The backclothing of wind turbines in the Scottish landscape

A report to the
Cairngorms National Park Authority

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Final report

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Executive summary

1. This report describes the findings of a study commissioned by the Cairngorms National Park Authority (CNPA) to examine the landscape and visual effects of windfarms that are seen against a land backdrop – commonly termed 'backclothed'. Its key purpose is to bring-together, analyse and understand existing research, guidance and experience of backclothing as it relates to the landscape and visual effects of windfarms.

2. From the brief, the key research question identified was:
   a. What are the landscape and visual effects of backclothed windfarms in the Scottish landscape?

   In addition, subsidiary questions were identified as follows:
   b. What are the conditions that result in the backclothing of wind turbines?
   c. What published literature exists on the concept and effects of backclothing?
   d. How do the effects of backclothed wind turbines compare to the effects of other large structures that are backclothed in the Scottish landscape?

3. Addressing these research questions, supported by both published literature and assessment of case study windfarms, the key findings of this study are:

   a. Windfarms are typically more prominent and result in greater visual effects where they appear in strong visual contrast to their backcloth – mainly in terms of colour and pattern contrast.

   b. Light-coloured wind turbines seen against a dark-coloured backcloth will typically have greater prominence than either light or dark-coloured wind turbines seen against the sky.

   c. The prominence of backclothed wind turbines tends to reduce with distance, strongly affected by atmospheric scattering. However, in certain conditions, backclothed wind turbines viewed over a simple landscape pattern may be perceived to be closer than they actually are.

   d. Backclothed wind turbines can contrast to a landform in a number of ways, including compromising its distinct focal qualities, contrasting to simple slopes, diminishing the sense of scale of the landform, and appearing visually unbalanced. Located part-way up slopes, a windfarm may also seem incongruous in relation to the typical location of built elements within a landscape.

   e. Backclothed wind turbines can affect the qualities of a simple skyline feature, even if not actually seen to 'cross' this. This results from the contrast of turbine visual shape in relation to a simple and mainly horizontal skyline, the distinction of which tends to rely on a lack of visual distractions seen nearby.

4. This study finds that there is not a great deal of academic literature on the specific subject of backclothing and future work on this topic is encouraged, particularly in terms of the relative influence and thresholds of determinants. However, a range of academic papers do exist in which backclothing effects are raised in relation to the general acuity of structures. Within this field, there are a number of studies that have researched the prominence and visual effects of wind turbines and other large structures, typically using computer simulation to show variables. In addition, visual contrast is addressed within many published books on the principles of vision, visual perception and design, and in guidance documents on the general siting and design of large structures.

5. While the design approach of backclothing is advocated for some development types, this study finds that backclothing of wind turbines results in very different landscape and visual effects and is typically not advised for Scottish upland landscapes due to the prominence of colour and texture contrast.

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Introduction

1. Contemporary windfarms have been developed across Scotland since the early 1990s. They have typically been located within very open landscapes and/or upland locations in order to serve their function – harness of the wind – meaning they tend to be seen upon the skyline, against the sky. However, in certain circumstances, wind turbines are sited upon hill side-slopes, plateaux or landform shelves; in these situations, they are often seen against a backdrop of land that is typically darker than both the sky and the wind turbines (University of Newcastle, 2002).

Scope and method of study

2. This report describes the findings of a study of the landscape and visual effects of windfarms that are seen against a land backdrop – commonly termed 'backclothed'. It has been commissioned by the Cairngorms National Park Authority (CNPA), primarily to bring-together, analyse and understand existing research, guidance and experience of backclothing as it relates to the landscape and visual effects of windfarms and windfarm design.

3. This study combines the findings of peer-reviewed research and publications, and the assessment of existing backclothed windfarms using standard professional methods. In this way, it is neither purely an academic paper nor guidance document; alternatively, it combines both approaches to build upon robust academic research in order to identify, analyse and explain effects encountered in practice. Quality Assurance review of the study has been undertaken by the CNPA.

4. From the brief, a key research question was identified as being:
   a. What are the landscape and visual effects of backclothed windfarms in the Scottish landscape?

   From this, subsidiary questions were identified as follows:
   b. What are the conditions that result in the backclothing of wind turbines?
   c. What published literature exists on the concept and effects of backclothing?
   d. How do the effects of backclothed wind turbines compare to the backclothing of other large structures in the Scottish landscape?

5. To address the research questions, the following method was followed:
   a. Background research — A review of published and grey literature[1] on relevant subjects, including review of information on the World Wide Web.
   b. Case study windfarms — Site assessment of 5 windfarms within Scotland that demonstrate landscape and visual effects of wind turbine backclothing – Gordonbush, Kilbraur, Beinn Tharsuinn, Farr and Paul's Hill.

[1] Grey literature is a term used to describe documents, reports, policy guidance etc that is not officially published in terms of having an ISBN or ISSN number and thus cannot always be sourced through official library catalogues

		The method of assessment of these windfarms followed the Guidelines for Landscape and Visual Impact Assessment (LVIA) (Landscape Institute and Institute of Environmental Management and Assessment, 2002).
		Review of LVIA site assessment previously carried out for 8 windfarms that have backclothing effects - Braes of Doune, Clyde, Harlock Hill, Achany, Edinbane, Causeymire, Buolfruich and Novar.
c.	Analysis	Analysis of the key factors affecting backclothing, including windfarm siting and design, visual acuity and contrast, landform and skyline, landscape character, and distance of viewpoints. Analysis of the different landscape and visual effects of wind turbine backclothing.

6. The scope of the study was limited by time, extending over a period of four weeks between mid August and mid September 2012. While fieldwork carried out specifically for the study was also limited to this timescale, the review of previous site assessment included data from a wide range of seasons and weather conditions, as well as assessment of developments of various siting and design and at different stages of construction and operation.

7. While this study focuses on the landscape and visual effects of backclothed wind turbines, it is highlighted that this is just one consideration for siting and design of a specific windfarm development in a particular landscape.

Author

8. This study has been carried out by Caroline Stanton CMLI. Caroline works as a consultant landscape architect as well as undertaking PhD research at Edinburgh College of Art, Edinburgh University. She has considerable experience of Landscape and Visual Impact Assessment (LVIA) and Landscape Character Assessment (LCA) and has worked as a landscape architect in Scotland for both private and public sectors. Caroline has not only produced LVIAs for windfarms, but has also reviewed a wide range of these studies prepared by others for development proposals. She has worked for a broad range of clients, including windfarm developers, council planning authorities, community trusts and individual landowners, and was also a landscape advisor for Scottish Natural Heritage (SNH) spanning 17 years.

9. Caroline has written or contributed to the production of many guidance documents on windfarms, including the SNH guidance 'Siting and designing windfarms in the landscape' (2009) and the 'Visual Representation of Windfarms Good Practice Guidance' (VRWGPG) (SNH, Scottish Society of Directors of Planning and Scottish Renewables, 2006). She has also provided presentations to Scottish Government, SNH and RenewablesUK (formerly The British Wind Energy Association) on the landscape and visual impacts of windfarms and has advised the United States National Wind Coordinating Collaborative on the analysis of windfarms.

What is a backcloth?

10. A 'backcloth' is commonly defined in relation to its use in theatre – as 'a painted curtain at the back of a stage set'[2]. Leading from this, the term tends to be used in landscape architecture to describe what is seen within the background of a view. It is often used interchangeably with the terms 'backdrop' and 'background', but tends to be associated more commonly with visual effect rather than landscape effect[3]. This study concerns views of wind turbines where there is a backcloth of land rather than sky or water.

11. A windfarm tends to be backclothed by land when seen from viewpoints that are at a higher elevation than the development or, alternatively, where a windfarm is seen in front of steep hill slopes. In certain circumstances, both situations may occur, for example looking towards an upland landform shelf. Visibility and prominence of a land backcloth will vary in different viewing conditions, including in response to different season, weather and light conditions.

What influences the effects of backclothing?

12. This section of the report will describe the various factors that influence the effects of backclothing, which are:
    - Visibility and perception of an object;
    - The distinction of an object by contrast; and
    - Varying influences on contrast.

13. This section has been informed largely by existing research and literature. The study of this material was limited generally within the scope of the study, as described in paragraphs 5-7 above; however, in addition, a number of more specific constraints were encountered, including:
    - There is little academic literature available on the specific backclothing effects of onshore wind turbines; rather, most research and guidance is based on the general detection and prominence of structures or in relation to other types of development such as power stations and electricity transmission lines.
    - Much of the research testing thresholds of visual detection, prominence and judgement of visual effects is based on computer simulation; while this offers the benefits of consistency of images considered by respondents, computer simulations cannot replicate the experience of a landscape in the field (SNH, Scottish Renewables and the Scottish Society of Directors of Planning, 2006; University of Newcastle, 2002; Hammarlund, 2002).

[2] Collins English Dictionary, 2nd Edition.
[3] The distinction between these effects is explained within The Guidelines for Landscape and Visual Impact Assessment (The Landscape Institute and Institute of Environmental Management and Assessment, 2002)

- Landscape context strongly affects perception of effects (Vroom, 2006). Thus research on landscape perception is inevitably limited in its application in landscapes other than that in which the original research was carried out.
- There is a great difference between detecting an object and perceiving it to have landscape or visual effect. Following the ecological approach and affordances[4], this judgement will depend on the viewer – whether they think it is relevant to them and how (Greggory, 1998; Appleton, 1996; Heft, 2010).

14. Bearing in mind the constraints discussed above, the following section describes some key factors influencing the landscape and visual effects of backclothing.

Visibility and perception of an object

15. Our eyes are simple optical instruments, and our understanding of how these operate is long-established and well-documented, based on works dating as far back as the tenth century and the discovery of the camera obscura. It was not, however, until the start of the seventeenth century that it became widely understood that light does not enter or leave the brain, but that the retina provides an interface between the optical projection of objects and neural-coded signals to the brain. Thus what we 'see' and what we notice and perceive is very different, as our brains contribute enormously to vision[5].

16. While interpretation of what we see is commonly believed to relate to what we judge to be of value for survival (Gregory, 1998; Bruce *et al*, 1996; Appleton, 1996; Tveit *et al*, 2006) and our cultural background (Bell, 1999), a number of different theories exist in psychology to explain perception of our surroundings. Bruce *et al* (1996) state that most of these theories "…assume that perception should be regarded as a process of interpretation or construction from the incomplete information provided by the retinal image (p71)".

17. With regards to vision, the ability of a person or animal to detect fine spatial pattern is expressed as visual 'acuity'. This can be measured by the use of a grating - a pattern of parallel vertical dark bars equal in width and separated by bright bars of the same width. As the dark and bright bars are made narrower, there comes a point when an observer is no longer able to resolve the grating – that is to distinguish it from a uniform field of the same average brightness (Bruce et al, 1996).

18. Visual acuity is limited by several processes. The first is the efficiency with which the optical apparatus of the eye maps the spatial pattern of the optic array onto the retina; the second is the efficiency with which receptor cells convert that pattern into a pattern of electrical activity; and

[4] The ecological approach builds upon the work by Gibson in the 1960s, considering there are more 'natural' ways of perceiving the environment than just receiving stimulation, and that there is a dynamic relationship between perceiver and environment. Built upon the ecological approach, the concept of 'affordances' follows the premise that perception of our landscape relates to what we perceive it offers us – ie perceptible properties of the environment that have functional significance for an individual.

[5] This is why the common analogy between vision and the workings and product of a camera has significant limitations, and also why the photographic illustrations in the following section are limited in what they can convey

the third is the extent to which information available in the pattern of receptor cell activity is detected by the neural apparatus of retina and brain (Bruce et al, 1996).

The distinction of an object by contrast

19. Detection of an object relies upon contrast to distinguish it from its background. This contrast is determined predominantly by variation of colour and texture, although it is also influenced by the shape and size of an object (Shang and Bishop, 2000).

20. Wong (1993) states that "Contrast happens all the time". "There is contrast when a form is surrounded by blank space. There is contrast when a straight line meets a curve. There is contrast when one form is much bigger than another" (p105). He also explains that contrast is not just about opposites - a range of contrast may occur, from "mild or severe, vague or obvious, simple or complex." While he explains that "contrast is just a kind of comparison whereby differences are made clear" (p105), he also highlights that colour contrast doesn't just represent individual differences, it may also emphasize differences. Arnheim (1974) describes the root of this phenomenon as being because "… the identify of a colour does not reside in the colour itself but is established by relation." (p362) – why the perception of the brightness of one area is affected by the perception of the brightness of another juxtaposed. Hoffman (1998) describes the relevance of this to the perception of white, black and grey in abrupt contrast and how a grey shape on a black background may appear lighter than an adjacent grey shape on a white background. However, he also highlights that contrast theory is complex and not fully understood, particularly the way in which people seem to group portions of an image together and judge the relative luminance of regions both within and between groups.

21. Colour can be distinguished in terms of hue, saturation and lightness; however, it is the difference of lightness that is commonly referred to as colour 'contrast', usually measured by comparing luminance of a particular object in relation to luminance of the background. Contrast of an object is usually expressed as a ratio of luminance in relation to its surroundings; however, the sample area over which this luminance is measured varies between different studies – an object sometimes measured in direct reference to the background area it screens, sometimes in relation to the 'edge' surrounding the object, and sometimes in relation to an area circling (or 'elipsing') around the object (Bishop, 1997).

22. When studying contrast, Bishop (2002) states that "the use of lightness alone is not entirely satisfying, as different-coloured objects may be clearly visible even if the lightness values are identical" (p717) – ie also recognising hue and saturation of colour. However he concedes that this is not a significant limitation for current research on wind turbines as most are white or light grey and thus "… lightness will tend to dominate colour differences" (p717).

23. The terms 'figure' and 'ground' are sometimes used to distinguish objects in contrast to their background. Bell (2004) highlights that a figure is not necessarily perceived as negative or positive in a view; while attempts are made to mitigate the prominence of some figures by reducing their

contrast, a prominent figure is sometimes desired, for example a sculpture or church. However he does warn "if the figure stands out too strongly from its surroundings and in so doing contrasts too much then it may be intrusive. This is a particularly common effect when geometric shapes are introduced into natural landscapes" (p125). He also advises "if the continuity of the texture and pattern of the background is important then individual elements should not stand out as figures." (p126). Tveit *et al* (2006) account for a perception of intrusion in relation to perceived 'disturbance'. They define this as "… a lack of contextual fit and coherence, where elements deviate from the context. Disturbance is related to constructions and interventions occurring in the landscape, of both temporary and permanent character" (p240).

24. Acuity of an object also depends on the scale of the object. Iverson (1985) describes how "…the ability of the retina of the human eye with 20/20 vision to perceive separation of an image from its background is normally limited to a visual angle of one minute[6]…", leading to the calculation that a "…1.5 foot square form of high colour contrast can be perceived at one mile under good viewing conditions. The visual angle of that 1.5 foot square at one mile is one minute" (p15). In tests, Shang and Bishop (2000) also found that there was high correlation between detection rates for objects and visual size.

25. Considering detection of an object in different landscape types, Shang and Bishop (2000) found that detection was highest in landscapes where "…the object is brighter (positive contrast) than its background", rather than where the object is darker (negative contrast). When detection rates were plotted against object size, they found that "it was much easier to detect, in similar conditions and for these sizes, a bright object on a dark background than a dark object on a bright background" (p134). When compared against judgements of visual impact, they found that a high positive contrast (30%) object was assessed as having 'high' impact at the same object size that a low positive contrast object (13% and 7%) was perceived as having 'low' impact. At this same size, all negative contrast objects were also perceived to be of 'low impact'. Shang and Bishop (2000) conclude that this means that "for the same object to reach the same level of visual impact under negative contrast conditions, it would require a much greater size and contrast" (p136).

26. Detection of an object depends not only on colour contrast with a backcloth and scale, but also on object shape and contrast of pattern. It tends to be greatest where a shape is simple and the backcloth pattern is simple (Hull and Bishop, 1988; Shang and Bishop, 2000). Magill (1990) confirms that an "… important feature for accurate perception is the outline of an object, which creates a figure in relation to its background. Thus, the thin line of a road or powerline, especially at a distance, is less likely to be perceived than are better-defined objects such as powerline towers, satellite dishes, clearcuts, buildings, or mine tailings" (pp12-13). Shang and Bishop (2000) explain that irregular structures tend to be harder to detect, and thus typically have a higher threshold of detection for the same size and contrast, while Hull and Bishop (1988) highlight that

[6] A minute of arc MOA) is a unit of angular measurement equal to one sixtieth of one degree. In turn, a second of arc is one sixtieth of one minute of arc. Since one degree is defined as one three hundred and sixtieth of a rotation, one minute of arc is $^{1}/_{21,600}$ of a rotation.

electricity transmission towers have less impact in scenes with higher complexity. Crowe (1958) states that "a shape which assimilates with the landform behind it, or which lies long and low on the ground, or which rises in slender towers, like the chimneys at Burry Point, fades into its backgrounds sooner and more gracefully than some huge and uncompromising rectangle, which refuses either to amalgamate with the landform or to permit an infiltration of light and shade" (p36).

27. Shang and Bishop (2000) state that, at a certain level of contrast, "for a given object, the more complex its background (eg texture, shape, pattern, contrast, etc) the more difficult it becomes to discern and recognize" (p129). Additionally, Ode *et al* (2008) highlight that "an overly complex landscape is also likely to affect the legibility of the landscape as a consequence of offering too much information" (p92). The University of Newcastle (2002) describe how this, conversely, means contrast of structures will often be greater in the elevated landscapes of Scotland due to their simplicity of land cover as other "…visual detractors and man-made elements will be more limited" (p54).

28. While links between contrast, size, shape and acuity of an object have been established, the interactions between these variables and identification of the primary determinants is not always clear (Shang and Bishop, 2000). Studies of the visual effects of offshore wind turbines have helped to some extent, as they allow isolation of some of the variables, such as turbines being at the same elevation and views extending over a simple expanse of water rather than affected by pattern and intervening structures. Research such as this has been carried out by Bishop and Miller (2007) and confirms that colour contrast remains one of the most influential factors affecting impact levels for wind turbines.

Varying influences on contrast

29. The perceived contrast of objects will vary with changing atmospheric conditions day-by-day, and even hour-by-hour, although some geographical areas have a greater frequency and probability of certain conditions that reduce contrast, such as mist. The University of Newcastle (2002) highlight that "as the sky darkens, those turbines seen against the darkening sky become more difficult to perceive, and the ones which are seen against a backcloth of landform and vegetation become relatively more prominent" (p53), although they highlight that backclothing of light coloured turbines is less obvious during snow cover.

30. More predictable than the weather, although still variable, is the effect of atmospheric scattering which results in a reduction of perceived contrast with increased distance. Bishop (2002) found that this haziness can reduce detection of wind turbines by a significant degree, although he also found contrast levels could be enhanced where there is "…very clear air that often precedes a storm" (p715). The University of Newcastle (2002) also found that acuity can be increased at higher elevations due to greater "air clarity" (p54).

31. Movement of wind turbine blades is typically thought to also increase prominence, as described by The University of Newcastle (2002) who state "the movement of the blades [of a wind turbine], in all cases where this is visible, increases the visual effect of the turbines because this tends to draw the eye" (p77). Research reveals that wind turbine blade movement is more noticeable when seen in high contrast and the University of Newcastle (2002) state that movement is "… more perceptible when backdropped against dark vegetation compared to grey sky" (p52). Bishop and Miller (2007) reveal too that "…the difference between still and moving effect gets greater as the turbines become increasing prominent (either closer or with higher contrast)" (p825). However, this is not the 'whole story' in terms of movement and prominence, as some contradictory responses have been obtained from perception studies; for example, Bishop and Miller (2007) found in one study that "the negative visual effects when turbines had moving blades were consistently lower than when the blades were stationary" (p825). Bishop and Miller suggest two possible explanations: one, that people prefer to see wind turbines 'working' as they feel "when stationary they are an intrusion with no evident purpose" (p830); and, two, that moving wind turbine blades relate better to a landscape if this is evidently 'windy'. There may also be an additional reason; if stationary, the varying blade positions of different wind turbines within a particular development can increase the apparent complexity and incongruity of a windfarm image within a simple landscape. This is in contrast to when all the wind turbine blades are rotating, when differences in blade position tend to be difficult to discern as it is not easy to focus upon more than one machine at a time.

32. Perceived contrast varies according to the elevation and aspect of a viewer in relation to the elevation and position of an object. Iverson (1985) explains that measures of 'visual magnitude' are partly based on aspect relative to the observer and slope, describing how "the more directly a face of an object is turned toward a viewer, the larger it will appear" and "the steeper the slope, the more 'seen area' will be revealed" (p14). The University of Newcastle (2002) describe how, from higher elevations, "… turbines will also be backdropped to a greater extent than from lower elevations and the colours of the turbines and vegetation types will have an effect of increasing relative visibility" (p54).

What are the landscape and visual effects of backclothed windfarms?

33. Building upon the theory, research and literature described within the previous section, and informed by assessment of case study windfarms as described within paragraph 5, the following section of this report describes some of the landscape and visual effects of backclothed windfarms in Scotland. This description of effects is supported by the inclusion of photographs of existing windfarms (which are solely illustrative[7]).

[7] ie they are not intended to be accurate representations of the specific effects of particular windfarms, for example to a defined scale that would require a defined viewing distance. The limitations of photographs in relation to what people see and perceive in reality needs to be borne in mind as raised previously in the 2nd point of paragraph 13 and described in detail within the Visual representation of windfarms good practice guidance (SNH, Scottish Renewables and the Scottish Society of Directors of Planning, 2006)

34. The landscape and visual effects described within the following section focus upon the backclothing effects of windfarms. However, it is highlighted that these are just one aspect of a wide range of landscape and visual effects of windfarms, as described by other reports and publications[8]. In addition, as for any landscape and visual effect, perception of specific backclothing effects will depend on how the landscape is experienced, for example within different seasons and weather, while stationary or moving, from different elevations, or in views that are open and panoramic or framed (figure 1).

Figure 1a – Prominence of backclothed wind turbines influenced by being seen upon slopes facing the motorist, framed within the view, and in the direction of travel

Figure 1b – Further along the road, the same wind turbines are seen within a wider and more open landscape setting, although still prominent due to colour and pattern contrast with the backcloth

[8] Including the University of Newcastle, 2002, and SNH, 2009

35. Within the Scottish landscape, backclothing of wind turbines tends to occur primarily in two different situations as described previously in paragraph 11: where a windfarm is seen from 'above', from a location more elevated than the development site (figure 2); or where a windfarm is seen against a hill or ridge behind (figure 3). In certain locations, however, both circumstances can occur where a windfarm is viewed not only from above, but also against a hill backdrop (figure 4). This tends to occur where a development is located upon a landform shelf or plateau adjacent to hills; typically it results in the windfarm being seen predominantly backclothed from key viewpoints within the surrounding landscape.

Figure 2 - Backclothing of wind turbines due to elevated view from adjacent hill

Figure 3 - Backclothing of turbines due to location of windfarm upon hill side slopes

Figure 4 - Backclothing of wind turbines due to elevated view in addition to visibility against hill behind

36. Some windfarms will appear backclothed from some directions and skylined from others or, alternatively, will have some wind turbines backclothed and some skylining within the same view. In addition, colour contrast and thus prominence of backclothed wind turbines will vary between different season, weather and light conditions, and also with distance. With regards to the latter, the colour contrast of a windfarm backclothed against an adjacent hill will obviously be stronger than if backclothed against a hill seen in the far distance whose prominence will be diminished by atmospheric scattering. Where a windfarm has a backdrop of both land and sky, this may represent the 'worst of both worlds', as the development will usually have some wind turbines contrasting to their background whatever the weather and light conditions.

Colour contrast with backcloth

37. As described within the previous section of this report, detection of objects depends on contrast between an object and its background; in addition, light objects seen in contrast to a dark background tend to be detected more easily and assessed as having greater visual impact than dark objects in contrast to a light background (described at paragraph 25). As wind turbines in Scotland are typically light-coloured, this means that they tend to be most clearly visible and have greatest negative effect when seen against a dark land backdrop such as heather-clad or wooded hill slopes as shown in figure 5a below. This is supported by The University of Newcastle (2002) who state "It is clear from some photomontages and some viewpoints assessed that off-white or pale-grey structures seen against a backcloth of moorland vegetation, including heather, semi-natural grassland and conifer plantations, are much more prominent than when seen against either clear or grey skies. This suggests that the effect of backclothing against vegetation is to extend the visible distance considerably. We observed at a few locations when backclothed turbines were lit by sunlight that they were much more conspicuous than when lit but skylined" (p52) (figure 5b).

Figure 5a –Colour contrast with a land backcloth

Figure 5b – Colour contrast with a sky backcloth

38. It is not only the wind turbines of backclothed windfarms that contrast in colour, but also their associated infrastructure such as tracks, crane pads, anemometers and substations (figure 6a). In addition, looking down on a windfarm, the shadows of wind turbines can be prominent in certain light conditions, especially as these move with the rotation of the turbine blades (figure 6b).

Figure 6a – wind turbine tracks contrast to dark vegetation background (Photograph taken 8 years after commissioning)

Figure 6b – wind turbine shadows seen in strong contrast to wind turbines and backcloth, reducing simplicity of turbine image, particularly as they move with blade rotation

Pattern contrast with backcloth

39. As discussed within paragraphs 26 and 27 of the previous section, contrast depends not only on varying colour or lightness of wind turbines with their background, but also on pattern. Where wind turbines are seen against a simple landscape backdrop, for example grass or heather hills, the contrast tends to be greatest (although with a simpler combined pattern); alternatively, where they are seen against a patterned landscape, such as agricultural fields, the level of contrast is less (although with a more complex combined pattern).

Figure 7 – Contrast of pattern is less where the pattern of wind turbines relate to a distinct landscape pattern

40. In addition to windfarm infrastructure such as access tracks and crane pads having a strong colour contrast, as described in paragraph 38 above, windfarm infrastructure will often appear to contrast in pattern when backclothed and viewed from elevated viewpoints. This is particularly the case where seen within an area of simple vegetation cover, as illustrated in figure 8 below.

Figure 8– Access tracks have cumulative effects in combination with the wind turbines in contrast to the pattern of a simple moorland backcloth

41. Features of a windfarm layout that appear in contrast to the underlying landform or landscape pattern will be emphasised by the colour contrast of a land backcloth, for example highlighting isolated turbines, variable spacing and elevation, and lines of turbines, as shown in figure 9 below.

Figure 9 – Wind turbines that contrast in layout to the underlying landscape pattern or landform tend to be emphasised by the contrast of backclothing

Contrast of movement with backcloth

42. The movement of wind turbine blades appears to contrast to a 'stationary' backdrop, such as a remote hillside, increasing their visual prominence and compromising perceived qualities of tranquillity. However, as explained in paragraph 31 of the previous section, the relationship between turbine blade rotation and perceived magnitude of effect is complex and their movement may be assessed as relating to other characteristics of a landscape, such as apparent 'windiness'. In addition, while the rotation of blades will tend to make wind turbines 'eye-catching', this movement can mean that there is less inconsistency apparent between different turbines' blade positions and thus the visual complexity of these together.

Figure 10 – Differences of turbine blade position tend to be clearest when it is easy to focus on more than one turbine at a time – either because they overlap or because they are stationary

Contrast with the landform and skyline

43. Backclothed windfarms tend to appear more closely linked to the underlying landscape. This is partly because their specific position is more clearly marked (discussed further in paragraph 49 below) than when seen on a skyline, but also because their colour contrast depends on the backdrop as much as their own colour, as discussed in paragraph 20. This symbiotic relationship is explained by Ching (1996) when he states "…figures, the positive elements that attract our attention, could not exist without a contrasting background. Figures and their backgrounds, therefore, are more than opposing elements. Together, they form an inseparable reality – a unity of opposites…" (p94).

44. Backclothing of windfarms in relation to the landform and skyline typically influences landscape and visual effects in two key ways: one, the visual relationship between a windfarm and the profile of the landform as outlined by the skyline, as per figure 11a below; and, two, the relationship between the windfarm and the form of the topography, as per figure 11b below.

Figure 11a – Wind turbines appear to contrast directly to the profile of the landform feature beyond

Figure 11b – Wind turbines appear to contrast to the character of the hill landform, with an inconsistent relationship to the side slopes

45. The following section considers the backclothing effects of wind turbines in relation to landform with regards to 5 separate aspects:
    a Wind turbines affecting the simplicity of the hill backcloth
    b Backclothed wind turbines affecting the skyline as a distinctive feature and contrasting to its simplicity
    c Backclothed wind turbines creating a scale indicator in the landscape
    d Backclothed wind turbines part-way between the top and bottom of slopes
    e Backclothed wind turbines and apparent edge and visual stability

Wind turbines affecting the simplicity of the hill backcloth

46. The distinct land use pattern of many landscapes in Scotland is emphasised by being seen against a simple hill backcloth. This sometimes forms a distinct shape, as per figure 12 below which adds to uniqueness of the place. The location of wind turbines upon this backcloth will compromise these qualities so that the distinct characteristics of the landscape are diminished.

Figure 12 - Wind turbines appear to contrast directly to the profile of the landform feature beyond

47. SNH (2009) state "The distinctive character of some landscapes relies on strong contrasts of pattern, for example an intricate arrangement of fields and regular spacing of croft houses seen against a simple moorland hill backcloth. In these locations, it is important that the addition of a windfarm neither compromises the simplicity of the backcloth hills or the hierarchy or pattern of the lowland landscape below" (p.26).

Backclothed wind turbines affecting the skyline as a distinctive feature and contrasting to its simplicity

48. Within many landscapes in rural Scotland, particularly within open moorland and rounded hills character types, the skyline forms a key landscape and visual feature. This is distinguished by its smooth, 'clean' simplicity of line that divides the strong contrast of dark vegetation and light sky.

Wind turbines located upon a skyline will diminish the simplicity of the feature; however, they typically have low colour contrast in most weather conditions so that their prominence and imposition may appear minimal. Conversely, wind turbines backclothed below a simple skyline, even if not actually 'touching' the feature itself, can compromise its simplicity of line and shape by appearing in strong contrast of colour and pattern, including a difference of form and movement.

Figure 13 – Backclothed wind turbines appear to contrast strongly to the simple skyline feature

Backclothed wind turbines creating a scale indicator in the landscape

49. Within upland areas of Scotland, it is often difficult to scale the landscape, and this often contributes to a perception of areas being more extensive than they actually are - hills and peatland frequently seeming to extend infinitely into the distance. This perception is strongly influenced by the fact that it is difficult to perceive distance over open landscapes with simple land cover due to a lack of distance 'markers' (for example as may be provided by field boundaries, roads or buildings within a lowland landscape); this is particularly the case within upland areas where the intervening glens are screened (that accommodate most human elements that would provide a scale reference). A distant windfarm seen on the skyline does not typically affect this characteristic, as its size and distance are also unknown, particularly where it is unclear whether the turbines are actually located on the nearest landform skyline visible or another hill top beyond. However a backclothed windfarm does not have this same ambiguity of location or distance as the base of the wind turbines are seen and thus their position clearly marked in space; this demarcation can diminish the sense of scale and expanse of the landscape and make the wind turbines appear closer than if they were on the skyline. The University of Newcastle (2002) describe this effect when they say "from higher sites with their long distance views of the landscape beyond the windfarm, there is an effect that can appear to make the turbines look closer than those at the same distance but skylined…" (p54). In combination with the edge formed by the landform backcloth, these closer-appearing wind turbines can also seem more impinging.

Figure 14a – Position of backclothed wind turbines appears clear due to visibility of turbine bases in relation to intervening ground

Figure 14b – Position of wind turbines seen upon skyline appears unclear due to screening of bases and intervening ground

Backclothed wind turbines part-way between the top and bottom of slopes

50. A windfarm located upon a shelf or slopes part-way between the hill tops and lowland often appears irrational - neither relating to the hill top/ plateau landscape character, nor the glen floor/ plain landscape character. The perception of seeming to fit into a shelf depends on the scale of the shelf and whether this is clearly distinguishable, both from distant and nearby viewpoints.

Figure 15 – Backclothed wind turbines upon a landform shelf, relating neither to the hill top or glen floor

51. Although the location of a backclothed windfarm upon mid-slopes part-way between the highest tops and surrounding glens or plains can limit visibility, the view of a windfarm backclothed within these areas can seem to 'flatten' the vertical dimension and distinction of the landform by 'filling in' or 'evening out' the vertical spaces and edges. It can also seem to distract attention from the characteristic focus of views within upland areas which tends to be either on foreground details or the distant skyline, but not usually the simple midground in-between.

Figure 16 – Wind turbines upon landform shelf reduce perceived vertical distinction of surrounding hills

52. By appearing lower than the highest hills visible, a windfarm can convey a kind of subservience, so it seems less 'dominating' in relation to the hill tops. However a perception of dominance can derive from the horizontal extent of a development as well as its vertical position. So, even if a windfarm does not appear to tower over the vertical aspect of the topography, it can seem to dominate by appearing extensive or by encircling the landform (figure 17). A backclothed windfarm located upon mid slopes can also seem to break up the perceived solidity and massiveness of a hill range.

Figure 17 – Although the windfarm does not seem imposing upon the distant skyline, it appears to 'overwhelm' the surrounding topography with its horizontal extent and apparent disregard of local landform features

Backclothed wind turbines and perceived edge and visual stability

53. Where ground cover is simple and consistent, a hill backdrop often seems two-dimensional in image as it is difficult to discern the landform shape (apart from in conditions of low side-lighting); this mean its vertical attributes as a distinct edge tend to be emphasised in contrast to surrounding lowland. A windfarm upon this backcloth will tend to appear visually unstable, 'perched' upon the slopes, and seem to breach what is otherwise read as a distinct edge within the landscape. In this way, a backclothed windfarm can often appear less fitted within the landscape and, alternatively, more imposing upon its surroundings.

Figure 18 – Backclothed wind turbines appear visually unstable, seeming to breach the distinct landform edge

54. Bell (2004) states "in the landscape the position of elements in relation to landform can produce very marked effects, particularly on the summits of hills. This is in part due to the visual forces in landform and also because the eye is attracted to hilltops and horizon lines. A line of electricity pylons crossing the skyline on a hill instead of in a valley produces visual tension as well as conflicting with visual forces. A sculpture or monument, on the other hand, may produce tension if it is not precisely on the summit. Technical installations such as wind turbines can also look unbalanced if placed just off the main summit of a hill or ridge" (p44). SNH (2009) support this by saying "it is important to site and design a windfarm so that it appears visually balanced in relation to the underlying and surrounding landform. Turbines seen upon steep slopes often appear to be 'unstable'" (p22).

Backclothing as a design approach

55. Backclothing has long been adopted as a design approach for locating built elements within a landscape. This has been mainly for two key reasons: one, coincidental, because backclothed locations tend to offer favourable siting conditions for many types of development, such as good shelter, drainage and access; and two, where a development is not restricted by siting constraints, a backclothed location may be more discrete. However, key factors affecting the feasibility and success of backclothing to mitigate landscape and visual effects relate to the function and scale of a structure as well as how it will typically be viewed. This is why backclothing has generally served as a good design approach for elements such as houses, woodland and powerlines, but why it is often not possible for larger structures that need an exposed location such as monuments, telecommunication masts and wind turbines.

56. This does not mean that wind turbines cannot be backclothed, or won't benefit from backclothing in specific circumstances; however, what is highlighted is that the inherent function and scale of commercial wind turbines mean that backclothing tends to be more difficult to achieve successfully, and may result in an increase of adverse landscape and visual effects of a windfarm. These effects are described within the

Figure 19 –Dark-coloured domestic wind turbine is of a scale that offers greater scope for backclothing compared to a commercial-scale wind turbines (1.4 km beyond)

previous section – the predominant issue being the contrast of colour and pattern between wind turbines and a dark and simple landscape backcloth that often exists in rural Scotland.

57. These challenges are at variance to the long-established design approach adopted for siting electricity transmission lines with which wind turbines are sometimes compared. In 1959, Sir William (later Lord) Holford, who was a member of the Central Electricity Generating Board (CEGB) developed guidelines for routeing overhead power lines that comprised 7 rules, later adopted as 'The Holford Rules' (National Grid, undated b). Rule 4 states: "Choose tree and hill backgrounds in preference to sky backgrounds wherever possible; and when the line has to cross a ridge, secure this opaque background as long as possible and cross obliquely when a dip in the ridge provides an opportunity. Where it does not, cross directly, preferably between belts of trees". While this rule advocates backclothing, what is clear from the instructions, is that the nature of the structures are very different from conventional wind turbines by being significantly smaller in scale (typically between 25-50 metres high, rather than 100-150m to tip) and being able to be visually 'porous' due to having a lattice structure. The National Grid (undated a) and Turnbull (2009) have set out more recently how backclothing can reduce the prominence or 'perceptibility' of pylons.

58. Figure 20 highlights some of the key differences between wind turbines (seen in the background) and electricity pylons (seen in the foreground) that affect the success of backclothing.

Figure 20 - Differing colour contrast of wind turbines between a sky background and a hill background (this can be compared to the colour contrast of high voltage powerlines in front)

59. This leads to a common question raised by the public – why can't wind turbines be 'camouflaged' and dark-coloured? Indeed, in a study of the public perception of wind turbines over the Altamont Pass in the US, respondents most frequently cited "painting windmills a neutral colour" as a way of mitigating the adverse effects of the wind turbines (Thayer and Freeman, 1987, p392). In response, camouflaging of wind turbines has been explored by many people within both the wind energy industry and by artists, architects and landscape architects. However, it has been found consistently that, because of the very large scale of commercial wind turbines, attempts to assimilate them usually fail. Gipe (2002) explains "wind turbines will always be visible on the landscape. This cannot be avoided. No amount of camouflage will make wind turbines invisible" (p198). Some of the problem is that large scale wind turbines are typically never seen solely against a land backcloth to which they could be 'matched'; rather, they tend to be seen against both land and sky; this means that, if coloured to blend with one, they tend to contrast with the other. Hence the appeal to adopt just a 'neutral' colour. SNH (2009) state "as a general rule for most rural areas of Scotland:… a light grey colour generally achieves the best balance between minimising visibility and visual impacts when seen against the sky" (p9). Bell (2004) supports this by stating "If positioned so that they are mainly silhouetted against the sky, the use of pale grey tends to work for most of the time, but if they are seen against the land this emphasizes their visibility… Camouflage colours merely make them dull and unattractive from a short distance" (p77).

60. Another factor that affects the varying effects of backclothing between electricity pylons and wind turbines is the distance over which they tend to be seen and thus over which contrast with their backcloth is detected. While wind turbines up to 130 metres high to tip may have significant visual impacts over a distance up to 35km away (SNH, Scottish Renewables and the Scottish Society of Directors of Planning, 2006), Hull and Bishop (1988) conclude for electricity transmission lines that "most of the scenic impact occurs in the 100m – 1km distance range" (p106). Given the closer distances over which pylons tend to be viewed, there is greater scope to site them in relation to a particular land backcloth that they are then seen against from most viewpoints. Conversely, because large scale wind turbines will be seen from much further distances and within a wider variety of landscape contexts within different views, there is less scope to 'match' them to a particular backdrop. This is why SNH (2009) state "the use of coloured turbines (such as greens, browns or ochre) in an attempt to disguise wind turbines against a landscape backcloth is usually unacceptable" (p9).

61. While wind turbines differ from powerlines in their scope for backclothing, other developments have encountered similar challenges due to their inherent scale and form. As far back as the 1950s, the late Dame Sylvia Crowe wrote in her seminal book 'The Landscape of Power' (1958):
"In a countryside in which it is intended to keep nature dominant the treatment of the surroundings of any installation of power should be designed to limit its zone of influence. This does not necessarily mean that concealment, even if possible, is the best answer. The sight of a structure which can be made to look part of the landscape composition, may well be less disruptive than an effort to conceal it (p37)". Bell (2004) states "Huge structures such as power

stations are too big to blend into their surroundings and dark colours may emphasize their silhouette rather than reduce their bulk…" while visibility of elevated parts can be reduced by "…choosing colours which may be borrowed from the sky or clouds. This technique appears to detach the building from the earth (the opposite of many other methods), and diffuse the mass into the sky, using the pale colour to increase its apparent lightness" (pp 76-77).

62. This is not to suggest that skylining of wind turbines is not without its own adverse landscape and visual effects, nor that backclothing should be avoided in every situation; rather, it is highlighted that the design approach of backclothing used for other structures raises distinct problems for wind turbines and thus should not be assumed as an appropriate method. Crowe (1958) states: "...there are new shapes which instead of growing out of the ground, are balanced upon it or suspended above it. Because of their detachment they are easier to combine with the human scale than those which are earth-bound. They are the realm of the clouds and stars, vast and ethereal, and human life and the human scale can continue beneath them" (p49).

Conclusions

63. This study brings-together and analyses existing research and guidance concerning the landscape and visual effects of backclothing, and builds upon this through assessment of case study windfarms. Supported by this material, in addressing the key research questions identified at the beginning of this study, key findings are as follows:

64. *What are the landscape and visual effects of backclothed windfarms in the Scottish landscape?*

    a. Windfarms are typically more prominent and result in greater visual effects where they appear in strong visual contrast to their backcloth – both in terms of colour and pattern.

    b. Light-coloured wind turbines seen against a dark-coloured backcloth are typically more prominent than light-coloured wind turbines seen against the sky (although occasional exceptions occur such as during snow cover and when light-coloured wind turbines are highlighted against dark skies by a low angle of sun).

    c. Although not such a strong determining factor as colour or pattern contrast, prominence of backclothed structures also relates to their shape, with regular-shaped objects tending to appear more prominent than irregular shapes.

    d. The prominence of wind turbines due to contrast with their backcloth tends to reduce with distance, strongly affected by atmospheric scattering. However, where light-coloured wind turbines are seen in strong contrast to a dark land backcloth and viewed across an area of simple landscape pattern with few distance indicators, they may be perceived to be closer than they actually are, and the scale of the landscape seem diminished.

    e. Backclothed wind turbines can contrast to a landform in a number of ways. This includes: compromising the distinct focal qualities of a landform; contrasting to the simplicity of

landform slopes; diminishing the sense of scale of a landform and seeming to fragment its massive form; appearing unbalanced in relation to a landform and thus increasing the sense of imposition of the wind turbines; and/or seeming to compromise the distinct shape, edges and juxtaposition of one landform feature in relation to others. Located part-way up slopes, a windfarm may also seem to contrast to the typical location of built elements either upon the top or at the base of a hill, but not typically over the slopes in-between.

f. Backclothed wind turbines may contrast to a simple skyline feature, even if not actually seen to 'cross' this in views. This results from a contrast of turbine visual shape in relation to the simple and horizontal emphasis of some skylines, the distinction of which tends to rely on a lack of visual distractions within the vicinity.

g. Prominence of wind turbines, like other landscape and visual effects, depends on how the landscape is experienced, including elevation of the viewer in relation to the development and the composition of views, such as being framed or panoramic (these can increase or reduce prominence). This study finds that some adverse effects are increased by the rotation of wind turbine blades, while some effects are reduced by movement.

65. What are the conditions that result in the backclothing of wind turbines?

a. Backclothing of wind turbines occurs mainly where a development is seen from locations within the surrounding area that are of higher elevation than the windfarm site, or where the windfarm is seen in front of hill slopes. This means that windfarms within or adjacent to hill areas, rather than on ridges, are more likely to be backclothed, and windfarms upon landform shelves or plateaux next to higher hills will typically be backclothed from a majority of viewpoints.

66. What published literature exists on the concept and effects of backclothing?

a. There is little academic literature on the specific subject of backclothing, including the backclothing of windfarms. However, there is a range of academic papers in which backclothing effects are raised in relation to the general acuity of structures. Within this field, there are also a number of studies that have researched the prominence and visual effects of wind turbines and other large structures, typically using computer simulation to show variables. In addition, visual contrast, the main factor affecting the prominence of backclothed structures, is addressed within many published books on the principles of vision, visual perception and design.

b. Where the specific subject of backclothing is raised more frequently is in published guidance documents on the landscape and visual effects of industrial and utilitarian structures in rural areas, including in relation to windfarms. This perhaps reflects that, while backclothing may be an uncommon subject of academic research, it is nonetheless an important and common issue raised with regards to the practice of siting and design of large scale structures in the landscape.

c. References for this study are listed at the end of this report. It should be noted that much of the published material within this list is based on the assessment of first or second generation wind turbines which are typically up to 80m high, compared with contemporary wind turbines that are typically 125-150m high to tip. This reflects the time lag between development proposals, consent, construction and monitoring/ review.

67. How do the effects of backclothed wind turbines compare to the backclothing of other large structures in the Scottish landscape?

a. This study finds that the design approach of backclothing results in very different landscape and visual effects for wind turbines compared to other structures such as electricity transmission lines or buildings. This is because of a number of distinct characteristics of wind turbines, but particularly reflects their larger scale; this means that windfarms, compared to other structures for which the backclothing approach is taken, are seen from further distances and in relation to a wider range of different landscape settings that limits the ability for wind turbines to be seen consistently backclothed.

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