magnitude of Effect occurred	17.5km

4.3.5 Walney

The proposed Walney offshore wind farm is located off the North West Coastline. The SVIA assumed 102 6MW wind turbine generators at have a height to blade tip of 202.5m.

In order to carry out the assessment, the Walney Landscape, Seascape Visual Assessment was extracted from the COWRIE website.

18 viewpoints were chosen to represent the visual study area as part of the ES; basic viewpoint information can be found in **Appendix C2**. Detailed assessment information which considers the perceptual effects of Walney on each viewpoint receptor can be found in **Appendix C2**. Analysis of the relative maximum and average distances for viewpoint receptors with low or moderate magnitudes of change can be found in **Table 4.10**.

Table 4.10 – Analysis of Walney: Visual Impact Assessment

Maximum Distance where Low Magnitude of Effect occurred	23.4km
Average Distance where Low Magnitude of Effect occurred	23.3km
Maximum Distance where Medium Magnitude of Effect occurred	18.8km
Average Distance where Medium Magnitude of Effect occurred	16.5km

4.3.6 West of Duddon Sands

The proposed West of Duddon offshore wind farm is located off the North West coastline. The SVIA assumed 139 3.6MW monopole wind turbine generators with a maximum capacity of 500MW and have a height to blade tip of 150m. The total wind farm area is 880km².

In order to carry out the assessment, the West of Duddon Landscape, Seascape Visual Assessment was extracted from the COWRIE website.

18 viewpoints were chosen to represent the visual study area as part of the ES; basic viewpoint information can be found in **Appendix C2**. Detailed assessment information which considers the perceptual effects of West of Duddon Sands on each viewpoint receptor can be found in **Appendix C2**. Analysis of the relative maximum and average distances for viewpoint receptors with low or moderate magnitudes of change can be found in **Table 4.11**.

Table 4.11 – Analysis of West of Duddon Sands: Visual Impact Assessment

Maximum Distance where Low Magnitude of Effect occurred	26.3km
Average Distance where Low Magnitude of Effect occurred	23.3km
Maximum Distance where Medium Magnitude of Effect occurred	14.6km
Average Distance where Medium Magnitude of Effect occurred	11.1km

4.3.7 Gwynt Y Môr

The proposed Gwynt Y Môr offshore wind farm is located off the North Wales coastline. The SVIA assumed 150 5MW monopole wind turbine generators with a maximum capacity of 750MW and have a height to blade tip of 165m.

In order to carry out the assessment, the Gwynt Y Môr Landscape, Seascape Visual Assessment was extracted from the COWRIE website.

10 viewpoints were chosen to represent the visual study area as part of the ES; basic viewpoint information can be found in **Appendix C2**. Detailed assessment information which considers the perceptual effects of Gwynt Y Môr on each viewpoint receptor can be found in **Appendix C2**. Analysis of the relative maximum and average distances for viewpoint receptors with low or moderate magnitudes of change can be found in **Table 4.12**.

Table 4.12 – Analysis of Gwynt Y Môr: Visual Impact Assessment

Maximum Distance where Low Magnitude of Effect occurred	35.8km
Average Distance where Low Magnitude of Effect occurred	28.0km
Maximum Distance where Medium Magnitude of Effect occurred	15.3km
Average Distance where Medium Magnitude of Effect occurred	14.3km

4.3.8 Beatrice Demonstration Project

The Beatrice Demonstration offshore wind farm is located off the East coast of Scotland. The SVIA assumed 2 5MW monopole wind turbine generators with a maximum capacity of 10MW.

In order to carry out the assessment, the Beatrice Environmental Statement was extracted from the Beatrice Demonstration website.

11 viewpoints were chosen to represent the visual study area as part of the ES; basic viewpoint information can be found in **Appendix C2**. Detailed assessment information which considers the perceptual effects of Beatrice on each viewpoint receptor can be found in **Appendix C2**. Analysis of the relative maximum and average distances for viewpoint receptors with low or moderate magnitudes of change can be found in **Table 4.13**.

Table 4.13 – Analysis of the Beatrice Demonstration Project: Visual Impact Assessment

Maximum Distance where Low Magnitude of Effect occurred	41.0km
Average Distance where Low Magnitude of Effect occurred	30.3km
Maximum Distance where Medium Magnitude of Effect occurred	*Moderate Magnitude of Change – N/A*
Average Distance where Medium Magnitude of Effect occurred	*Moderate Magnitude of Change – N/A*

4.4 Analysis of SVIAs

Results from each SVIA concerning the viewpoint receptors subject to Medium or Low Magnitudes of Change were collated into wind turbine generation models (i.e. 3.6MW and 5-6MW) and averaged**.**

The conclusions of the analysis are that for 2/3.6MW turbines windfarms, the average distance where medium magnitude of effect occurs is around **11.2km** and the average for low magnitude of effect is **19.2km**. For 5/6MW turbine windfarms the average distance where medium magnitude of effect occurs is around **14km** and the average for low effect is around **26km**. The result for the one wind farm with 7 MW turbines is a low effect at a **21km** distance. This last figure is regarded as statistically insufficient evidence.

4.5 Further Analysis

Following the initial analysis of the SVIAs, further time has been spent on reviewing the number of wind farms considered within each SVIA baseline assessment. This analysis has shown that about half of the SVIAs analysed have included other existing or consented windfarms. In these assessments the effects of the proposed windfarms are considered as additional visual impacts rather than a standalone visual impact on currently 'unaffected' coasts. Therefore, there is potential for a perception of a reduced level of impact. To distinguish how this could affect the magnitude of impact distance, it has been necessary to split the two types of windfarm assessments.

Lincs wind farm was identified as an anomaly to the rest of the SVIAs for Round 2 wind farms with a much lower set of distances for the magnitudes of change; this is because two Round 1 Wind Farms have been included within the baseline assessment. Therefore, an assessment of average distances has been carried out with/without Lincs Offshore Wind Farm.

Tables indicating the category of each wind farm can be found in **Appendix D**.

Following the initial set of conclusions in Section 4.4, the results show that:

- For 2/3.6MW turbine wind farms with no other wind farms considered in the baseline assessment, the average distance for a moderate magnitude of effect is **11.2km** and the average distance for a low magnitude of effect is **19.7km**.
- For 2.3.6MW turbine wind farms with other wind farms considered in the baseline assessment, the average distance for a moderate magnitude of effect is **11.1km** and the average distance for a low magnitude of effect is **18.7km**.
- For 5-6MW turbine wind farms with no other wind farms considered in the baseline assessment, the average distance for a moderate magnitude of effect is **17.5km** and the average distance for a low magnitude of effect is **25.9km**.
- For 5-6MW turbine wind farms with other wind farms (and Lincs not included) considered in the baseline assessment, the average distance for a moderate magnitude of effect is **15.0km** and the average distance for a low magnitude of effect is **25.7km**.
- For 5-6MW turbine wind farms with other wind farms (and Lincs included) considered in the baseline assessment, the average distance for a moderate magnitude of effect is **13.0km** and the average distance for a low magnitude of effect is **25.7km**.

5 Review of Lighting Effects

This chapter briefly considers the requirements for lighting and discusses SVIAs assessments of the impact of lighting.

5.1 Lighting requirements

5.1.1 Navigational lighting

The requirements for navigational lighting are set out in the IALA Recommendation O-117. Towers should be painted yellow to 15m above the Highest Astronomical Tide [HAT]. Lighting should be exhibited between 6m and 15m above HAT. Lighting on the corners of windfarms should have a minimum visibility of five nautical miles (9km) with intermediate lighting having a visibility of no less than two nautical miles (3.6km).

5.1.2 Aviation lighting

The general requirements for aircraft warning lighting are set out in the Civil Aviation Authority (CAA) '*Article 134*' requirements. Section 1 Part 13 refers to *Lighting of Wind Turbine Generators in United Kingdom Territorial Waters*.

Article 134 refers to a set of lighting requirements that must be displayed when considering wind turbine generators 60m or above at the Highest Astronomical Tide (HAT). Each structure must be fitted with at least one medium intensity steady red light as close as reasonably practicable to the very top.

If visibility in all directions from each turbine is greater than 5km, the light intensity may be reduced to no less than 10% of the minimum peak intensity. In any particular case during consultation, the CAA may direct additional lighting to wind turbine generators.

5.2 SVIA Lighting assessments and Conclusions

5.2.1 Summary

The assessments for each SVIA are found in **Appendix E**. Most state that lighting will be implemented in line with Trinity House or IALA requirements for navigational lighting and to CAA requirements for aviation lighting. Whilst the navigational lighting distances are stated [9km minimum] in most SVIAs, the effects of this lighting are considered to be minimal given the visual effects of wind turbines during the daytime. This is due to the fewer number of light sources than turbines, their small scale and 'point' character in comparison with the size and bulk of wind turbines and the reduction in the number of sensitive receptors at night. For wind farms further offshore, lighting will potentially be located below the horizon therefore rendering the effect non-existent.

Aviation lighting distances are only mentioned in the Beatrice Demonstration Project. The Beatrice ES states that '*Two red flashing aeronautical obstruction lights would be mounted upon the nacelle of each turbine…assuming an observer is at the same elevation as the lights and is looking at them at night and in good visibility, they should be visible to a distance from the turbines of 10.8 nautical miles (20km)*'. Environmental conditions such as the level of light and the position of the observer have not been described elsewhere within the report on the assumption that a level observer at night-time would be the worst case scenario.

According to the Beatrice ES, each Beatrice turbine nacelle is located 88m above sea level. It may therefore be possible that the aviation lighting may be viewed from further distances. However, without further evidence, it is not possible to say whether the effects of this would be significant.

6 The International Perspective

6.1 Extent of Research

Full research into each country has not yet been fully completed due to the limited timescale of the first stage of the project and the lack of information in English. The commentary below outlines the main findings to date. Table 6.1 indicates constructed and approved offshore wind farms in Europe. **Table 6.1 – Constructed and approved wind farms in Europe**

Country	Name of Wind Farm	Turbine Size (MW)	No. Turbines	Distance from Shore
Denmark	Horns Rev 1	2	80	14
	Horns Rev 2	2.3	92	20
	Tunø Knob	2.2	11	6
	Middelgrunden	2	20	2
	Nysted	2.2	72	10
	Samsø	2.3	10	3.5
Germany	Aplha Ventus	5	6	43
	Amrumbank West	3.5-5	80	36
	BARD Offshore I	5	80	89
	Borkum Riffgrund	3	77	34
	Borkum Riffgrund West	3.5	80	50
	OSB Offshore- Bürger- Windpark Butendiek	3	80	37
	Dan Tysk	5	80	70
	Global Tech I	5	80	93
	Offshore North Sea Windpower	4-5	48	40
	Gode Wind	5	80	33
	Hochsee Windpark, He dreiht	3.6-5	80	85
	Hochsee Windpark Nordsee	5	80	90
	Nordsee Ost	4-5	80	30
	Offshore- Windpark Nordergründe	5	25	13
	Nördlicher Grund	3-5	87	86
	Meerwind	5	80	15-50
	Sandbank 24	5	80	90
	Offshore NorthSea Windpower	5	48	39
Belgium	Thornton Bank phase 1	5	6	27-30
	Thornton Bank phase 2	5	18	27-30
Netherlands	Egmond aan Zee	3	36	10-18
	Wind-park Q7	2	60	23
Sweden	Lillgrund	3	48	10
	Yttre Stengrund	2	5	4
	Utgrunden I	1.5	7	7
	Bockstigen	0.56	5	3
Republic of Ireland	Arklow Bank	3.6	7	7

Across Europe, large offshore schemes are subject to direct Governmental involvement in the selection of offshore development zones in order to avoid any conflicts. A common pattern that is occurring with European wind farms outside of the UK is the response to public perception and preventing visual intrusion to onshore receptors. Table 6.1 indicates that many developments are significant distances offshore, especially those in German waters.

This is shown more clearly in Table 6.2 which highlights the correlation between larger turbines and the scale of offshore development, and how it can influence the distance offshore in order to prevent any potential conflict.

Table 6.2 – Turbine size, development size and distance offshore for European wind farms

Turbine Size	Average No. of Turbines	Average Distance Offshore
0.5MW – 1.9MW	6	5km
2MW – 3MW	49	13.6km
3.1MW – 3.6MW	44	28.5km
5MW	61	55.7km

6.2 Approaches – Nation by Nation

6.2.1 Denmark

Early research into the visual impacts of offshore winds in Europe was carried out by Enviros Consulting Ltd, this confirmed that '*relatively little work has been undertaken in Denmark to assess the visual impact and public attitude*'. The report considered the visual assessment conclusions for Horns Rev and Nysted. The EIA assessment of Horns Rev concluded that visual impacts would be minimal given the scale of the project and the fact that the wind farm was 15-20km offshore. At Nysted, where the wind farm can be found at a much closer distance to the coastline of Lolland-Folster, the EIA recognised that the turbine array is a '*significant element in the coastal landscape*'.

Research into the International guidance and perspective on seascape and visual assessments has been sought through a number of sources, including the Danish Energy Agency (DEA) and Danish Forest and Nature Agency (DFNA). Although seascape and visual impacts are considered within the environmental process, there does not appear to be as much emphasis on a suggested buffer distance other than the limitations of the territorial boundaries.

As picked up within the 'Future Offshore Wind Power Sites – 2025 (DEA) '*It is estimated that depending on visibility conditions large scale offshore wind farms will be visible from a distance of 20 km for 125 m high turbines and 34 km for 260 m high turbines. Thus, turbine height greatly affects visibility. In calm conditions visibility across the sea is extremely good, but due to changing weather conditions visibility will be partially or substantially reduced most days of the year; there are only few days each year when visibility exceeds 19 km*'.

Having reviewed the EIA summary documents for Horns Rev, Nysted, Rodsand 2, and experiences from Middelgrunden, the research carried out by the Enviros Consulting Ltd appears to be true. Although visualisation and landscape issues are discussed within these reports, there is no mention of buffer distances and guidance to which they should refer to. Consideration has been given to the appearance of the wind turbines (colour/height) and their distance offshore; however, public involvement within the decision making tends to reduce the risk of refusal.

At public exhibitions held during the planning process, members of the public are given the opportunity to choose between different scenarios (mainly differing in turbine numbers, distance offshore and the height of the turbines). As stated in a study by Hans Christian Sorenson et al (2002) which looked at lessons learnt from Middelgrunden Wind Farm, '*a more pro-active willingness for the public to participate in the decision process through co-operative schemes, where local people are able to share expenses and income from a wind project, supports acceptance at a local level where the possibility of resistance is usually high due to the environmental impacts*'. Middelgrunden wind farm, which received very little resistance considering the visual impact of large turbines just 2-3.5km away from a very popular recreational area, the reason for which is believed to be the strong public involvement, both financially and in the planning phase.

6.2.2 Germany

Guidance provided by the *Bundesamt Für Seeschifffahrt und Hydrographie* called '*Investigation of the Impacts of Offshore Wind Turbines on the Marine Environment*' suggests that a photorealistic simulation (text and visualisation) of the landscape affected by the wind farm in question must be presented, unless the project is located further than 50km from the nearest point on the coastline.

Future areas of wind farm developments in the North Sea and Baltic Sea are predominantly located in areas outside of the territorial limit. Nearly all German projects are planned for areas that are much more than 30km from the coast and in waters 20-25m in depth. This is a consequence of the heavy use of the German coastal waters for shipping, gravel extraction and military use. But in addition, most planners voluntarily keep to a minimum distance of 30km from the shore, as a result the wind farms become hardly visible from land or from the German Islands (German Energy Agency).

6.2.3 Belgium

To date, offshore windfarm development off Belgium's coast has been limited. The Electrabel development 12.5km off the coast at Knocke was granted a concession in March 2002. This was subsequently withdrawn by the Government due to local opposition. Following this, subsequent applications for other windfarms between 5km and 16.5 km offshore were also rejected.

In June 2004 an offshore windfarm zone was defined by the Government running from just inside the 12 nautical mile (22.2km) territorial waters out to sea. Within this area there has been considerable interest and three applications have been granted. These are at Thornton Bank 27km offshore, Bank zonder Naam (Eldepasco) 38km off shore and Bligh Bank (Belwind) 42km offshore. There is pressure now to extend the size of the windfarm zone available. The Thornton Bank visual impact assessment states that as the windfarm will be at 27 km from the coast, the visibility of the wind turbines will be very limited and heavily dependent on the weather. The effect of the windfarm is judged to be slightly negative to non-existing.

In order to move forward, the Belgian initiative for placements of offshore wind farms is similar to Germany. Offshore Zones have been allocated to lease wind farm developments that are too far for visual intrusion.

6.2.4 Netherlands

The Netherlands have established a 'Near Shore Windfarm' demonstration project at Egmond a Zee to gain knowledge and experience to use further offshore. This temporary project is 8km from the shore in territorial waters.

An Exclusive Economics Zone has been established 12 nautical Miles offshore. The target for energy production is 6,000MW which the government estimates to be able to be delivered in 750km² (15 windfarms covering 50km² maximum each). In practice it is considered that no large-scale wind farms will be closer than 25km from the coast.

6.2.5 United States of America (USA)

The best example of an offshore wind development seascape and visual assessment is Cape Cod. Although there appears to be no formal visual buffers with which developers are required to adhere to, consideration into the seascape, landscape and historic landscape must be assessed in order to meet the National Environmental Protection Act (NEPA).

The '*Cultural and Recreational Resources and Visual Studies*' section of the draft Environmental Impact Report (DEIR) and the supporting *Visual Impact Assessment of Multiple Historic Properties* Appendix, both made public in January 2008, provide an overview of visual assessment methodology. Other associated assessments including a *Seascape and Shoreline Visibility Assessment* have been reviewed.

Although visual assessments have been included within the DEIR, the methodological approach compelled by national law and regulations does not focus on any visual distance guidelines. On a similar level to UK methodology, areas of sensitivity (in this case historic landmarks aboveground and recreational users) are assessed for any potential adversities to their setting from the wind farm development. However, the levels of adversity are not determined against a benchmark or set of guidelines.

6.3 Summary

The visual assessment of offshore wind farms across Europe and North America are progressively becoming more essential within environmental assessment work. However, the level of guidance and influence of visual buffer zones remains unclear. Overall, European countries appear to be adopting an approach that rules out or minimises visual intrusion as an environmental consideration. Outside of Europe, there is no clear indication of how the visual impacts influence decision making.

Denmark has identified a number of offshore ‘wind park’ locations to meet offshore renewable energy targets. The DEA and DFNA have both recognised the importance of visual assessments in the planning process as recognised in published documents; however, evidence suggests from previous EIA work in Denmark that public interaction at an early stage is more beneficial than setting offshore limits. The main reason for this is the acceptance of offshore wind farms and a full understanding of its benefits to the local community. This is perhaps a concept that is not yet fully established within the UK.

In Germany, planners appear to favour a 30km visual buffer to deter any refusals based on the visual and noise impacts. Not only does this assist in planning consent, but it also prevents any conflicts with other nautical activities around the coastline. Alternatively, the trend in the Netherlands and Belgium now appears to be to allocate areas 12 nautical miles [22km] from the coast as a minimum.

From reviewing the Cape Cod DEIR, visual impact assessment in the USA appears to concentrate on aboveground historic landmarks and settings rather than coastline sensitivity and significance of varying visual change as a whole. Therefore, at present there is limited information to suggest that a recommended visual distance has been set or will be in the near future.

Overall, information available for the allocation of offshore wind farm buffers across Europe and North America is limited. A number of sources have been reviewed to establish trends and experiences that have helped to inform wind farm spatial planning. Public participation is crucial in establishing support and acceptance of the visual impact, the examples above clearly indicate that greater distances are being considered to prevent refusal on visual grounds and problems to navigational/communication lines operating around the coastline at closer distances.

Guidance in determining the extent of the visual impact also appears to be limited outside of the UK. Seascape and landscape issues are considered in a more general context and visualisations are encouraged, however, these are not tested against a particular benchmark level of significance.

7 Wireframe Analysis

7.1 Introduction

The size of developments likely to be constructed as a result of Round 3 and subsequent leases will be defined by practical considerations such as maintaining safe access between windfarm blocks, maintaining wind speed and avoiding wind steal. A BWEA study suggests that in order to achieve this, windfarm blocks using 5MW turbines may be 7km by 11km in size separated from surrounding blocks by 5km in all directions. This would achieve a 500MW output per block. However, a note of caution is introduced in the report as to the potential for large areas of windfarms to reduce the overall wind speed and therefore the output of each windfarm. Spacing may need to be increased both between turbines and turbine blocks as new information is received.

Using this model there is the potential for large blocks of wind turbines to be arranged on the skyline, with associated movement and lighting. This suggests a requirement for a 'minimum distance' between each block to be established with regard to seascape issues.

The aim of the wireframe analysis is to act as a visual aid to assess the apparent magnitude of effect of different generic windfarm scenarios, to act as a comparison to, and check against, the SVIA visualisations studied in Chapter 4, and for the purpose of informing the DECC Offshore Energy SEA. The wireframes will not only be used to inform these preliminary working paper conclusions but will also be taken on site to compare with existing offshore windfarms.

7.2 Outline Method

A scenario has been developed to reflect a typical or generic wind farm that might be constructed as part of Round 3 or subsequent developments. Developments utilising three different sizes of wind turbine have been considered – 3.6MW, 5MW and 10MW. The 3.6MW size is based on those typical of some Round 1 and Round 2 sites. The 5MW has been implemented at Beatrice and Thornton Bank at a limited scale and is used as an upper size for proposed Round 2 sites. A 10MW turbine is now under development by Clipper [initially mooted as a 7.5MW output]. This is perceived as being at the upper end of what is currently technically possible in offshore locations.

The dimensions of turbines have been ascertained through research in SVIAs and through talking to manufacturers. In deeper water at +40m depth the use of Quattro-pod bases/foundations would be expected and this has been applied to the 10MW scenario although may also be appropriate for the 5 MW turbines as at Beatrice. For each turbine size an indicative block layout has been devised which approximately equates to 500MW output, although the 3.6MW layout is slightly larger than this. The turbines are placed in an offset grid with spacing in accordance with outline findings of a BWEA offshore report (BWEA, 2008).

For each layout, wireframe views on the coast have been derived at viewing heights of 6m, 22m and 100m above sea level. These simulate views respectively from promenades, low-lying hills such as found in eastern England and from cliffs and coastal hills found in parts of England, Scotland and Wales. It should be noted that there are several other areas along the coast which reach significantly higher elevations (e.g. Exmoor, Beachy Head).

The 3.6MW turbine layout views from the coast have been derived at distances of 13km, 18km and 24km. The 5MW turbine layout views from the coast have been derived at distances of 13km, 18km, 24km and 35km. The 10MW turbine layout views from the coast have been derived at distances of 18km, 24km and 35km. It is considered that these represent a realistic range to explore the magnitude of effects.

The effects of the curvature of the Earth and the refraction of light through the earth's atmosphere have been taken into consideration.

Images are at a size to be viewed at a normal, comfortable distance [500mm and 440mm] and the size of image represents the normal area of vision in focus, excluding the area of peripheral vision.

It should be noted that there are limitations with this wireframe method of visualisation. The turbines are rendered grey rather than white or very light grey and yellow. The sea is only indicated by a single horizon line with white sky and white sea. The effect of the atmosphere creating haze has not been taken into consideration. The wireframes do not represent the movement of turbines and do not catch the light. Overall, while the size of turbines is considered to be an accurate representation, on balance the above factors may mean the wireframes exaggerate the contrast of the turbines with their background.

A sample of wireframes viewed from a height of 22m above sea level is included in **Appendix F**.

7.3 Preliminary conclusions

There is a significant difference between the visual effect of 3.6MW, 5MW and 10MW turbines. This is because of the height of turbines, width of tower, the size of blade sweep and foundation. The 3.6MW scenario has more turbines at a closer spacing in order to achieve the same power output and this gives a more confused, denser visual image. However, it is considered that larger arrays with a greater number of turbines are likely to be implemented in future licensing rounds, and these may well achieve the same apparent densities of image and so this factor has been ignored. Cumulative effects have not been taken into consideration. It is likely that any visual effects would be increased with greater areas of the horizon being covered by wind turbines.

Initial evaluations for the scenarios viewed from 22m above sea level are set out in **Table 8.1**. These are the result of a viewing by one landscape architect without verification and review and therefore should be considered with caution.

Table 7.1 – Initial view of potential magnitude of effects for each scenario viewed at 22m above sea level

Size of turbine [MW]	Distance from shore			
	13km	**18km**	**24km**	**35km**
3.6	Medium [possibly medium-large]	Small-medium	Very small	n/a
5	Medium-large	Medium	Small	Very small/negligible
10	Large	n/a	Small	Very small/negligible

*Note: magnitude of effect based on size classes set out in **Table 4.1** Section 4.1.4.*

Based on the above, for high sensitivity seascape units and receptors [where a low or small magnitude of effect is found at the following maximum thresholds]:

- For 3.6MW turbines the threshold of no significance is just beyond 18km.
- For 5MW turbines the threshold of no significance is beyond 24km.
- For 10MW turbines the threshold of no significance is beyond 24km.

For medium sensitivity seascape units/receptors [where a medium magnitude of effect is found at the following maximum thresholds]:

- For 3.6MW turbines the threshold of less than moderate significance is beyond 13km.

- For 5MW turbines the threshold of less than moderate significance is beyond 18km.
- For 10MW turbines the threshold of less than moderate significance is likely to be beyond 18km.

8 Preliminary Conclusions

8.1 Round 2 SEA

The SEA was based on the current best practice and guidance. The distances for magnitude of effects were derived from initial research by CCW and others without the benefit of assessment of windfarm proposals such as SVIAs or a review of constructed offshore windfarms. The conclusions were:

- Substantial/high effect: 0-8km
- Moderate/medium effect: 8-13km
- Minor/low effect: 13-24km
- Negligible effect: 24km+

In order to avoid significant effects, the outer limits of each of these ranges were applied i.e. 8km the closest distance for low sensitivity coasts, 13km for medium sensitivity coasts and 24km for high sensitivity coasts.

8.2 Analysis of SVIAs

The conclusions of the SVIA analysis are that for 2/3.6MW turbines windfarms the average distance where medium magnitude of effect occurs is around **11.2km** and the average for low magnitude of effect is **19.2km**. For 5/6MW turbine windfarms the average distance where medium magnitude of effect occurs is around **21km** and the average for low effect is around **26km**. The result for one wind farm with 7 MW turbines is a low effect at a **21km** distance. This last figure is regarded as statistically insufficient evidence to be used as a sound conclusion since it was only possible to obtain one SVIA with 7MW turbines and one viewpoint with this evaluation. It therefore does not provide a robust number of data or a suitable range of distances to analyse.

An issue requiring further consideration has been the effects of cumulative impact on potential buffers. It has been found that about half of the windfarms SVIAs analysed have included other existing or consented windfarms in their baseline analysis. In these assessments the effects of the proposed windfarms are therefore considered as additional visual impacts rather than a standalone visual impact on currently ‘unaffected’ coasts. There is potential here for a perception of a reduced level of impact. Therefore it has been considered necessary to split the two types of windfarm assessments. The figures show a slight difference between the two types.

The main change to the previous analysed figures is the exclusion of Teesside windfarm assessment. It is considered that its location 1.5km offshore and its proximity to the Corus steelworks (and other detractors) is not helpful in determining buffers for the majority of UK coastline. The revised findings are brought together in **Tables 8.1 and 8.2**.

8.3 Lighting effects

IALA requirements for navigational lighting are 9km minimum effective distance for the main corner lighting beacons at between 6m and 15m above sea level.

Article 134 refers to a set of lighting requirements that must be displayed when considering wind turbine generators 60m or above at the Highest Astronomical Tide (HAT). Each structure must be fitted with at least one medium intensity steady red light as close as reasonably practicable to the very top.

Aviation lighting distances is only mentioned in the Beatrice Demonstration Project. The Beatrice ES states that ‘*Two red flashing aeronautical obstruction lights would be mounted upon the nacelle of each turbine…assuming an observer is at the same elevation as the lights and is looking at them at night and in good visibility, they should be visible to a distance from the turbines of 10.8 nautical miles (20km)*’.

8.4 International perspective

Denmark has identified a number of offshore 'wind park' locations to meet offshore renewable energy targets. Evidence suggests from previous EIA work in Denmark that public interaction at an early stage is more beneficial than setting offshore limits.

In Germany, planners appear to favour a 30km visual buffer to deter any refusals based on the visual and noise impacts. The trend in the Netherlands and Belgium now appears to be to allocate areas 12 nautical miles [22km] from the coast as a minimum.

In the USA, from the example reviewed, visual impact assessment concentrates on above ground historic landmarks and settings rather than coastline sensitivity and significance of varying visual change as a whole. Therefore, at present there is limited information to suggest that a recommended visual distance has been set.

Overall, information available for the allocation of offshore wind farm buffers across Europe and North America is limited. Public participation is crucial in establishing support and acceptance of the visual impact, the examples above clearly indicate that greater distances are being considered to prevent refusal on visual grounds and problems to navigational/communication lines operating around the coastline at closer distances.

8.5 Wireframe analysis

There is a significant difference between the visual effect of 3.6MW, 5MW and 10MW turbine scenarios. Based on preliminary analysis, which needs review, for high sensitivity seascape units and receptors [where a low or small magnitude of effect is found at the following maximum thresholds]:

- For 3.6MW turbines the threshold of no significance is just beyond 18km.
- For 5MW turbines the threshold of no significance is beyond 24km.
- For 10MW turbines the threshold of no significance is beyond 24km.

For medium sensitivity seascape units/receptors [where a medium magnitude of effect is found at the following maximum thresholds]:

- For 3.6MW turbines the threshold of less than moderate significance is beyond 13km.
- For 5MW turbines the threshold of less than moderate significance is beyond 18km.
- For 10MW turbines the threshold of less than moderate significance is likely to be beyond 18km.

8.6 Preliminary conclusions

The preliminary findings are brought together in **Tables 8.1** and **8.2**:

Table 8.1 – Low/small magnitude of effect threshold- buffers for high sensitivity seascapes

Size of turbine [height to blade tip and output]	Distances offshore [km]			
	Round 2 SEA	SVIA analysis average [no other windfarms]	SVIA analysis average [additional to other windfarms]	Wireframe analysis
137m/3.6MW	n/a	19.5	18.5	18+
Up to 160m	13-24	n/a	n/a	n/a
175m/5MW	n/a	26	25.5	24+
10MW	n/a	n/a	n/a	24+

Table 8.2 – Medium magnitude of effect threshold- likely minimum buffers for high sensitivity seascapes

Size of turbine [height to blade tip and output]	Distances offshore [km]			
	Round 2 SEA	SVIA analysis average [no other windfarms]	SVIA analysis average [additional to other windfarms]	Wireframe analysis
137m	n/a	11	11	13+
Up to 160m	8-13	n/a	n/a	n/a
175m/5MW	n/a	17.5	13	18+
10MW	n/a	n/a	n/a	18+

The SVIA average [no other windfarms] highlighted in orange is probably the most reliable indicator of minimum buffers for 3.6MW and 5MW turbines. These now appear to be similar to wireframe analysis, which gives some confidence in the results, albeit further information still needs to be assessed as part of the wider project. The minimum distance for 10MW turbines has not been defined, other than it is more than 18km but less than 24km to achieve a medium magnitude of effect and more than 24km but less than 35km to achieve a low magnitude of effect.