Scottish Natural Heritage

Visual Representation of Wind Farms

Version 2.1

December 2014

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad

CONTENTS

1 Introduction

1 'Pictures speak louder than words'. Images are a powerful way of conveying information, illustrating options and capturing our imagination. They also form an important part of planning applications and Environmental Statements. The landscape and visual assessment of wind farms, however, involves much more than just looking at visualisations.

2 This guidance is aimed at landscape practitioners, those involved in producing visual representations of wind farms and at planning officers or decision makers involved in the planning process. A condensed version aimed at members of the public is also available on our website. The visualisations described are designed for use by **all** stakeholders within the planning process.

3 Visualisations are very useful in communicating information, but they can never tell the whole story. They cannot replicate the experience of seeing a wind farm in the landscape, whether they are photographs, maps, sketches or computer-generated visualisations, prepared using the highest specification and skill possible. They are an aid to decision making which must be considered alongside further information.

4 Experience gained since this guidance was first published in 2006 has led to a better understanding of how to represent proposed wind farm developments in a more accessible and realistic way. The revised methodology provides visualisations which are easier for both the public and decision makers to use. A new section on offshore wind farms has also been included. The key changes are summarised in a separate document available on our website.

5 Nonetheless, anyone using visualisations should be aware of their limitations, and these are explained throughout the text and in **Annex A. It is recommended that the standard text in Annex A should be inserted into the Environmental Statement and made available at public exhibitions.**

6 **All applications requiring a Landscape and Visual Impact Assessment as part of an Environmental Impact Assessment should conform with the requirements set out within this document**. Applications which do not require an EIA should follow a proportionate approach agreed with the determining authority. Different landscapes, types of wind farms and conditions in other countries may require different approaches.

7 It is recognised that smaller scale wind farm proposals (up to 3 turbines) and single turbine applications do not usually require the same level of visual representation. A tailored, proportionate approach is required which is likely to include fewer viewpoints and fewer visualisations per viewpoint. Our guidance on assessing small scale wind farms should be referred to.

8 Some aspects of this guidance are **prescriptive and must be complied with**. A summary of these requirements is provided in **Annex B**. Other aspects include options, and it is for the landscape assessor to choose the most appropriate approach for the site in question, agree it with relevant consultees, and justify these choices in the ES.

9 Some planning authorities have also produced specific guidance for wind farms and single turbines. Early engagement with authorities is encouraged to establish their information requirements.

Landscape and Visual impact assessment

10 Landscape and visual impact assessment (LVIA) is the method used to identify and assess the effects of, and the significance of, change resulting from development on both the landscape as an environmental resource and on people's views and visual amenity (see Guidelines for Landscape and Visual Impact Assessment, 3rd edition, 2013 (GLVIA)). Visual analysis forms just one part of a Visual Impact Assessment (VIA), the process by which the potential significant effects of a proposed development on the visual resource are methodically assessed. In turn, VIA forms just one part of a Landscape and Visual Impact Assessment (LVIA) and the wider process of Environmental Impact Assessment (EIA).

11 It is essential that a wind farm proposal is assessed within its wider landscape and visual context. For those who visit the viewpoints described, the context will be visible in the field. However, many people, including members of planning committees and other decision makers, may not be able to visit all of the viewpoints for themselves. It is therefore essential that visualisations which demonstrate the wider landscape and visual context are provided to all audiences throughout the development process. The combination of images in this revised guidance seeks to achieve this.

Stages in the planning process

12 Different types of visualisations (plans, maps, wirelines, photographs, photomontages) will be used at different stages in the process. Flexibility is required to provide the right information to the right audiences at each stage in the process. An indication of likely requirements is provided below.

13 To clarify the intended use of different materials at different stages in the process, as well as how they should be used, the methodology makes a distinction between the use of visual material:

- within the ES
- at the viewpoint
- online or on screen

14 Different users may use the images in different ways depending on their preferences, experience and whether they can access the viewpoints. The purpose of the different images is described in more detail in section 4 and is summarised in **Annex C.**

Pre application

15 Prior to the application being submitted, draft wirelines and Zone of Theoretical Visibility (ZTV) maps will be most useful for the designer, assessor, Planning Authority and consultees such

as SNH. Draft photomontages, which comply with the standards set out in section 4, may also be useful for public exhibition. It is important that draft images are clearly labelled as such so that it is clear to everyone that the design of the wind farm is likely to change prior to the submission of the application.

Submission of the planning application

16 A combination of images will be required to support the planning application, and these are described in more detail in section 4. All images submitted alongside the application should conform with this guidance and be as accurate as possible in terms of turbine height and turbine locations, noting that these may alter through the decision-making process.

Decision making

17 Whether the application is determined by the Planning Authority, or by an appeal or inquiry, or by Scottish Ministers, it is for the decision-maker to determine which images to use to inform their decision. In some cases a detailed examination of all the images may be required, including visits to viewpoints. In others it may be possible to reach a determination on the basis of a selection of images. Either way, the purpose of this guidance is to generate a suite of images, both physical and digital, that all decision makers, consultees and members of the public can use to inform their judgement.

18 In all cases **it is important that decision makers consider the proposal within the wider landscape and visual context**, ideally by visiting the viewpoint or by viewing suitable panoramas. Zone of Theoretical Visibility maps should also be referred to.

Visiting viewpoints

19 It is important that key viewpoints are visited in order to assess likely effects. To facilitate this, the guidance requires production of a **Viewpoint Pack**. The purpose of the pack is to make it easier to use illustrations in the field. This is described in more detail in Section 4.

20 To improve public access to visualisations a loan copy of the Viewpoint Pack should be made available to the Planning Authority and Community Councils in the areas affected by the proposal.

Cumulative Landscape and Visual Impact Assessment (CLVIA)

21 As the number of proposed wind farms increases, cumulative impacts become more prevalent. Separate guidance from SNH describes how to assess cumulative impacts. The methodology in this guidance takes account of the need to illustrate cumulative effects and recommends the use of additional tools to do so.

Scope of this guidance

22 This guidance is focussed on the production of visualisation-related materials to be included within an Environmental Statement (ES) LVIA, made available to the public and to inform decision making. Other methods of visualisation using computer animation and video

montage are not covered in this guidance. These methods may be helpful to illustrate the effects of the proposal, in some situations adding value to the decision making process, although the outputs are difficult to verify. These methods are not currently considered appropriate as a replacement for hard copy visualisations in the ES, although advances in technology may facilitate this in the future.

23 This guidance applies to both **onshore and offshore** wind farms. Slight differences in the methodology apply to offshore wind farms and these are described in Section 5.

Glossary of key terms

Cylindrical projection A method used to map a panorama onto a curved surface using software. The arc of curvature in degrees is equal to the overall horizontal field of view.

DTM Digital Terrain Model. A 3D model of the topography within the study area.

Environmental Impact Assessment (EIA) The evaluation of likely significant effects on the environment of development proposals.

Focal Length Refers to the focal length of the lens used to take the photograph(s).

Landscape and Visual Impact Assessment (LVIA) This is the professional and methodical process by which assessment of the effects of a proposed development on the landscape and visual resource is undertaken. It comprises two separate but related parts - Landscape Impact Assessment and Visual Impact Assessment.

Landscape Impact Assessment This is the process by which assessment is undertaken of the effects of a proposed development on the landscape as a resource, including its character and quality; and the significance of the likely effects.

Panorama An image covering a horizontal field of view wider than a single 50mm frame. Wirelines and photomontages may also be produced as panoramas.

Photomontage A visualisation which superimposes an image of a proposed development upon a photograph or series of photographs.

Planar projection A method used to map a panorama onto a flat surface using computer software. The result is the same as the way in which a camera lens creates an image on the flat film or sensor.

Principal distance The perpendicular distance from a printed image at which the exact perspective 'as seen by the camera' is reconstructed.

Scoping The process of identifying the likely significant effects of a development on the environment which are to be the subject of assessment.

Visual impact assessment The professional and methodological process used to identify and asses the visual effects, and their likely significance, of a proposed development. Visual effects are effects on specific views and on the general visual amenity experienced by people.

Visualisation A computer simulation, photomontage or other technique to illustrate the predicted appearance of a development. This includes photographs, wirelines and photomontages, but not Zone of Theoretical Visibility (ZTV) maps.

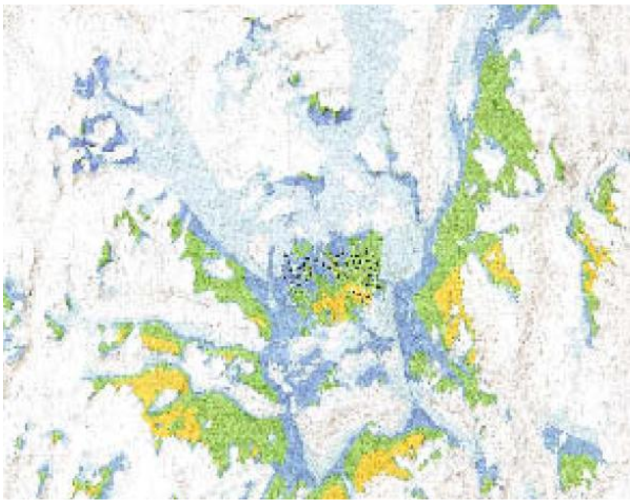
Wirelines These are also known as **wireframes** and **computer generated line drawings**. These are line diagrams that are based on DTM data and illustrate the three-dimensional shape of the landscape in combination with additional elements such as the components of a proposed wind farm.

Zone of Theoretical Visibility (ZTV) Previously known as **Zone of Visual Influence (ZVI).** This represents the area over which a development could theoretically be seen, based on a DTM. The ZTV usually presents a 'bare ground' scenario – i.e. a landscape without screening structures or vegetation.

2 Zone of Theoretical Visibility Maps

24 The term 'Zone of Theoretical Visibility' (ZTV) is used to describe the area over which a development can theoretically be seen, based on a Digital Terrain Model (DTM) and overlaid on a map base. This was previously known as a Zone of Visual Influence (ZVI), however the term ZTV is preferred for its emphasis of two key factors:

- the maps indicate **theoretical** visibility only - that is, the areas within which there may be a line of sight, but the proposal may not actually be visible in reality due to localised screening which is not represented by the DTM; and
- they do not convey the **nature or magnitude** of visual effects, for example whether visibility will result in positive or negative effects, and whether these are likely to be significant or not.



25 Production of ZTVs is usually one of the first steps in LVIA, helping to inform the selection of the study area in which impacts will be considered in more detail. ZTVs provide the following information:

- from where wind turbines are most likely to be visible;
- how many of the wind turbines are likely to be visible;
- how much of the wind turbines is theoretically visible (if separate ZTVs are produced showing theoretical visibility to blade tip height, and also theoretical visibility of the hub or nacelle); and
- a means of identifying the extent and pattern of theoretical visibility.

ZTV maps are a powerful tool, but require careful interpretation. The number of ZTV maps should be kept to the minimum required to enable proper assessment of the proposal.

26 In combination with a site visit, possibly with initial wireline diagrams, this information enables the landscape architect or experienced specialist assessor to identify a provisional list of viewpoints (see Section 3). It also allows the determining authority and consultees to judge how representative these are of the range of likely landscape and visual receptors and whether they include particularly sensitive vantage points. Information such as designated landscapes and popular walking / scenic routes can also be included.

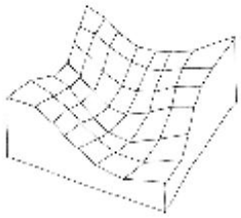
27 Importantly, **ZTVs indicate areas from where a wind farm is theoretically visible within the study area, but they cannot show what it would look like, nor indicate the nature or magnitude of landscape or visual impacts**.

USES OF ZTVs	LIMITATIONS
• A ZTV gives a good indication of the **broad areas** from where wind turbines might be seen and can help identify the LVIA study area • The ZTV can be used to help **identify viewpoints** from where turbines may be visible, enabling an assessment of these with the aid of visualisations • A ZTV is a useful tool for comparing the relative theoretical visibility patterns of different wind farms or different wind turbine layouts and heights	• A ZTV is only as accurate as the data on which it is based and the algorithm used in its calculation • A ZTV alone **cannot indicate the potential visual impacts** of a development, **nor show the likely significance of impacts**. It shows theoretical visibility only • It is not easy to test the accuracy of a ZTV in the field, although some verification will occur during the assessment from viewpoints

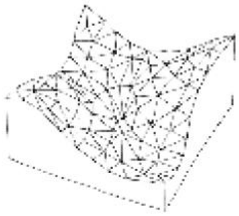
ZTV preparation

ZTV height and/or terrain data

28 A ZTV is produced using a specialised software package. Several of these are commercially available and most wind farm design packages, and many Geographical Information System (GIS) packages, have this facility. However, operation of even the most user-friendly package requires a high level of expertise and understanding of all the specific features and assumptions applied by the software. The name and details of software used should be noted in the ES and on the ZTV itself, including the version and the date of the data used.



Square grid DTM



TIN

29 ZTV production begins with a DTM that represents the ground surface as a mesh of points. This may form a regular grid of squares when seen on plan, known as a Square Grid DTM; or an irregular network of triangles, known as a TIN (Triangulated Irregular Network).

30 A Square Grid DTM cannot represent terrain features smaller than the cell size, for example a small knoll or outcrop. Such features are either lost between grid points or represented by one point only. A TIN can, in principle, illustrate finer detail than a Square Grid DTM, as it can represent all the detail shown by contours. However, in practice, a Square Grid DTM with a suitably chosen cell size will represent almost as much detail, and it may also interpolate better between contours on less steeply sloped land.

31 Both formats are acceptable. The choice between them is most likely to depend on the software being used, and the source of the data. It is common practice for a Square Grid DTM to be chosen if OS data is to be used, while a TIN is used when based on independent and/or detailed survey data, enabling high and low points to be better represented.

32 The Ordnance Survey (OS) supplies data in two formats - gridded, which has already been interpolated into a Square Grid DTM, and as contours, which is the usual starting point for constructing a TIN. The OS Square Grid DTM product, 'Terrain 5', uses a 5m cell size and is interpolated from a TIN maintained by Ordnance Survey. 'Terrain 50' (which is part of the OpenData initiative and therefore free) uses a 50m cell size and is derived from the same TIN.

33 The Terrain 5 DTM provides a more precise representation of topography than its Terrain 50 counterpart. Although they are interpolated from the same TIN, the smaller cell size of Terrain 5 allows smaller features of landform to be represented.

34 The recommended preference is for OS Terrain 5 data especially on ridge crests or in "rough" terrain where small-scale undulations have a significant effect on visibility. However, OS Terrain 50 is considered acceptable, especially if the terrain comprises hills or mountains with well-defined slopes. Legacy datasets, such as Landform Profile or Landform Panorama, may also be appropriate depending on the characteristics of the site and the availability of data.

35 Although considered adequate for the purposes of LVIA (given that ZTVs are just one part of the process), the accuracy of most DTMs is limited and they do not include accurate representation of minor topographic features and may not represent areas of recent topographic change, such as opencast coal mines, spoil heaps and road cuttings. Known significant discrepancies between the DTM and the actual landform should be noted in the ES text. If survey information on recent topographic change is available, together with the necessary software to amend the DTM, it may be useful to include it. Any changes to the DTM should also be noted in the text.

36 The OS provides accuracy figures for each of its data products (expressed statistically as root-mean-square error (RMSE) in metres). Where the DTM is obtained from another source, the accuracy can also usually be obtained from the data supplier. These accuracy figures should be stated within the ES.

37 ZTV production also requires accurate data on the locations and heights of the proposed wind turbines. For the purposes of ZTV calculation, it is sufficient to represent each proposed turbine as a single point in space, located directly above the centre of the proposed base of the turbine. The height specified is usually that at either hub or nacelle height, or at a blade tip pointing straight up, but can be at any other point on the turbine depending on the ZTV analysis required.

38 It is recommended that separate ZTV calculations are run for the overall height (to blade tip) and for the height of the turbine to its hub (representing the nacelle that houses the generator on top of the tower). This is a useful comparison that helps to identify areas where turbine blades may be visible, but not the tower.

39 In some cases it may be useful to provide alternative ZTVs showing different turbine heights to enable comparison of the effects on wind farm design. Creating a draft ZTV for different

portions of the wind farm can also aid wind farm design, particularly for large applications on complex terrain.

ZTV calculation

40 Some software packages offer both a standard and 'fast' option for ZTV calculation. 'Fast' implies the use of mathematically approximate methods in order to speed up the computation, which tends to result in a more generalised pattern of visibility. It is recommended that this is only used to obtain a provisional result which will be later superseded by a more comprehensive calculation for presentation in the ES. It is also important that users of ZTV software are clear about the technical limitations inherent in their chosen package.

41 Visibility is affected by earth curvature and the refraction (bending) of light through the atmosphere, particularly at greater distances. The effect of earth curvature should be included in the ZTV calculation as its absence will tend to overestimate visibility. **Annex D** describes this issue in more detail and includes a table of the vertical difference introduced by earth curvature and refraction with distance. At 10km, the vertical difference is enough to hide a single storey house and it increases thereafter.

42 These limitations, inherent in the data and in the method of calculation should always be acknowledged and, if possible, quantified. Note that these limitations may either over or under-represent visibility. As a general rule, **ZTVs should be generated to err on the side of caution, over-representing visibility**.

43 A ZTV usually represents visibility as if the ground surface were bare. It takes no account of the screening effects of intervening elements such as trees, hedgerows or buildings, or small scale landform or ground surface features. In this way, the ZTV can be said to represent a 'worst case scenario'; that is, where the wind farm could potentially be seen given no intervening obstructions, and in favourable weather conditions (while accepting that the DTM data can sometimes understate visibility at the very local level). To assess how this might be affected by typical visibility conditions within a particular area, Meteorological Office data on visibility conditions can be obtained.

Taking account of surface screening

44 Some software allows the use of more sophisticated datasets, enabling some screening effects to be taken into account. One example is the application of different "thicknesses" to various land uses such as forestry and urban areas. When doing this the results will be closely tied to the specifications used, for example the height of trees; as a consequence, these should be noted within the ES. Another example is the use of digital surface data obtained from laser-based aerial surveys which represent the tops of vegetation and buildings.

45 For most projects these datasets do not make a significant difference to the pattern of visibility and they tend to be quite expensive (though some datasets such as VectorMap are free); therefore, their use should be limited to specific projects where the benefits will be notable. For example, it may be used to examine visibility in detail within a property listed in the

Inventory of Gardens and Designed Landscapes, or other key natural or cultural heritage assets.

46 Care needs to be taken when assessing the ZTVs which take screening into account, as their accuracy is limited by data availability and the constant change in landscape conditions. Particular care is required when representing forestry, which will be felled and replanted on varying timescales, and should not be considered a permanent screening feature. If these techniques are used too simplistically they can lead to turbines being indicated as visible from the roofs of buildings, and the top of woodland canopy, which may be correct but is unrealistic for the person on the ground.

47 In some situations, it might be useful to map other characteristics such as the number of wind turbines seen against the skyline, or what proportion of the horizontal field of view is likely to be occupied by the visible part of a wind farm - known as the 'horizontal array angle' or 'horizontal subtended angle'. This information is particularly useful for considering the impact of a very large wind farm, or several wind farms where they would be seen together within panoramic views. However, for most wind farms the width of view can usually be more simply judged by considering the distance to the development in combination with wireline diagrams from specific viewpoints.

48 Any analyses that calculate characteristics other than simple visibility over bare ground should be produced **in addition to bare ground visibility**, not as an alternative to it. Although these currently have various limitations, improvement and development of these kinds of datasets is likely to occur in the future.

Viewer height

49 Viewer height in a ZTV map is generally set at 2m above ground level. This is higher than the camera height recommended for photographic visualisations (1.5m) to compensate for potential inaccuracies in digital terrain data and to ensure that the 'worst case' is represented. There may, however, be specific circumstances when an alternative viewer height is more appropriate (such as a very extensive flat landscape). Where this is the case it should be explained in the ES.

Extent of ZTV

50 A ZTV map illustrates locations within a study area from where a development would potentially be visible. However, just because a development can be seen, it does not automatically follow that this will result in likely significant landscape and visual impacts. This creates a circular process of decision-making. The final distance of a ZTV should extend far enough to include all those areas within which significant visual impacts of a wind farm are likely to occur (LVIA "study area"); yet the significance of these landscape and visual impacts will not be established until the VIA has been completed; and the LVIA process needs to be informed by the ZTV. As part of this cycle of assessment, the distance recommendations given within the table below act as a starting point.

51 The extent of ZTV required may need to be adjusted inwards or outwards according to the specific characteristics of a landscape and/or proposed development. The extent of the final ZTV should be discussed and agreed with the determining authority and consultees. In some situations where cumulative effects are being assessed the ZTV may not be circular in shape, but may be extended to include a specific transport route, for example.

52 The table below recommends the initial ZTV distance for defining the study area based on turbine height. Greater distances may need to be considered for the larger turbines used offshore.

Height of turbines including rotors (m)	Recommended initial ZTV distance from nearest turbine or outer circle of wind farm (km)
up to 50[1]	15
51-70	20
71-85	25
86-100	30
101-130	35
131-150	40
150+	45

53 If a wind farm is very small and concentrated in layout, typically 5 wind turbines or fewer, it may be reasonable to measure the extent of the ZTV from the centre of the site. However this should always be agreed with the determining authority and consultees.

54 The purpose of the ZTV is to illustrate theoretical visibility (within reasonable limits), not significant effects. Wind turbines can be visible at considerably greater distances than 30km and, regardless of likely significance, potential visibility should be illustrated on the ZTV to an agreed radius. The reasons for establishing the eventual radius of a wind farm ZTV for use in an ES should be clearly documented.

Cumulative ZTVs

55 Representing cumulative ZTVs can be difficult when there are large numbers of wind farms involved. A sensible and pragmatic approach is required to focus on the **wind farms with which significant cumulative effects are likely to occur and which are likely to affect decision making**. Reproducing very large numbers of overlapping cumulative ZTVs does little to assist decision making. The selection of ZTVs should therefore be discussed and agreed with the planning authority and consultees at an early stage.

56 Presenting cumulative ZTVs in a sequence of pairs or trios can help avoid confusion. A maximum of three sites per ZTV is recommended. Where there are large numbers of combinations of ZTV it may be helpful to present the various iterations in digital format, enabling users to switch on and switch off the various layers of visibility on screen. It may also be helpful in some locations to treat multiple wind farms which are closely clustered together

[1] See Assessing the impact of small scale wind farms on the natural heritage (2012)

as a single wind farm to reduce the number iterations. If this approach is taken only the main ZTVs need to be provided in hard copy within the ES.

Presentation of ZTV information

Base map

57 A ZTV should be presented on a single piece of A1 paper folded within the ES, using OS 1:50,000 as the base map. For a ZTV to be clear and legible when overlain with colour shading the base map needs to be in greyscale. This is to prevent confusion of overlays: for example a yellow overlay upon blue coloured lochs will appear green, and this could be confused with woodland. To maximise legibility it is also important that the base map is of a high quality resolution and not too light or dark.

58 Each individual wind turbine should be clearly marked upon the ZTV, usually shown as a small circle or dot, depending on the base map against which it has to be distinguished. It is recommended that the ES includes a map that shows individual turbine numbers and their grid coordinates, and that the ZTV should include reference to this map. However, it is better not to include this information on the ZTV itself to keep this map as clear as possible.

59 Numbered viewpoint locations should also be shown on the main ZTV and it is important to label these carefully to avoid obscuring vital ZTV information.

60 For ease of legibility it is recommended that the ZTV shows concentric rings to indicate different distances from the proposed development, for example 10, 20 and 30 km. The areas encircled by these rings should not be shaded or coloured as this may imply a direct relationship between distance and relative visibility or visual impact that would be misleading. To maintain legibility, the number of rings should also be limited.

61 Comparing two ZTVs that separately show visibility at blade tip and hub height will indicate where only the turbine blades, or part-blades, may be visible from. Where this is required, the ZTVs should be clearly labelled:

- Blade tip ZTV; and
- Hub height (or nacelle) ZTV.

Colour Overlays

62 Areas of potential visibility should be illustrated by a colour overlay. This should be transparent so that the detail of the underlying map can be seen clearly. The level of overlay transparency chosen should ensure that the detail of the base map remains clearly discernible and no single colour appears more prominent than another.

63 If a range of colours is to be used, the shades and tones should be chosen carefully. Darker colours tend to read as portraying greater visibility than lighter colours, whilst several colours of similar tone tend to convey information of equal importance. Using different shades of only

one colour should generally be avoided, as the distinctions between bandings usually appear merged and this can also imply a gradation of impacts represented by the decreasing shades that is misleading. Legibility of a ZTV map tends to decrease with greater numbers of colours. Seven colours should typically be the maximum used on any one map, and it is recommended that these are bright and strongly contrasting.

64 When choosing a colour palette, it is also important to consider colour blindness. It is estimated that around 7-8% of males and 0.4-1% of females in Britain have some form of colour blindness. To them, legibility of maps depends on the type of colour blindness they have, the shade and brightness of the colour, and on the contrast and combinations of colours used. This requires careful consideration and is not just about avoiding the juxtaposition of red and green.

65 While it would be useful to specify a standard range of colours consistently legible to colour blind people, it is impossible to develop this without also standardising computer screens and colour printer reproduction. It is recommended that individual maps shown within each ES are checked for colour blind legibility using a quick clarification tool such as Vischeck.

66 One of the most important considerations is how the same colour will be represented differently according to the specification of different computer screens and/or printers. It is recommended that practitioners always print out draft copies to check that any discrepancy between these still produces a clearly legible map, and then print out all the final copies on the same printer.

Visibility bands

67 The theoretical visibility of different numbers of wind turbines (within a single development, or between different wind farms within a cumulative ZTV) is usually distinguished upon a ZTV as different coloured bands. These bands only differentiate between the visibility of different numbers of wind turbines. They are not intended to imply that greater numbers of turbines will necessarily result in higher levels of visual impact. These bands are particularly useful for identifying potential viewpoints where the visibility of the wind farm varies considerably within an area.

68 The number of visibility bands should be high enough for each band to represent just a small range of turbine numbers, but low enough to avoid the need for too many colours which can appear confusing. For example, with 30 turbines, it is better to have 6 bands each covering 5 turbines (1-5, 6-10, etc) rather than 3 bands of 10 turbines which would provide limited resolution, or 10 bands of 3 turbines which would appear confusing. It is recommended that no more than 7 colour bands should be used upon a ZTV.

69 Where equal banding is impossible (for example 11 turbines), then the widest band size chosen should apply to the lower end of the scale – for example 1-3, 4-5, 6-7, 8-9, 10-11, as greatest resolution is then retained where proximity is greatest. In cumulative assessments a single set of bands should be applied consistently to all maps to allow comparison if this is possible.

Recording ZTV information

70 It is vital to include information on all the key assumptions made in ZTV production, and to summarise these within the LVIA. This should include the following information:

1	The DTM data from which the ZTV has been calculated, including date, original cell size and whether this has been "down sampled" (note down sampling is not acceptable for 50m resolution data)
2	Confirmation that it is based on a bare-ground survey; where additional non-bare-ground ZTV(s) are included, provide information on the specifications of further land-use data if this has been incorporated
3	The viewer height used for the ZTV (generally 2m)
4	Confirmation that earth curvature and light refraction has been included
5	The extent of the ZTV overlay as a minimum distance from the development, in addition to the frequency of any distance rings shown
6	The numbers of wind turbines represented for each colour band
7	The height used for the turbine and whether this is to hub or blade tip
8	Confirmation that the ZTV software does not use mathematically approximate methods

3 Viewpoints

71 The term 'viewpoint' is used within VIA to define a place from where a view is gained, and that represents specific conditions or viewers (visual receptors). A number of representative viewpoints are chosen in order to assess:

- the existing visual resource
- the sensitivity of this resource and visual receptors to wind farm development
- the proposed design (incorporating mitigation measures to minimise any adverse impacts); and
- the predicted appearance of the proposed development

This section addresses the selection of viewpoints and the information that should be provided for them.

72 It is important to stress that **viewpoint assessment forms just one part of LVIA**. Because of the powerful nature of viewpoint images and the widespread recognition of some of the locations from where these are taken, there is often over-emphasis of their role. However, LVIA also includes assessment of the following:

- the extent and pattern of visibility throughout the study area (considering those areas from where a wind farm would not be seen, as well as those areas from where it may);
- views of the proposed wind farm from areas of potential visibility other than the selected viewpoints; and
- sequential views.

73 Separate assessment of impacts on residential properties is increasingly common. The production of visual materials for individual properties may be appropriate to assist this, but they will not normally form part of the LVIA.

USES OF VIEWPOINTS	LIMITATIONS
• Carefully chosen viewpoints enable representation of a range of views within a study area • Carefully chosen viewpoints enable representation of a range of viewers who experience the landscape in different ways • Viewpoints enable consultees to assess specific views from important viewpoints, for example settlements, tourist attractions and mountain tops • By considering a range of views at different viewpoints, the designer can consider how the wind farm would vary in appearance, informing design development	• Whilst the choice of viewpoints is very important, the LVIA should also be based on other aspects. Over-emphasis on viewpoint assessment may create the erroneous assumption that this is the only aspect of LVIA • There may be a tendency to focus on the particular characteristics of specific viewpoints, rather than considering these as being broadly representative of a wider area. It is inappropriate to make design modifications to change the visual effects of the proposed wind farm from a single viewpoint because this may have negative 'knock-on' effects from other viewpoints. A more holistic approach considers the wind farm from a range of viewpoints in relation to the design objectives.

• Views from several viewpoints can be assessed to determine sequential effects that occur as one moves through the landscape • By assessing viewpoints in combination with ZTV maps, it is possible to consider the potential pattern of visibility for a wind farm in 3 dimensions • Viewpoints which show no actual visibility of the proposal should not be shown in the ES (unless there is good reason to do so) – the rationale for this should be given in the supporting text of the ES	• A viewpoint is by its very nature static whilst views tend to be experienced on the move as well as when stationary • Some viewpoints are difficult to access and some people might not be able to assess the viewpoint on site. They will therefore rely on the landscape architect or experienced specialist assessor's assessment and visualisations to indicate predicted visual effects. It is therefore essential that sufficient landscape and visual context is provided on visualisations • Due to the limitations of DTM data several provisional viewpoints may need to be visited to find a suitable location • The exact location and conditions of individual viewpoints are required to be able to create accurate visualisations • Some requested viewpoints might be judged inappropriate for formal visualisations due to unacceptable health and safety risks

Selection of viewpoints

74 Viewpoint selection is informed by the ZTV and other maps, fieldwork observations, and information on relevant issues such as access, landscape character, designations and popular views (see GLVIA 3 for more detail). These datasets enable a provisional list of viewpoints that can be later refined through further assessment, consideration of provisional wireline diagrams and discussions with the determining authority and consultees. Interested members of the public, and in particular Community Councils, can also advise on sensitive local vantage points at public meetings and/or exhibitions held by the applicant.

75 A ZTV is very useful in focussing upon those areas with potential visibility of a proposed development, but the ZTV is only one source of information used to inform the selection of viewpoints. Over-reliance on a ZTV to identify viewpoints can result in concentration on open locations with the greatest visibility of a site, which may be far from the proposed development. This may be at the expense of potential viewpoints where visibility is less extensive, but from where views of the site are more typical.

76 During early consultations regarding the provisional list of viewpoints it is essential that the determining authority and consultees are provided with a copy of the draft ZTV at the appropriate scale and A1 size. A selection of provisional wireline diagrams may also be helpful to give an impression of possible effects from viewpoints.

77 Wirelines are used to inform the design development of the proposed wind farm during the initial stages of the LVIA. Some of the viewpoints will be described and assessed within the main ES report; however, others may ultimately be omitted, for example because they show very similar results to another viewpoint. Details regarding these original viewpoints should be

included within the ES appendices if they have informed the design process. Likewise, during the LVIA process, it may be found that some of the original viewpoints will not have a view of the wind farm due to local screening or changes to the wind farm design. These should also be documented within the ES.

78 The range of issues that influence the selection of viewpoints is listed in the table below. The aim is to **choose a range of viewpoints from where there are likely to be significant effects and those which are representative of views within the study area**. Local knowledge will greatly assist this process. It is desirable to choose viewpoints which represent several of the issues described below from the same location as this will reduce the overall number of viewpoints. These issues are discussed in more detail in the GLVIA 3 paragraphs 6.16-23. It is preferable not to include too many viewpoints as this can distract attention from the key significant effects.

View type	• **Settlements and visual amenity**
	• **Various landscape character types and areas** (separate and in combination)
	• **Areas of high landscape, scenic or recreational value** – for example views to and from designated areas; wild land; long distance routes; view points; tourist routes, local amenity spaces
	• **Various distances** from the proposed development
	• **Various directions and aspects** (viewpoints from all around the development should be considered; views to the north will result in a different effect to those facing south; for design in particular)
	• **Various elevations**
	• **Various extents of wind farm being visible**, including places where all the wind turbines will be visible as well as places where partial views of turbines occur
	• **Sequential** along specific routes
	• **Cultural heritage** including the wider setting of the heritage asset
Viewer type	• **Various activities,** for example those at home, work, travelling in various modes or involved in recreation
	• **Various modes of transport,** for example those moving through the landscape by road, train, ferry, bicycle or on foot (note, in some cases it may be desirable to choose an alternative camera height to represent typical views. If so, this should be noted in the ES)

79 The assessment of viewpoints should not involve unacceptable risks to health and safety. Examples of these situations include viewpoints from motorways, railway lines, scree slopes or cliffs.

80 Viewpoints within the local area surrounding the wind farm are particularly useful in understanding and developing the wind farm layout and design. They also represent the likely effects on residents living, travelling and working within the nearest area. Local residents will experience the wind farm on a regular basis (often daily) in different weather, lighting and

seasonal conditions. It is important that these effects are considered and that the assessment recognises the varying conditions in which residents will experience the wind farm.

81 When identifying viewpoints it is important to consider whether a CLVIA is also required as part of the ES. If it is, the choice of all viewpoints should be informed by the cumulative ZTV as well as the individual ZTV. In most parts of Scotland many of the viewpoints chosen will be used to represent cumulative effects. Although it is possible to add supplementary viewpoints as part of a cumulative LVIA, it is preferable to use the same viewpoints for both the individual and cumulative LVIA to enable direct comparisons to be made.

82 Likewise, it is also useful to choose viewpoints already used for other wind farm LVIAs in the surrounding area. This allows direct comparison and also assists the determining authority, consultees and the general public who are already familiar with these viewpoints. Some planning authorities have standard viewpoint lists and these should be referred to at an early stage.

83 The reasons for selection or omission of viewpoints recommended by consultees should be clearly justified and documented within the ES. **It is essential that a final list is agreed with the determining authority.** Not all viewpoints will require a photomontage. Distant viewpoints and those where there are no significant effects may be better illustrated by wirelines only.

Number of viewpoints

84 The number of viewpoints for different projects will vary depending on the scale of the proposal, the sensitivity of the receiving landscape and / or visual receptors, and how many are required to represent likely significant effects from the range of views and viewers of a development. The initial list of provisional viewpoints will probably be high. This is necessary to enable identification of the required viewpoints during the early stages of the LVIA, and to ensure that no key viewpoints have been omitted.

85 This process will involve the production of wirelines, as one will need to be produced for each layout and design option, including alternative turbine heights where these are being considered. However, these iterations are only likely to be helpful from several 'design viewpoints' and it is not necessary to provide these from all of the viewpoints agreed, or to include them in the ES.

86 After reducing the number of viewpoints to those that are required to illustrate the ES, it is common for there to be around 10-25 viewpoints within a LVIA in Scotland. However, this number will vary depending on the specific circumstances of a proposal. Over-provision of viewpoints can be as unhelpful as under-provision. This is because an excessive number of viewpoints may distract attention from the smaller number of viewpoints where impacts may be significant. **An appropriate balance must be struck through the LVIA consultation process to agree a proportionate number of viewpoints**.

87 Statutory consultees should provide a brief rationale for each viewpoint requested. A summary of the viewpoints considered throughout the process, with the reasoning behind the final viewpoint list, should be included within the ES.

Viewpoint siting

88 Following agreement on the general location of viewpoints through consultation, the selection of the precise viewpoint site should be considered carefully. If, on visiting a potential viewpoint, it is apparent that there will be no view of the proposed development, for example due to localised screening, this location should be amended or withdrawn and the reason recorded in the ES.

89 The siting of viewpoints needs to balance two key factors:

- the likely significance of impacts; and
- how typical or representative the view is.

For example, in choosing a viewpoint along a stretch of main road it may be difficult to choose one location to represent the range of views experienced. It may also be difficult to find a safe location for the viewpoint. Laybys and junctions are often used but may not always represent the ‘worst case’ views, or the first sight gained of the wind farm. Where this is the case it should be noted in the ES. In all cases, judgement needs to balance these factors, and the decision-making process must be documented.

90 Most importantly, **the location chosen must avoid the view of the wind farm being misrepresented by the inclusion of atypical local features, such as a single tree in the foreground**. Where this has mistakenly occurred, the viewpoint location should be revised and the photographs retaken. Conversely, it is also unacceptable to move too far from the most prominent viewpoint in order to avoid typical foreground objects, for example moving into a neighbouring field when the view is intended to be from a road, in order to avoid typical foreground objects, unless these would obscure views to the wind farm. An alternative location may be required.

91 Viewpoints should be free from any avoidable foreground objects and other obstructions such as fences, walls, gates, roadways, road furniture, summit cairns and unnecessary foreground, trees, shrubs or foliage unless these are typical of the view. It is also important that viewpoints are publicly accessible, for example not within private property.

Recording viewpoint information

92 It is important to record the field conditions in which a viewpoint is photographed, as well as the camera details including the information listed in the table below.

Viewpoint	Specification required
Precise location	12 figure OS grid reference, measured in the field, ideally using GPS or a large-scale map and a photograph of the tripod location.
Viewpoint altitude	Viewpoint altitude in metres Above Ordnance Datum (m AOD) (usually better interpolated from map or DTM than relying on GPS height).
Field of view	Horizontal field of view (in degrees).
Distance to wind farm	Approximate distance (in km) to the nearest turbine
	Compass bearings to distinctive elements in the view that will assist with the placement of the turbines in some circumstances (plus optional sketch of the view with these elements marked if appropriate).
Conditions:	Date
	Time
	Weather conditions and visual range
Camera:	Camera type, Lens focal length and make
	Spacing between the frames

93 This information is essential to allow others to visit precisely the same viewpoint and make on-site checks or assessment. It also helps others to understand the conditions under which professional judgements have been made.

94 All viewpoints should be numbered and their location shown upon separate maps as follows:

- detailed ZTV map(s) based upon a greyscale 1:50,000 OS base and printed at A1. Viewpoints should be marked using symbols and numbering that avoid obscuring or confusing the ZTV information.
- detailed map extract on each visualisation within the **viewpoint pack** which indicates the location and direction of the view on a 1:50,000 or 1:25,000 OS base map.
- Each visualisation should include a short description to make it easy for members of the public to find the exact viewpoint location.

95 It is recommended that the original viewpoint numbers are retained until all the viewpoints are finalised and agreed and the LVIA has been completed, to keep track of which viewpoints have been added or withdrawn during the LVIA process. At this point they can be re-numbered in a continuous and logical manner. Where material developed during the early stages of the LVIA process information is included this should show both the original and new numbering so these can be easily cross-referenced. If an extension is proposed, using the same numbering of viewpoints as in the original application will allow consultees to compare the impacts of the new proposal more easily. The same applies if different wind farms are proposed concurrently within a district. **Viewpoint numbering needs to be clear**.

4 Visualisations

96 Visualisations are illustrations that aim to represent the appearance of a proposed development. Visualisations of wind farms most commonly comprise photographs, wireline diagrams, photomontages, sketches and diagrams. However, it is important to stress that visualisations represent just <u>one source of information</u> that informs a LVIA.

97 Considerable debate on visualisations in the past has revolved around making them 'true to life'. **Visualisations, whether they are hand drawn sketches, photographs or photomontages can <u>never</u> exactly match what is experienced in reality.** They should, however, provide a representation of the proposal that is accurate enough for the potential impacts to be fully understood.

98 The assessor, consultees, decision-makers and any interested parties or members of the public **should ideally visit the viewpoint(s)** where visualisations can be compared to the 'real life' view. It is acknowledged this is not always possible – time, weather and accessibility will restrict the number of viewpoints which can be visited.

99 To support the consideration of the LVIA by consultees, members of the public and decision-makers, a **Viewpoint Pack** is included as a standard requirement. This is described in more detail in paragraphs 183-186 below. The images in the viewpoint pack should only be referred to at the viewpoint where the real landscape and visual context is visible. Decision makers, consultees and other interested parties can also select from the suite of visual information submitted with the ES when considering the proposal in the field.

100 Interpretation of visualisations must take account of additional information specific to the proposal, viewpoint and landscape which cannot be shown on a single 2-dimensional image. Factors include variable lighting, movement of turbine blades, seasonal differences and movement of the viewer through the landscape. **Visualisations in themselves can never provide the full picture in terms of potential impacts; they only inform the assessment process by which judgements are made**.

Key issues affecting visualisations

101 In order to see sufficient detail the photograph must have high resolution. Contrast also has a great influence on how well detail can be seen. Against a white background a black line is easier to see than a grey one. A key limitation of photographs in replicating the visual experience is that it is generally impossible to reproduce the full contrast range visible to the human eye.

102 On a bright day outdoors we may experience a brightness ratio of 1000:1 between the brightest and darkest shades, whereas a good quality computer monitor is only likely to achieve a ratio of about 100:1, and a printed image is only likely to manage 10:1. This is one reason why holiday snaps of mountain ranges often look disappointing when viewed on screen or as printed photographs – neither the screen nor the printed image can capture the contrast or depth you see in real life.

103 This has an effect on the representation of both the detail in the scene and the way in which contrast usually decreases with distance ('aerial perspective'). This has been a challenge since the beginning of photography. The methodology set out below seeks to ameliorate the lack of contrast and depth in printed images to ensure that they provide the best representation of the wind farm proposal – but it can never replicate the real life view.

Viewing distance

104 In the previous version of this guidance it was recommended that images should be viewed at a correct "viewing distance" to recreate the correct perspective geometry of the view. However, viewing printed images at a 'correct viewing distance' is not easy, especially when provided as a cylindrical projection (which should be viewed curved). More importantly, experience has shown that geometrically correct printed images, viewed at a theoretical viewing distance, do not necessarily portray the view as experienced by people in reality[2] .

105 The method described below results in significantly larger images, for which an accurate viewing distance is less important. The images are enlarged and this provides a better representation of the real view, at a comfortable viewing distance.

106 **As a result, it is recommended that photomontages are simply viewed at a comfortable arm's length**. This will vary depending on the length of the viewer's arms and their eyesight. However, the difference in viewing distance which results will have little impact on the impression of scale / depth in the image due to the increased size of the images. An instruction to view images at a 'comfortable arm's length' should be included on all visualisations produced. They should also **be viewed flat as they are in planar projection**.

107 Planar projection has been chosen for the photomontages as it is easier to use both in print and on screen (a computer screen cannot be curved to view a cylindrical image). Both planar and cylindrical projections have limitations. The main limitation of planar projection is that, if viewed incorrectly, it can slightly increase the scale of turbines at the edge of the image[3]. **Ideally the viewer should view the image with their eyes in the centre** – however, in practice the difference in scale in most images will be difficult to perceive.

108 Some technical users of the visualisations may still wish to know the principal distance of the image. This should be included on all images to allow technical comparison if required. It is not necessary, however, for members of the public or decision makers to view the images at this distance and it should **not** be referred to as the viewing distance.

[2] For a detailed discussion of this issue see 'Windfarm visualisation: Perspective or Perception ?' by Alan Macdonald (2012), Whittles Publishing.

[3] Conversely, if a cylindrical projection image is viewed incorrectly the turbines at the edges will appear too small

Making visualisations more accessible to the public

109 It is essential that decision-makers and consultees are provided with, and that members of the public have access to, a colour paper copy of the visualisations, printed at the correct size. To facilitate access to these images:

- **The Developer** must provide the Planning Authority and relevant Community Councils with the Viewpoint Pack described in paragraphs 183-186 below;
- **The Planning Authority** must make all images available through e-planning and through the Digital Viewer (see paragraph 180-182 below), as well as making hard copies of the ES available at appropriate local facilities for borrowing;
- **Members of the public** should either view images in hard copies of the ES; use the Viewpoint Pack in the field; or view the images electronically using the Digital Viewer (see below).

Using all the tools available

110 Visualisations are complementary to ZTVs and vice versa, and neither can be interpreted satisfactorily without the other. A visualisation simulates a photograph of the wind farm from a particular location, but gives no indication of whether this is characteristic of views over a wider area or is peculiar to a specific location. Used carefully together, a ZTV and a set of visualisations can provide information on all of these aspects.

USES OF VISUALISATIONS	LIMITATIONS
• Visualisations give an impression of a proposed wind farm	• Visualisations provide a tool for assessment that can be compared with an actual view in the field; they should never be considered as a substitute to visiting a viewpoint in the field
• Used carefully in the field, a visualisation can be used to inform assessment	• Neither photographs nor visualisations can replicate a view as seen in reality by the human eye.
• Visualisations can aid development and appraisal of the wind farm layout and design	• Visualisations are only as accurate as the data used to construct them
• Visualisations can help illustrate the location and nature of a proposed wind farm	• Visualisations can only represent the view from a single location at a particular time and in particular weather conditions
	• Static visualisations cannot convey the effect of turbine blade movement

Photography

Objectives

111 Undertaking photography for visualisations requires high quality specification and skill. This is because the perspective geometry of the resulting photographic image must be known in order to use software to generate an image with exactly matching perspective. This requires considerable care in the selection and use of appropriate photographic equipment.

112 Representing landscape conditions through photography (and thus photomontages) has limitations and, while some of these effects can be ameliorated and/or compensated for by using presentation techniques discussed in the following section, other effects are less easy to counteract. One of the most significant difficulties of photographing wind farms, in contrast to other types of development, is that they often appear on the skyline where there can be little contrast between the light-coloured turbines and a light-coloured sky. **It is therefore essential that all baseline photographs are taken in good visibility**.

113 This will generally mean clear skies, in suitably clear air to allow sufficient contrast between the different elements within the landscape. This is particularly important for long-range views where poor light and atmospheric conditions such as haze or cloud can reduce the clarity of the view, or for views where the turbines are predominantly viewed against the sky. In most circumstances, clear skies are preferred. However, in some locations, especially where the turbines will be predominantly backclothed, photographs taken in cloudy conditions can also be used to illustrate the effects. The key requirement is that the turbines are rendered with sufficient contrast against the backdrop (whether this is the sky or the landform).

Field of view

114 The term 'field of view' is used to describe the width and height of a view as represented by an image. These constitute the horizontal field of view and vertical field of view and are expressed as angles in degrees (the terms 'angle of view', 'included angle' and 'view cone angle' are all equivalent, but they can be ambiguous in some contexts).

115 The photomontages to be included in the ES (described in paragraphs 177-178 below) have a horizontal field of view of 53.5 degrees and a vertical field of view of 18.2 degrees[4]. In most situations this will capture the whole wind farm and provide sufficient landscape and visual context. In some situations, however, it may be necessary to provide a wider horizontal field of view. These include:

- Viewpoints which are very close to the wind farm;
- Very large wind farms

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[4] NB – this applies to the photomontage, not the baseline panorama which will have horizontal field of view of 90º, 180º, 270º or 360º as required

- Locations where cumulative effects require detailed representation (e.g. two wind farms on the same ridge).

Where these necessitate the use of a wider horizontal field of view which will not fit on an A1 width page, it may be necessary to print on slightly longer paper (folded in the ES), or to print several panoramas on separate sheets (with the wind farm shown on the central sheet) if the paper length becomes unwieldy, or distortion affects the edges of the image. In these situations the Digital Viewer will also be helpful by providing the wider field of view required.

116 To ensure that the photographs (which may be taken by someone other than the landscape architect or experienced specialist assessor) can accommodate the required horizontal field of view to assess cumulative effects, a series of photographs should be taken from each viewpoint to include the entire width of view. It is recommended to take 360° at each viewpoint to ensure this can be achieved.

117 Photographs should generally be taken in landscape format. However, in some circumstances, such as a steep sided valley or viewpoints which are very close to the proposal, it may be necessary to use portrait format to capture the full vertical extent of the wind turbines and/or landscape. Where this is necessary an alternative format of image will be required and this should be agreed with consultees.

Verification

118 In some cases the determining authority may wish to verify the accuracy of the image produced. This is possible using the original image data recorded by the camera (to check camera format and lens used) and a simple template (to check that the image dimensions have been correctly adjusted (by cropping and then enlarging)). This process is described in **annex E**. Camera metadata should be provided by the applicant on request.

Choice of camera and camera height

119 A high quality **digital camera** with a **full frame sensor** is required to produce satisfactory results for ES purposes. Note that full frame sensors can also vary slightly in size – this is discussed in more detail in **Annexes E and F**.

120 A **50mm fixed focal length** camera lens is required. Note – even fixed focal length lenses can vary slightly in their geometry; this and various other technical considerations are discussed in more detail in **Annex F**. Lenses need to be of high quality both in terms of resolving power (the ability to capture detail) and in freedom from excessive distortion.

121 The use of a fixed focal length reduces the scope for error in establishing the perspective geometry of the photographic image and reduces variables in the method used. Such lenses have less distortion than alternatives and are currently used as standard by most practitioners. It also facilitates the verification process set out in **Annex E.**

122 In some circumstances it may be necessary, or beneficial to use an alternative lens or camera. **Where this is the case it should be agreed with the determining authority and a clear justification should be included in the ES**.

123 The camera should be **1.5m** above ground level, unless there are good reasons to adjust this (such as a hedge, tree or similar obstruction). If an alternative camera height is used this should be marked on the visualisation and explained in the ES.

Post-photographic processing

Turbine image

124 The turbines shown on a visualisation should represent reasonably faithfully the shape of the intended turbines for a project. They should, at least, have the correct hub height and rotor diameter. This will allow the proportions of the turbines to be appreciated from the visualisation.

125 Some practitioners prefer to depict all turbines with the rotors set with one blade pointing straight up; whereas others prefer these set at random angles, helping to simulate more realistically the fact that the turbine blades will be moving. The disadvantage of setting blades at random angles is the risk of 'losing' turbines behind the landform because the blade angle happens not to place a tip high enough in its arc to be seen. On the other hand, having all the blades at the same angle can produce a very 'regimented' effect that appears less realistic.

126 It is recommended that, for all wireline diagrams (especially those used by the assessor), turbines are always shown with one blade positioned straight upwards, while photomontages, as illustrations, can show turbines at random positions. All the wind turbines that could potentially be seen from a viewpoint must be shown within the photomontage, even if their highest blades are on the diagonal. The rotors of every turbine in the proposed development should ideally face the same direction, forwards towards the viewpoint (note this may not be necessary on photomontages, see paragraph 164).

Image enhancement

127 Enhancement of images is an inherent part of photographic production. Photographic processing involves judgements - there is no process by which a 'pure' photograph can be produced without the application of human decision-making, from exposure timing to the specification of the camera, and whether this is applied manually or automatically.

128 Although enhancement, for example to maximise clarity, has traditionally occurred within the photographic darkroom, this practice has often raised concern with regards to producing photomontages. This may be because it is difficult to quantify the level of enhancement in a way that is easy to understand, raising the suspicion that an image has been 'enhanced', and is consequently misleading. In reality there is no way to avoid a photograph being enhanced as this is an integral part of photography and photomontage production.

129 Enhancement must be done to acceptable standards and this requires extreme care by a suitably experienced professional. The extent of enhancement must be limited to that which would conventionally occur in a darkroom to improve the clarity of an image, not change its essential character. For example, it is important that any enhancement, such as sharpening elements within a view, is carefully balanced throughout an image, not just the wind turbines, otherwise other features may seem less prominent in comparison.

130 Sharpening an image slightly can also help to make fine details, visible in the field, also be visible on printing. This operation works by identifying areas of high contrast in the image, which correspond to the detail we see, and locally further increasing the contrast so that the detail becomes more apparent. However, this operation must be applied carefully as over-sharpened images can result in a hard dark line that appears at the skyline, with a corresponding light edge to the sky above it, while miniscule details can appear unrealistically prominent. **Overall, there should be a minimum of post-processing image enhancement.**

Other considerations

Information to provide on the visualisations

131 Information provided on the visualisation should be sufficient for the user to understand the basis of the visualisation, but not so much as to be overwhelming. Each image should also include a small thumbnail location map, either located beneath the image or on a fold out at the right hand side of the page. The information provided on the visualisation should include:

Viewing instructions, including standard text in **Annex A**
Figure number and viewpoint number
Information on viewpoint location, altitude and both vertical and horizontal fields of view
Direction to centre of photograph as a bearing
Distance to nearest visible turbine in kilometres
Principal distance (mm), Camera make, Lens, Camera height
Date and time of photograph

Paper and printing

132 There is an extremely wide variety of printers and paper types available. To obtain the best results in relation to the size and type of visualisation, it is recommended that advice is sought from specialist providers.

133 The quality of a printed visualisation will depend significantly on the printing process and set-up. Colour inkjet printers tend to show more detail than other machines because of their higher colour range and resolution. However, it is generally difficult to produce large numbers of pages in this way so colour laser printing may be necessary. Whichever method is used a good quality finish is essential.

Constructing the visualisations required in the ES

134 Three visualisations are required as standard within the ES and these are described in turn below:

1. Baseline panorama and matching wireline
2. Wireline
3. Photomontage

1) Baseline panorama and matching wireline

Construction of baseline panorama

135 The first image required from each viewpoint is a baseline panorama. This shows the **existing view** and captures the overall landscape and visual context. This information is essential to underpin the LVIA and to provide those who cannot visit the viewpoint with an understanding of the wider context within which the wind farm would sit.

136 In most cases 180° should be sufficient. In some cases (such as a popular Munro summit or viewpoint, or to illustrate cumulative effects) it may be necessary to provide a 360° baseline panorama. In a few cases (such as a narrow view down a glen) a reduced field of view of 90° may be adequate.

137 To construct the panorama a series of frames should be taken which cover the full 360° from each viewpoint. The decision whether to present 90°, 180°, 270° or 360° can be taken later by the assessor.

138 The images should be stitched together by a competent professional using suitable software. Each 90° image should be presented on a single A1 width page as shown in **figure 1** below. The size of the image will be 820mm by 130mm. To accommodate 90° horizontal field of view the vertical field of view will be 14.2°. Additional images (up to 4 for 360°) should be provided on separate A1 sheets as required.

139 To present images with this wide field of view **cylindrical projection** is required – however, it is not important to view this image in a curve, as they are provided to illustrate the wider landscape and visual context only. **The wind farm proposal should <u>not</u> be represented on this image,** in order to avoid confusion.

140 To facilitate the verification process described in **annex E,** the horizontal extent of the central 50mm frame should be indicated on the image, along with the extent of the 53.5° panorama which will be extracted from this. An example of these markings is provided in the pdf version of the image available on our website.

141 The following information should be included: "**This image provides landscape and visual context only.**" More detailed guidance on wireline production is provided below.

142 In some locations it may be useful to annotate key features (such as hilltops, key routes and popular destinations) on the baseline panorama where these are not easily identifiable.

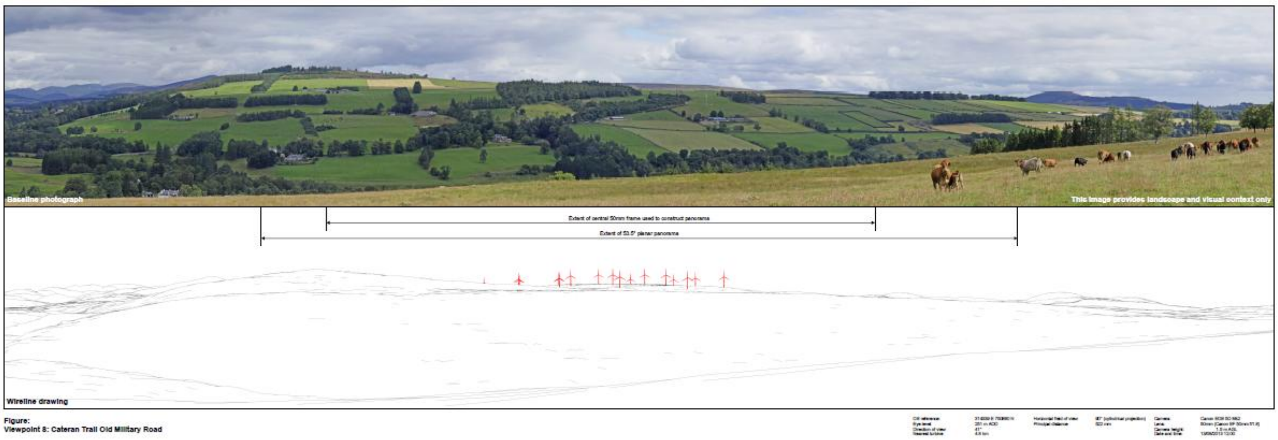
Construction of matching wireline

143 A wireline with matching dimensions and geometry should be constructed for either 90°, 180°, 270° or 360° horizontal field of view as required. The resulting vertical field of view will be 14.2°. The image will be 820mm by 130mm. The wireline will be particularly helpful to show cumulative effects, which cannot be captured in the illustration described below. It should also be provided in cylindrical projection, to match the baseline panorama. **The wind farm proposal and all other wind farms included in the cumulative assessment (including existing wind farms) should be illustrated on the wireline** – but not the baseline panorama which is an illustration of the current landscape.

144 Turbines at different stages in the planning process (i.e. existing, consented, proposed) should be shown in different colours to make it clear what the baseline is and what is proposed. Potential scenarios of development, depending on which applications receive approval and are constructed, can therefore be assessed.

145 It can also be helpful to show the horizontal extent of each wind farm with a small bar at the top of the image, particularly when there are multiple wind farms in the same angle of view. In some cases it will be difficult to annotate the wind farm(s) on the wireline, especially if the viewpoint is close to the proposal and the turbines fill the vertical field of view. In these circumstances, labelling should be included on a separate wireline image or the individual wind farms (or turbines) identified on a key.

Figure 1 90º Baseline panorama and matching wireline



2) Wirelines

Use of wirelines

146 Wirelines are computer generated line drawings, based on a Digital Terrain Model, that indicate the three-dimensional shape of the landscape in combination with additional elements. They are a valuable tool in the wind farm LVIA process as they allow the assessor to compare the position and scale of the turbines to the existing view of a landscape.

147 Wirelines are particularly useful to the landscape architect or experienced specialist assessor as they portray objective data. This means that, by comparing wirelines with the views on site, the assessor can make judgements on the likely visual impacts in a variety of environmental conditions, safe in the knowledge that the wirelines have not been subject to manipulation that cannot be quantified. They can also reveal what would be visible if an existing screening element, for example vegetation or a building, were removed.

Data

148 The accuracy of a wireline depends on the accuracy of the data used to create it. In general, this data will be the same as that used for calculation of the ZTVs, commonly the OS Terrain 50 or Terrain 5 DTM products, or the older 'Landform' products.

149 It is important that sufficient DTM data is used to enable the full landform background to the turbines to be appreciated and thus easily matched to a view on site or photographs of the existing landscape. For some views, DTM data may need to extend further than the LVIA study area because the distant horizon extends beyond this.

150 In some locations, such as very flat landscapes with few features, achieving a good fit with the digital terrain model will be difficult. The use of artificial features such as a meteorological mast or other infrastructure may be required to position the image.

Geometrical properties

151 To allow direct comparison (and reduce confusion) wirelines should be provided using the same perspective geometry and image height as the photomontage described in paragraph 178 below. They should also be presented in **planar projection** to provide a consistent representation of the wind farm.

Drawing style

152 Wirelines consist of little more than simple line-drawings of the DTM and the wind farm. However, there are a range of graphic styles used to depict these which can affect the clarity and legibility of the finished image. A number of options are acceptable; however it is important that the same format is used throughout a single ES.

153 The DTM is most commonly drawn as a mesh seen in perspective. While this is a faithful depiction of the landform as represented by the DTM, it can often result in the more distant parts of the scene becoming unreadable as the grid lines get closer together, eventually

merging into solid colour. This is not helpful and in these circumstances **grid lines should, if possible[5], be removed to maintain a simple image**. Only the outline of the topographic features in the scene, approximating to the lines one might draw as a sketch of the scene, should be shown.

154 Colour is useful to highlight the wind turbines in contrast to the landform lines, especially in distant views where the effect of merging lines noted above often occurs, and where some turbines may only just be visible against the landform. There are a number of options, such as those listed below:

- Green turbines on a black DTM
- Red turbines on a black DTM
- Black turbines on a grey DTM
- Blue turbines on a grey DTM
- Grey turbines on a green DTM

The use of pale colours, such as yellow, is not recommended as these have insufficient contrast with the white paper background and cannot be seen clearly.

155 Using the same colour and/or shade for the turbines and DTM is not recommended due to the lack of distinction between them. All the other options listed above are acceptable with the caveat that care must be taken to ensure that the type of colouring does not produce an illusion that the turbines are closer (or further away) than the landform on which they are sited.

156 Varying colours of turbines can be used to distinguish different wind farms within a view or existing turbines from proposed turbines planned as an extension.

157 Turbines should be numbered so that the individual turbines can be directly referred to a layout plan also showing the turbines numbered[6]. Unless the wind farm comprises a small number of turbines, however, this information will usually take up a large amount of space upon the wireline image and, similar to any other labelling, may distract from the wireline image itself. It is preferable to label duplicate wirelines within an appendix (a selection of key viewpoints may suffice, if agreed during consultation). For cumulative wirelines, only the turbines relating to the proposal need to be numbered.

158 Features other than wind turbines can also be modelled into the wireline, depending on the software being used. Existing landscape features can be shown, such as pylons or distinctive buildings, which will help direct comparison with the photograph of the existing view (as long as these do not obscure the wind turbines). This can be particularly helpful for offshore sites where platforms and other existing infrastructure can be useful. Other elements of the wind

[5] It is noted that some wind farm visualisation software does not have this function at present, hopefully this will rectified in due course. In the meantime it is accepted that some practitioners may not have the ability to easily remove all grid lines.

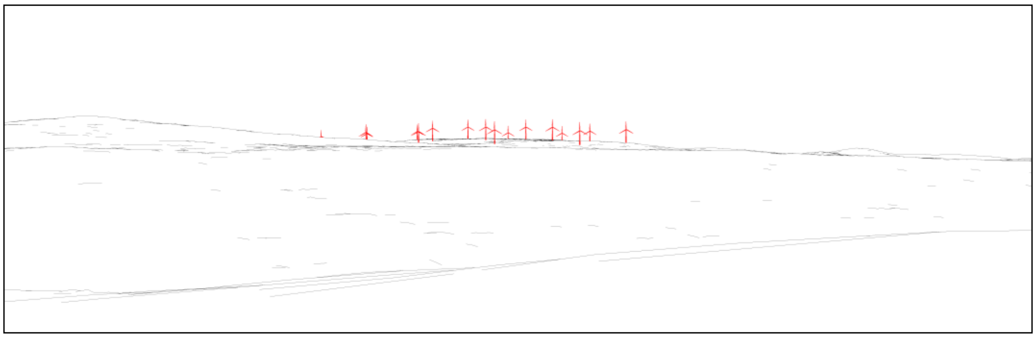
[6] NB, not for offshore wind farms as this is likely to be impractical

farm development can also be shown, such as access tracks and other permanent ancillary infrastructure.

Construction of wireline

159 The production of wireline images is well understood, using standard software, so detailed guidance is not provided here. The key objective is to provide a wireline of the same geometry and image height as described for the photomontage below. **Planar projection** is required. The wireline should be 260mm by 820mm wide. The horizontal field of view should be 53.5° and the vertical field of view should be 18.2°.

Figure 2: Example wireline



3) Photomontages

The use of photomontages

160 The basic concept of photomontage is simple: it combines a photograph of an existing view with a computer-rendered image of a proposed development. In this way, **photomontages are used to illustrate the likely view of a proposed development as it would be seen in a photograph (not as it would appear to the human eye in the field)**.

161 **Although photomontages are based on a photograph of the existing landscape, it is important to stress that they are not a substitute to visiting a viewpoint in the field**. They are only one tool to aid assessment. They provide a two-dimensional image that can be compared with an actual view of the landscape to provide information, such as the scale and potential appearance of a proposed development; but they cannot show other qualities of the landscape experience that can only be appreciated in the field.

162 Given the limitations of depicting turbines in photomontages, their production will usually be of most value for views within 20km of a wind farm site, for turbines up to 150 metres high to blade tip. At distances greater than this it can be difficult to represent the turbines well on a photomontage. However, this will depend on issues such as the specific wind farm design and environmental conditions**, so this parameter, and which viewpoints require photomontage, should be discussed and agreed with the determining authority and consultees.**

Rendering of photomontages

163 In order to address the difficulty of representing wind farms clearly within photos, it is common practice to exaggerate the prominence of the turbines to ensure that they stand out in the finished photomontage. When done poorly, this results in a level of predicted visibility unwarranted by the conditions seen in the photograph. However, where done sensitively, this can improve the clarity of an illustration, comparable to the conventional processing of photographs within a darkroom. It is recommended that the rendering of photomontages is carried out extremely carefully by a suitably experienced professional. The nature of any enhancement should also be noted within the ES.

164 Where a project involves an extension to an existing wind farm, existing turbines have sometimes been ‘painted out’ in the photograph of existing conditions and re-montaged back in, so that the images of both existing and proposed turbines match. This effectively changes the record of baseline conditions and is not recommended. However, in some conditions it may be necessary to enhance the depiction of existing turbines if they are not clear in the photographs taken (for example due to weather conditions, or because the rotors are oriented perpendicular to the viewpoint).

165 **Enhancement and rendering cannot compensate for photographs that have been taken in poor light or weather conditions**. In these circumstances, the photographs should be retaken.

166 It is important to use turbine locations, dimensions and heights which are as accurate as possible. The location and height of turbines in visualisations can be verified using the process set out in **Annex E.** The production process should be documented within the ES to enable this.

Accuracy of match to photography

167 In order to create a photomontage, the geometry of the overlain rendered image of the wind farm must match as exactly as possible that of the base photography. The viewpoint location, height and direction of the view must be **identical**, as must the horizontal field of view. Both the resulting panoramic photograph and the rendered image must be **planar projections**. In some cases, to achieve an accurate match, the images will need to be produced in cylindrical projection, thus allowing a much wider horizontal field of view and providing more features to achieve a match. Once a good match is achieved, the image should then be converted to planar projection for presentation in the ES.

168 The most reliable method of obtaining an accurate match is to generate a wireline image that matches the photograph. If the wireline can be accurately overlaid onto the photograph, then the fit is good. However, where there are few landform features, this process may require the matching of specific structures identified and mapped on site. A transparency copy of the image can also be used to check this on site.

169 An accurate GPS position, taken when the photography was carried out, is almost always sufficient for wind farm applications. Viewpoint location errors usually manifest as a mismatch in the horizontal position of elements in the photograph and wireline and are always more apparent in closer objects or landscape elements. If it is impossible to obtain a simultaneous match on both near and distant landform features, then the viewpoint position is incorrect and will need to be either re-measured on site or identified through iteration.

170 In certain landscapes, where there are few distinctive topographic features, it is necessary to use man-made features such as masts, pylons or buildings. Even when these types of features are clearly visible in photographs, it is often difficult to identify them accurately on the map. Where there is no view of a distant skyline a hand-level or, better, a surveyor's level, can assist in setting the correct vertical alignment of panorama and wireframe. Without this one may be reliant solely on the leveling of the camera.

171 Adjustments should be made until a satisfactory match between topographic features in the wireline and the photograph are achieved across the whole width of the panorama, to ensure that there are no errors of scale. If this cannot be achieved, then the fields of view do not exactly match and the parameters must be adjusted further. It is often the case that a small rotation needs to be applied to the panorama to compensate for residual errors in levelling the camera.

172 Once a satisfactory match has been achieved, it is possible to use the parameters for the wireline as perspective parameters for rendering the turbines for photomontage. Many packages combine wireline and rendering and some also include the facility to overlay the wireline on the photograph while adjusting parameters. However, the best quality is usually

obtained using a separate computer program designed for high-quality rendering. Most rendering programs do not include the effect of the earth's curvature, so it may be necessary to make vertical adjustments to the turbine positions before rendering. The rendered wind farm should be overlaid on the photograph using a matched wireline for reference, to ensure that the position is correct.

Accuracy of lighting

173 The lighting model used to render wind farm images for photomontages should be a reasonably faithful match to the lighting visible in the base photograph. Consequently, the date and time that the photographs were taken should be recorded by the photographer or assessor to enable an exact sun direction to be calculated. In practice, however, as long as the direction of light is correct to within about 10 degrees, a convincing match can be obtained. The effect of light and shade on wind turbines is an important aspect of their visual character and should be represented well.

Associated infrastructure and land use change

174 Wind farm proposals include elements other than wind turbines, such as access tracks; borrow pits, crane pads, site compounds, cabling, and a substation. A wind farm development may also be both directly and indirectly responsible for vegetation and land use change. If these elements are likely to result in permanent significant impacts (for the duration of the consent), either individually and/or collectively, they should be included in photomontages where this is practical.

175 Some of these components may be difficult to model well, particularly changes in vegetation. In these circumstances it may be necessary to "paint" them directly onto the photomontage, guided by a wireline or other computer generated image to ensure that the positioning, perspective and scale of these elements is represented as accurately as possible. In some circumstances it may be beneficial to include an illustration of lighting on turbines, if this is required to address military and/or civil aviation requirements.

Image requirements

176 Production of the photomontage requires care to ensure that an accurate image is created. **This section is prescriptive and images must comply with these requirements. This will avoid concerns over the 'accuracy' of images or the method by which they have been produced.**

Construction of photomontages

177 The photomontage should be formed from several 50mm photographs stitched together by a competent professional using suitable software. The information that should be included on the photomontage is described in paragraph 131.

178 The panorama should be printed on A1 width paper[7] in **planar projection**. The image size should be 260mm high by 820mm wide. The horizontal field of view should be 53.5° and the

[7] Unless a wider Horizontal Field of View is required

vertical field of view should be 18.2° in the centre of the image. The image will have a principle distance of 812.5mm.

179 A clear viewing instruction should be included on the photomontage as follows: “**View flat at a comfortable arm’s length**”.

Figure 3: Panoramic photomontage

Preparing images for use in the Digital Viewer

180 To help provide better access for the public, and to facilitate the viewing of visualisations more accurately onscreen, all applicants should provide a set of digital images to be uploaded in to the Digital Viewer. It is only necessary to provide the digital version for key viewpoints to be agreed with the determining authority. These are likely to include viewpoints for which photomontages are produced, but fewer may be required depending on the sensitivity of the site.

181 The Digital viewer is still under development and is likely to be rolled out over a period of 12-18 months. In the meantime, applicants <u>do not need to submit jpegs</u> for insertion in to the digital viewer until further notice.

182 To produce the image required for the viewer the following steps should be followed:

1. Choose the same horizontal field of view used in the baseline panorama described above (unless a wider field of view is required to illustrate cumulative effects)
2. Crop the image to a vertical field of view of 18.2°
3. Render turbines (including any cumulative proposals) on to the image following the same process described above
4. Scale the image height to 1600 pixels and save in “jpeg” format.
5. The image should also be presented in cylindrical projection

Figure 4: 90º panoramic photomontage ready for insertion into Digital Viewer

Preparing the Viewpoint Pack

183 To facilitate comparison in the field, a set of single frame images to use at the viewpoint(s) is required. These should be provided on thicker A3 paper for durability and ease of use in the field. Images contained within the pack should be loose leaf and should have a detailed location map printed on the reverse side to make it easier for users to find the exact viewpoint location. A brief description of how to find the viewpoint should also be included.

184 The pack should contain images from a set of key viewpoints, to be agreed with the determining authority. It may not be necessary to provide them for every ES viewpoint.

185 Each image should be clearly labelled: "**This image is intended only for use at the viewpoint. Further information in the ES should also be referred to**."

Construction of A3 single frame photomontage

186 The images should be prepared from the same baseline photography and using the same process for rendering turbines[8]. The image height should be 260mm by 390mm wide. The horizontal field of view should be 27° and the vertical field of view should be 18.2°, The image will have a Principal Distance of 812.5mm.

Figure 5: A3 single frame for use in viewpoint pack

Using the viewpoint pack

187 The pack should be provided to the Planning Authority and to each of the Community Councils in the area affected by the proposal. Additional copies may be required should the application result in a public inquiry. The pack holder or title page should be clearly labelled "Images for assessment only at the identified viewpoints" along with the name of the wind farm and supplementary information. It should include a map showing the location of each viewpoint and detailed grid references to help users find the viewpoint location in the field.

188 It is important to get as close to the precise viewpoint location as possible. The viewpoint map, grid reference and photograph of the tripod location can all be used to achieve this.

189 In poor weather the use of an A3 Perspex holder, or document wallet, can help keep the images dry and reduce the effect of wind. Planning officers and other users who visit viewpoints regularly should consider purchasing a holder for this purpose and in particular for presenting images to the planning committee in the field (when it is often not possible to choose optimal weather conditions). These are widely available at low cost.

190 The Viewpoint Pack should only be used at the viewpoint location, or by those who have previously visited the viewpoint (such as on a Committee site visit). At viewpoints which are very close to the wind farm it may be necessary to take the larger panoramas or wireframes as it is unlikely that the whole wind farm will be captured on the single frame. It is not necessary to produce multiple single frames to cater for this situation.

Presentation of visualisations

191 It will usually be appropriate to present the photograph, wireline and photomontage such that the proposed wind turbines are centred in the horizontal field of view. However, at certain viewpoints it may be appropriate to centre the view on an alternative feature, or part way between two or more foci. These additional foci may or may not be wind farms. In these circumstances, it is important that the proposed wind farm does not appear at the far edge of the image. This is because sufficient context or horizontal field of view needs to be provided for each of the foci.

192 Paper copies of all ES materials will be required by the Planning Authority and SNH. The number of copies should be agreed for each application. Additional loan copies for members of the public will also need to be provided, and these should be made available at accessible locations throughout the study area. Typical locations include local libraries, Council offices and village halls. The number of loan copies should be agreed with the Planning Authority.

Public Exhibition display

193 Stakeholder engagement is extremely important and exhibitions provide an important opportunity to present visualisations to the public. Given the changes in focal length and image height adopted by this guidance, it is recommended that **the same visualisations**, printed at the same size, should be used for public exhibitions. The limitations of visualisations should be clearly marked on all of the material, and the information in **Annex A** clearly displayed at the exhibition. The viewpoint pack should **not** be provided at the public exhibition – unless users intend to visit the viewpoints.

Presentation to council planning committee

194 It is for the Planning Authority to determine which images are presented to the committee – but it is important that those who are unable to visit viewpoints are provided with a suitable

[8] The single frame can be extracted from the panoramic photomontage, as long as it is cropped from the centre of the panorama.

panorama to provide landscape and visual context. The Digital Viewer may also be helpful in these circumstances. All hard copy images should be printed in colour at the correct size.

195 Projection of a selection of the visualisations on PowerPoint slides, or similar, may be helpful to the planning officer and committee members. However, **it is essential that members are also provided with hard copies of the images, printed at the right size** to aid their decision-making and that they read the supporting text assessment in the ES. Visualisations on their own cannot substitute for the assessment of likely effects.

196 Committee members should **visit a representative selection of viewpoints** as part of the decision-making process, especially where there are differing opinions on the likely effects.

Optional visualisation techniques

Hand-drawn illustrations

197 Drawings and paintings have been used for centuries to illustrate proposed landscape or architectural changes. However, digital photography has resulted in radical changes to the way images are conventionally presented, with an associated demand for these to be based on technical data for which accuracy can be measured.

198 There are instances when hand-drawn illustrations remain an invaluable tool in the process of visual analysis and the illustration of impacts within an ES. This is because they can offer:

- clarity of image, by omitting some of the distracting details that might be prominent within a photograph but which are overlooked on site;
- an element of interpretation by highlighting prominent focal features; and,
- their limitations are obvious – they are clearly not trying to replicate an exact view as it would be seen.

199 However, for these same reasons, hand-drawn illustrations also have disadvantages, chiefly that their quality is closely linked to the abilities of the illustrator and they may be distrusted for incorporating 'artistic licence'.

Diagrammatic sketches and annotated visualisations

200 Diagrammatic sketches allow the key elements of the composition to be drawn out and highlighted. This may be in relation to the landscape or the wind farm development, highlighting the main characteristics and principles of design. The advantage of using this medium is that important points can be stressed without them being clouded by insignificant details.

Animation

201 Wind turbines are intrinsically dynamic objects, with large moving parts and variable orientation, so static images are in many ways a poor illustration. Computer animation, videomontage and virtual-reality techniques are being used to some extent to address this issue.

202 To date, most animation and videomontage has been used principally as a means of conveying a general impression of a development to the determining authority and the public, rather than as a tool for carrying out VIA or as part of an ES. However, considerable scope exists for their use in the future as various techniques are developed and presented, and then tested against wind farms once these have been built (similar to the scrutiny applied in the past to wirelines and photomontages). At present, the application of these techniques requires specialist contractors.

203 The provision of animation may assist in the decision making process. However, it cannot replace the need for professionally produced photomontages and wirelines from selected viewpoints.

Additional techniques for cumulative assessment

204 Additional guidance on further techniques to illustrate cumulative effects is provided in our guidance on Assessing the Cumulative Impacts of Wind Farms. The presentation of sequential effects as bar charts or on coloured maps is increasingly common. Video and virtual reality simulations of journeys have also been used with varying success. All such approaches should be carefully considered and discussed with the determining authority. Care is required not to use technology for technology's sake, nor to overburden the ES and decision-makers with additional information.

5 Offshore wind farms

205 Offshore wind farm visualisation presents different challenges to onshore situations. As well as having different environmental factors to consider, developments are usually significantly larger in turbine size and number.

206 In general terms, given good meteorological conditions, visibility is higher on the coast than inland; periods of exceptional visibility occur in north and west Scotland. However, in the coastal and marine environment, light quality and weather conditions change more rapidly and are more variable than onshore, so it is difficult to represent these varying conditions in a single image. Practitioners should aim to prepare visualisations representing the worst case scenario, thereby assessing the specific time of day and season when there is optimum visibility and clarity. The reasoning and background to choosing this seasonal or diurnal 'window' should be explained, for example by supporting Meteorological Office data.

Specific photographic requirements

207 It is difficult to judge the distance of an object when it is out at sea. It can also be difficult to judge the scale of a single turbine, or of a wind farm, where there is no scale indicator giving a familiar, comparative size. Thus, it is essential to include local landmarks or familiar features within a photograph where at all possible[9]. Where existing offshore features, such as oil platforms, existing turbines or lighthouses are present, they may aid in estimating the scale of the turbines, as well as the overall size and extent of the wind farm.

208 Photography at sea can be difficult because of wave action, so in some instances relaxation of photographic standards to reflect this may be appropriate, provided they are supported by wirelines. In some locations, especially those which are difficult to access, wirelines are the only feasible approach.

209 Scotland's east and west coasts differ in terms of their light, aspect, weather and coastal character. This needs to be considered when planning photography and visualisations. The direction of sunset and sunrise are also a key consideration from sensitive viewpoints and should be illustrated in some circumstances.

210 There is limited evidence to support an alternative 'focal length' for offshore wind farms. A report by the DTI[10] recommended using a 70 or 80mm 'focal length'. **To maintain consistency with the approach used onshore, the same methodology and image specification is recommended for offshore wind visualisations.** Note – as for the images described in section 4 above, this should be cropped and enlarged from a photograph taken with a **50mm fixed focal length lens**. This will be kept under review and determining authorities may chose an alternative focal length if circumstances support this.

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[9] Longer than A1 paper lengths may be required

[10] Guidance on the assessment of the impact of offshore wind farms: Seascape and Visual Impact Report, DTI, (2005)

Viewpoint choice for offshore wind farms

211 Because of the way offshore wind farm proposals are progressed through the marine planning system[11] it is common to require the preparation of multiple visualisations, depicting different development options, from any single viewpoint[12]. This results in ESs containing large numbers of visualisations, which is onerous for the consultant to produce and for consultees and assessors to process. It is essential, therefore, to select viewpoints carefully, to maximise the range of landscape sensitivities and receptors, and to represent the range of, but not all, scenarios, as seen from one viewpoint. Agreement on viewpoint choice will be needed between the parties involved.

212 Factors affecting viewpoint choice include, but are not limited to:

- Choosing key viewpoints to illustrate design options and evolution adequately
- Importance of representing land to sea, sea to land, and sea to sea views, including the coastal, sea and land interfaces
- Choosing viewpoints that represent recognised circulation routes, such as ferry routes (reflecting the type of boat and therefore viewing height from which the view will be seen), beaches, onshore roads and footpaths, cruising routes, popular sailing competition areas and other sea users, even if these may not be the most easily accessible points
- Use of inland viewpoints to see offshore proposals in the context of onshore foreground
- Representing a variety of lighting conditions, e.g. side-lit, back-lit and front-lit
- The need to choose viewpoints to show tidal differences in inshore locations
- Inclusion of appropriate features or foreground to help the location and scale of the wind farm to be appreciated

In all cases it remains essential that the number of viewpoints remains proportionate to the assessment.

Elevation of viewpoint

213 The horizon is the most distant point seen on the sea surface – this distance increases with the elevation of the viewpoint, and decreases the lower your position (because of the curvature of the earth). Under special weather conditions, on many days of the year from high points, it is possible to see the horizon up to 80+km distance[13]. On a clear day, viewed from a beach, the horizon is of the order of three nautical miles (approximately six km) distant. This means that the nature of views of offshore wind farms will vary significantly according to the elevation of the viewer, and any visual assessment should examine a range of viewpoints from different elevations.

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[11] using the Rochdale Envelope approach (which is designed to demonstrate the potential maximum extent of a project, and can involve the presentation of many different scenarios)

[12] See Marine Scotland/SNH Advice Note: Offshore Wind farm SLVIA and Cumulative Assessment. Annexe 2 in *Offshore Renewables guidance for Scoping an Environmental Statement.*

[13] *An assessment of the sensitivity and capacity of the Scottish seascape in relation to wind farms.* SNH Commissioned Report 103 (2005), p 12

Photomontage for offshore wind farms

214 In the production of offshore wind farm photomontages:

- It is important to recognise that the greater distances involved are a technical challenge. There may be a need to ‘zoom in’ for detailed design assessment.
- It is often difficult to represent turbines on the horizon in photomontages as this zone is generally hazy. The horizon may need to be rendered back in to the image in such situations, and wireframes will be particularly helpful.
- A key factor is achieving sufficient contrast between the sky and the sea so that the horizon is clear.
- It may be necessary to prepare images wider than 180^{o} to capture important landscape and visual context[14].
- It will be necessary to show the visual impacts of any ancillary infrastructure (including offsite implications), such as on-shore grid connections, converter stations, associated tracks, access routes or buildings, fencing, car parks, lighting, borrow pits and service platforms. Any additional colouring on the turbines (such as coloured foundation jackets) should be represented on the photomontage where possible.

Wirelines for offshore wind farms

215 The use of wirelines is especially useful in offshore visualisation where producing photomontages may be very difficult, and these will replace photomontages in some instances.

Turbine lighting

216 All offshore wind energy development will require lights for marine navigation and aviation safety. It is often one of the major visual issues relating to this type of development, although it is difficult to show on visualisations. Generally, the turbines are proposed in areas currently characterised by their darkness.

217 Precise lighting requirements are not usually known until late in the design process. This is due to the wide spectrum of different design variations (the use of the ‘Rochdale Envelope’ in planning schemes) which make it difficult to finalise Civil Aviation Authority, Ministry of Defence and Northern Lighthouse Board requirements.

218 Therefore, it is difficult to accurately represent likely lighting effects. Nevertheless, **it is recommended that night time visuals are provided to illustrate the likely effect of turbine and any other lighting requirements (such as substations).**

[14] NB – cylindrical projection is required for wider fields of view and the Digital Viewer should be used to illustrate views which cannot be captured on the A1 panorama described above.

Annex A Information on limitations of visualisations.

Visualisations of wind farms have a number of limitations which you should be aware of when using them to form a judgement on a wind farm proposal. These include:

- A visualisation can **never show exactly** what the wind farm will look like in reality due to factors such as: different lighting, weather and seasonal conditions which vary through time and the resolution of the image;
- The images provided give a reasonable impression of the scale of the turbines and the distance to the turbines, but **can never be 100% accurate**;
- A static image cannot convey turbine movement, or flicker or reflection from the sun on the turbine blades as they move;
- The viewpoints illustrated are representative of views in the area, but cannot represent visibility at all locations;
- To form the best impression of the impacts of the wind farm proposal these images **are best viewed at the viewpoint location shown**;
- The images **must** be printed at the right size to be viewed properly (260mm by 820mm);
- You should hold the images **flat at a comfortable arm's length**. If viewing these images on a wall or board at an exhibition, you should stand at arm's length from the image presented to gain the best impression.

Viewing instruction to be provided on every image

To minimise the risk of images being viewed incorrectly on screen, every photomontage should contain the following instruction: "View flat at a comfortable arm's length". The correct paper size and image size should also be provided.

Annex B Standard requirements which all visualisations should comply with

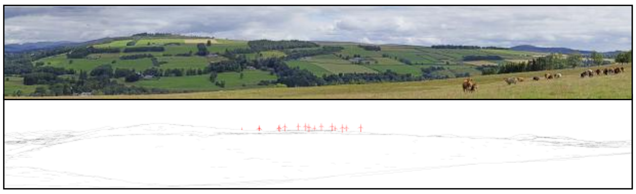
Checklist

Photography	**Camera**	Full Frame Sensor Size	
	Lens	50mm fixed focal length	
	Camera height	1.5m (unless alternative height can be justified, in agreement with planning authority)	
	Location	Grid reference, relevant location map, and photograph of tripod location provided	
Photomontage	**Image**	Clear of foreground objects	
	Conditions	Visibility sufficiently good	
	Baseline panorama and wireline	Cylindrical projection 90, 180, 270 or 360 degrees printed on A1 length sheet(s). Image size for both the baseline panorama and wireline should be 820mm by 130mm	
	Wireline	Planar projection, image size 260 by 820mm on A1 sheet. HFOV 53.5° and VFOV 18.2°	
	Panorama	Planar projection, image size 260 by 820mm on A1 sheet. HFOV 53.5° and VFOV 18.2°	
	Viewpoint pack	A3 single frames from viewpoints agreed with determining authority, image size 260 by 390mm. HFOV 27° and VFOV 18.2°	
	JPEG	Cylindrical projection jpeg for uploading to digital viewer. VFOV 18.2° and HFOV as required	
	Principal Distance	Printed on visualisations	
Maps	**Viewpoint map**	To include overall viewpoint location map (combined with ZTV). Thumbnail location map provided on each panorama	
Methodology		Statement of methodologies used to produce visualisations including ZTVs and software used	

HFOV = Horizontal field of view
VFOV = Vertical field of view

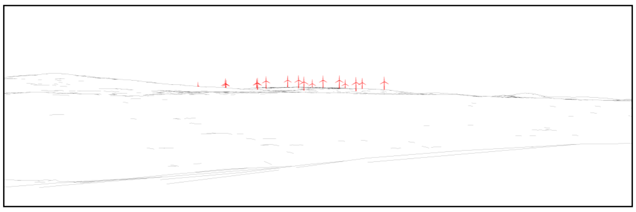
Annex C Summary of visualisation requirements[15].

Baseline panorama and wireline



- Illustrates wider landscape and visual context
- Illustrates cumulative effects

Wireline



- Very useful in design stages
- Illustrates 'bare ground' visibility
- Provides clear view to inform assessment
- Illustrates turbine placement clearly

A1 Panorama

- Illustrates the proposal within the landscape and visual context
- Provides good impression of scale and distance

A3 single frame in Viewpoint Pack

- Illustrates the proposal and provides good impression of scale and distance
- Useful in the field where landscape and visual context is clearly visible
- Easier to use outdoors in poor weather conditions than A1 format

Jpeg for Digital Viewer

Note – jpegs do not need to be submitted until further notice as the viewer is not yet available to planning authorities.

- Easily accessible format for the public to view on screen / online
- Useful for illustrating some cumulative effects and wide horizontal fields of view that cannot be captured on A1 panorama

[15] Note – it is not always necessary to produce all 5 images. In some cases a wireline may suffice, for example, if agreed by the determining authority and consultees

Annex D Earth Curvature and Refraction of Light

Ordnance Survey co-ordinates are not fully 3-dimensional. The northing and easting define a point on a plane corresponding to the OS transverse Mercator map projection, and the altitude above OS datum is measured above an equipotential surface passing through the OS datum point at Newlyn. In reality, the earth is curved so a correction has to be made in order to position geographical features correctly in three dimensions for ZTV calculation and for visualisations.

If it were not for the presence of the Earth's atmosphere, a simple allowance for curvature would be sufficient. The formula for this can be worked out quite easily from Pythagoras' theorem:

$$c^2 + r^2 = (r+h)^2$$
$$c^2 + r^2 = r^2 + 2rh + h^2$$
$$c^2 = 2rh + h^2$$
$$= 2(r+h)h$$
$$c = \sqrt{2(r+h)h}$$

h is very small in comparison with ***r***, so the formula can be approximated with:

$$c = \sqrt{2rh}$$

Rearranging for ***h***, we get:

$$\sqrt{2rh} = c$$
$$2rh = c^2$$
$$h = \frac{c^2}{2r}$$

In practice, rays of light representing sightlines over long distances are also curved downwards as a result of refraction of light through the atmosphere, allowing one to see slightly beyond the expected horizon. (The atmosphere reduces the vertical correction due to curvature alone by about 15%.) The standard formula used in surveying work is modified from the one derived above as follows:

$$h = \frac{c^2(1-2k)}{2r}$$

Where:

h is the height correction in metres
c is the distance to the object in metres
k is the refraction coefficient
r is the radius of the Earth in metres

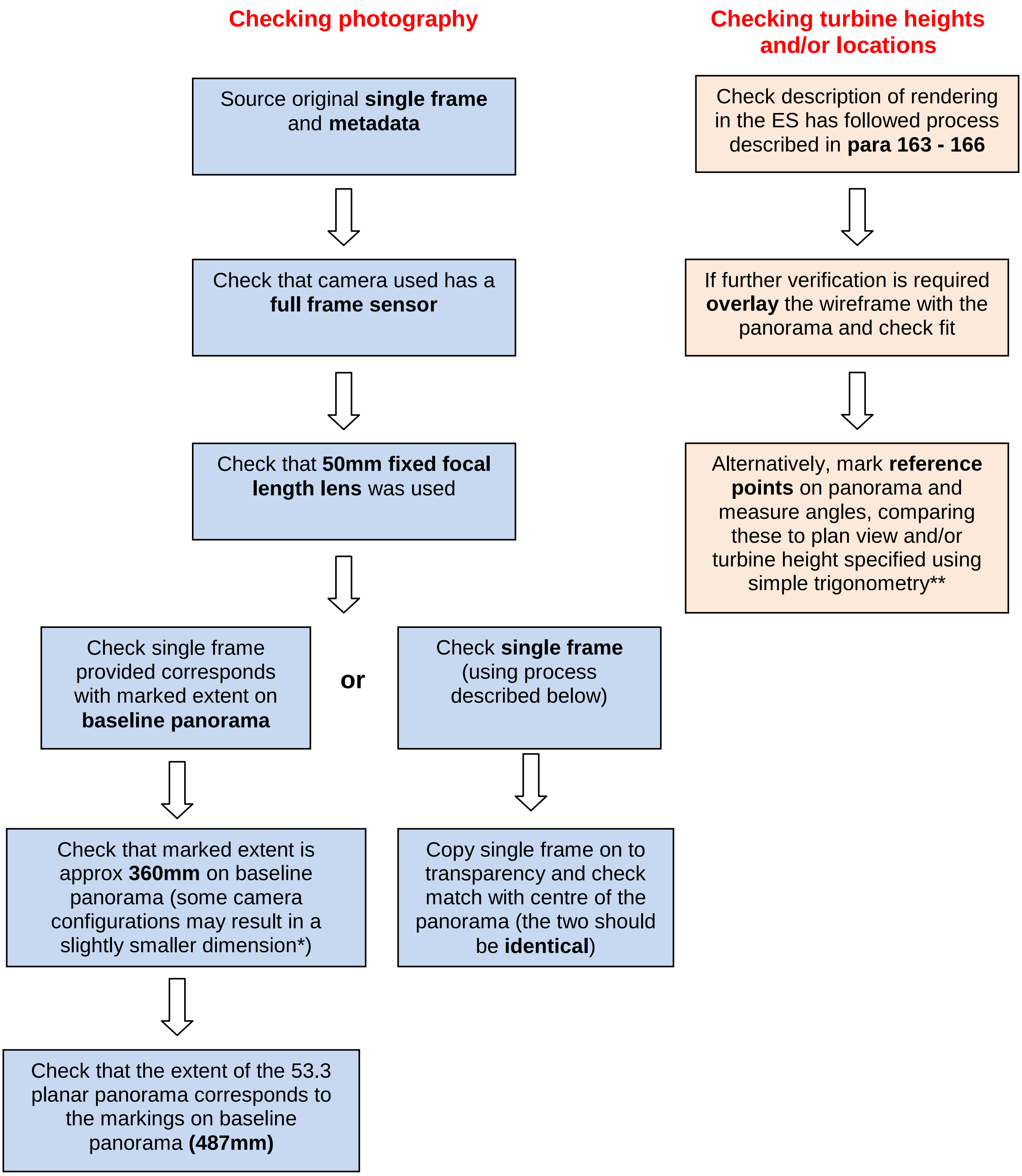
The parameter ***k*** is not constant but varies with temperature and barometric pressure (and therefore also with altitude). For precise geodetic surveying work both these quantities would have to be measured at both ends of a line of sight. Visualisation and visibility analysis do not require such precision; therefore a representative value may be used. 0.075 is a reasonable average for inland upland observations, but very slightly different values may be found quoted in surveying or navigation textbooks. (***k*** is a numerical coefficient and therefore has no units.) Taking ***k*** = 0.075 and ***r*** = 6,367,000m (a representative radius for the UK), the following example values are obtained:

Distance c	Vertical correction for Earth curvature and atmospheric refraction h
5 km	1.7m
10 km	6.7m
15 km	15.0m
20 km	26.7m
25 km	41.7m
30 km	60.1m

Annex E Verification of images

Some users of visualisations may wish to ‘verify’ the images provided. The following methods can be used. The first is provided to check that the photographs have been taken on the correct camera and lens and then enlarged appropriately. The second is to test that the turbines have been placed in the correct locations and at the correct size.

There are two ways to check the A1 panorama, both are described below. The verification of single frame images (for the viewpoint pack) is described separately on page 52.



Single frame images

The single frame image provided in the viewpoint pack can be verified using a similar process. A simple template can be used to check that the correct portion of the 50mm image has been cropped and then enlarged*. To check this:

- Obtain original 50mm photograph with **metadata**. Check full frame sensor camera and 50mm fixed focal length lens used

- print the original **50mm** photograph on A3 at **390mm** wide by **260mm** in height

- overlay a **template** to check that the correct proportion of the image has been cropped (an example is available on our website). The template should include two rectangles, one at 390mm by 260mm, and one at 260mm by 174mm as shown on the example.

- the cropped area should then be printed at **390mm** wide by **260mm** in height and this can be measured on the image submitted.

*** Note –** not all full frame sensors are exactly the same size. Very slight variations in sensor size and lens focal length may affect this measurement / comparison by a few mm. However, the difference is small enough that the horizontal field of view can be verified with sufficient confidence.

** **Note –** if measuring turbines on the image, make sure that you measure the full height of the turbine – i.e. check that the base of the turbine is not obscured either by vegetation, screening or topography.

Annex F Taking Good Photographs

This appendix is not intended to be a general manual of photography, there are plenty of good books available on that subject. It sets out briefly the main issues relating to photography aimed at constructing panoramas suitable for photomontages and ES work.

Camera and lens

A good quality camera is essential. A digital camera with **full frame sensor** is required to capture sufficient information and produce a verifiable image. A **fixed focal length 50mm** lens should be used to produce photomontages. A fixed focal length a) reduces the risk of inaccuracies and b) enables easy verification of the image should this be required. A full frame sensor also provides a verifiable reference point and a higher resolution than most alternative sensor sizes (depending on the camera).

Note, however, that sensor size varies slightly on most 'full frame sensor' cameras and that even high quality fixed focal length lenses can vary in their geometry. The precise sensor size and geometry of the lens should be recorded, where available. Any significant variation from 36x24mm sensor size or 50mm focal length should be recorded and, if significant, corrected for.

Tripod

A stable tripod is essential. As a minimum, a head with independent tilt adjustments for both pitch and roll should be used (ball-head tripods are more difficult to level satisfactorily). A panoramic head should be used, allowing a single adjustment to be made for an entire panorama. Camera height should be 1.5m. A photograph of the tripod in situ should be taken.

Levelling

In order to obtain photographs which will splice together satisfactorily to form the baseline panorama, it is essential that the camera is levelled accurately. A simple, cheap spirit level will do this quite satisfactorily and, with care, can produce images levelled to an accuracy of about 0.2°. A tripod head with a built-in sprit level and adjusting screws is better.

Focus

The camera lens should always be focussed on infinity. On auto-focus lenses, the focussing should be set to manual or locked on infinity.

Aperture and Exposure

If at all possible, the exposure should be metered once for a complete panorama and then used for all frames either by using a manual setting or by locking the exposure.

For greatest depth of field in the images, the aperture should be set to the minimum available on the lens (typically f/16 or f/22). If it is necessary to obtain slightly more resolution, it may help to use a slightly wider aperture: f/5.6 or f/8 are often the optimum settings. However, the photographer should use professional judgement to achieve the best results.

Shutter speed should be selected to obtain the correct exposure consistent with the aperture selected. If there are existing wind turbines in the view, the shutter speed will affect the degree of blurring seen in the photograph due to the movement of the blades.