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***Renewable Power Ventures
Capital Wind Farm
Review of Visual Impact***

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1. Introduction

The Capital Wind Farm comprising 63 wind turbines is proposed at a site about 40km to the north east of Canberra and approximately 30 km to the south of Goulburn (Figure 1). This report provides a review of the visibility of the proposed development and factors affecting its visual impact. The aim of the report is to provide information to assist the community and the consent authority to understand and assess the likely visual impacts. It forms part of the Environmental Impact Statement EIS for the project.

The Director-General of the Department of Planning NSW (DOP) has set the requirements for the scope and content of the Capital Wind Farm EIS including the requirements for a visual impact assessment. The visual impact assessment is required to be illustrated with photomontages of the turbine installations taken from strategic vantage points. A Guideline for Landscape and Visual Assessment methodologies for wind energy projects is provided in Appendix A.

This report addresses the Director-Generals' requirements relating to visual impact assessment. It includes a landscape analysis, a detailed description of the assessment methodology and provides material that can be used by others to make their own judgement of the visual impact of the project. These materials include:

- Several view field analyses prepared using a Geographic Information System (GIS);
- A series of photomontages from selected representative vantage points;
- Description of factors to be considered by visual impact assessment;
- A review of the wind farm visibility from key vantage points; and
- Options for mitigating visual impact.

1.1 Project Overview

The proposed development consists of 63 wind turbines, each with a capacity of about 2.1 megawatts, with a total generation capacity of about 132 megawatts. This is a moderate to large size wind farm by world standards.

This assessment is based on an advanced stage of project planning and reflects the impacts relevant to the proposed layout and equipment specification. Subject to the outcome of the planning approval process, only minor changes would be expected for implementation due to individual site conditions. Consideration has been given during planning and assessment to potential variations in the wind farm design and associated variations in visual impact. The proposed layout has been developed and is proposed to balance the project energy requirements and the associated environmental impacts and community issues. In some cases, turbines have been deleted from the wind farm layout to increase setbacks to residences and reduce potential for visual and noise impacts.

The proposed layout consists of three separate groups of turbines on elevated ridges of the Great Dividing Range to the east of Lake George. The groups are described in Table 1.1 below. It can be seen that the Hammonds Hill turbines are at higher elevations than turbines in the other two groups located closer to Lake George. The lowest turbines in the Hammonds Hill Group are at the level of the highest turbines in the Grose Hill and Ellenden Groups. The substation is at a level of about 765 metres.

Table 1.1 – Wind Farm General Arrangement

Group	No. of turbines		Location in Wind Farm	Level of footings (m)	Features
Groses Hill	17	(27%)	Northern	730 to 810	Several ridges
Ellenden	17	(27%)	Central west	730 to 830	Several ridges
Hammonds Hill	29	(46%)	South eastern	840 to 930	2 main ridges
Total	63	(100%)			

Figure 2 indicates the proposed arrangement of the wind turbines that are proposed be installed at the site.

The ridges on which the turbines would be located have elevations varying from 750 metres to 935 metres for the higher ridges and are up to 270 metres above the generally dry Lake George.

The wind farm's visual characteristics are outlined in Section 2.1. The turbines proposed for the site are large structures that have a height of about 124 metres to the top of the area swept by the turbine blades. When located on elevated ridges, they are prominent features in the landscape.

The turbine layout allows for a minimum spacing between turbines within each group or row of approximately 230 metres. The layout reflects the arrangement of ridges and the predominant, north westerly, wind direction. The exact locations of turbines may vary, depending on the outcome of detailed site investigations, environmental studies, design and construction considerations and development consent conditions.

Ancillary works are shown on Figure 2 and include:

- new access tracks and upgraded existing tracks;
- A 33,000 to 330,000 volt substation and a facilities building;
- Underground power and control cables between turbines and in some cases turbine groups and the substation; and,
- A 10 km section of 33,000 volt overhead line between the Groses Hill Group and the substation and 33,000 volt overhead line from Hammonds Hill to the substation.

Generator transformers are to be located close to the base of the wind turbine towers.

The visual impact of most of the ancillary works will be significantly less than that of the wind turbines, because they are low level aspects of the development and mostly will not be visible from public roads in the areas around the site. Nevertheless, each of the ancillary works will be designed to minimise visual impact. Visual aspects of the ancillary works are discussed in Section 8.

The wind farm will be connected to the electricity grid via a 33,000/330,000 volt substation located adjacent to an existing 330,000 volt transmission line. The visual impact of the substation is also addressed by this report.

2. Summary of Visual Characteristics

The five key characteristics affecting visual amenity that need to be considered in the planning stages of a wind power development (Arkesteijn & Westra, 1991) are:

- the number of turbines;
- the size and colour of the turbines and their supporting structures;
- the number of blades on each turbine;
- the turbine placement pattern; and,
- the landscape character.

More recently the Australian Wind Energy Association (Auswind) and the Australian Council of National Trusts (ACNT) have completed Stage One of a review entitled "Wind Farms and Landscape Values – Identifying Issues" (AUSWEA & ACNT, 2005). The report can be accessed at http://greenhouse.gov.au/renewable/landscape_values.pdf and also on the respective organisations' web-sites.

This report reviews the physical aspects of the wind farm, the landscape character and the visual elements that may affect the community's acceptance of the development.

2.1 Wind Farm Visual Characteristics

The wind farm involves the turbines, electrical connection works and access tracks. Of these, the wind turbines will be the most visible facilities. The key wind farm characteristics affecting visual impact are shown in Table 2.1 below. Wind turbine structures will have the general form shown in Figure 3.

Table 2.1 - Wind Farm Components and Key Visual Characteristics

Wind Farm Component	Visual Characteristic
Tower & Hub height	<ul style="list-style-type: none"> • Steel tubular supporting towers • 80 metre hub height • Tower 4.5 metres at base and 2.5 metres at top
Turbine	<ul style="list-style-type: none"> • Three bladed • Blade diameter of 88 to 90 metres (44 metre blades)
Turbine Rotation (rpm)	<ul style="list-style-type: none"> • 15.5 revolutions per minute
Colour	<ul style="list-style-type: none"> • Matt white colour or similar light neutral colour
Generator transformer	<ul style="list-style-type: none"> • located near the base of each turbine - green
Electrical Works	
Electrical Connection	<ul style="list-style-type: none"> • Underground power and control cables will connect the wind turbines within each group
Overhead line	<ul style="list-style-type: none"> • A 12 kilometre section of overhead 33,000 volt power line will connect the Grose Hill, Ellenden and Hammonds Hill Groups to the substation. • Wood or concrete poles could be used • Poles to be spaced at about 120 metres apart and about 16 metres above ground.
Substation	<ul style="list-style-type: none"> • About 70 metres by 160 metres with a few small buildings • Height of structures mostly less than 10 metres
Access Works	
Site Entrances	<ul style="list-style-type: none"> • Signposted, gates setback from the road
Access tracks	<ul style="list-style-type: none"> • Up to 5 metres wide and unsealed

The actual wind farm equipment details are being confirmed by a tender process. For this assessment the dimensions of a 2.1 MW 88 metre diameter wind turbine have been used.

The turbines will have three blades and the literature suggests that this number of blades is more visually balanced than turbines with only two blades (Arkesteijn & Westra, 1991). It is proposed that the turbines be finished in a matt white or similar light neutral colour. Documented experience of wind farms also suggests that finishing the turbines in a pale unobtrusive colour gives the most acceptable result (Gipe P, 1995).

The substation will occupy an area of about 160 metres by 70 metres. Its component elements will mostly have a height less than 10 metres and can be effectively screened by the combination of its siting and by trees. Additional screening through planting of trees could be undertaken, if required. One or two steel lattice towers may be required adjacent to the substation as part of the 330,000 volt grid connection.

Access tracks are at ground level and most will not be visible from surrounding viewpoints. Where necessary, their visibility can mostly be mitigated by positioning, earthworks formation and revegetation to minimise visibility. An exception is the access tracks on slopes that lead up onto the ridges where the turbines will be located.

2.2 Wind Farm Layout

The placement of the turbines, as shown in Figure 2 has been designed to utilise turbine sites that maximise the energy produced from the wind farm and included consideration of the following aspects:

- Selection of sites that have high energy potential;
- Selection of a turbine capacity that is commercially suitable and of proven reliability;
- Spacing of turbines so that the disturbance of air flow has minimal affect on adjacent turbines;
- Selection of tower heights which provide optimal utilisation of the wind energy regime;
- Ensuring that the wind farm output is within the capacity of the existing transmission infrastructure; and
- Provision of sufficient distance to existing residences to ensure acceptable noise criteria are not exceeded and to reduce visual impact.

Some sites offering high energy have been excluded from the wind farm due to either difficult access on very steep slopes or proximity to residences.

The layout will only be finalised after planning consent has been obtained and detailed pre-construction testing is complete. Any significant issues arising during the agency and community review of environmental impact assessment are likely to be addressed by mitigation measures incorporated in association with developing the final layout.

2.3 Visual Aspects of the Wind Farm

The wind turbines will have a height about 124 metres, measured to the blade tip at its highest point of rotation. At such heights, some people may compare the turbine structures to tall buildings. However, the wind turbines differ from bulky structures such as buildings in that the supporting towers are only 2.5 to 4.5 metres wide and the turbine blades are relatively slender structures that when viewed from the side present very little of the blade surface. Overall the blade is widest toward the hub (maximum 3.5 metres width) and tapers toward the tip. Due to their height, the turbine structures will nevertheless be visible from a considerable distance.

It is likely that most viewpoints will only have partial views of the wind farm with parts of it concealed by topography and/or woodland.

In many cases, the large size of the properties on which the wind farm is located and the low settlement density of some surrounding areas, means that public views of the wind farm will be distant. Neighbouring residences will be at least one kilometre from the nearest turbine and mostly at greater distances. The closest public road to a wind turbine is Taylors Creek Road at a distance of 0.7 kilometres. Parts of the wind farm will be visible at many points along Taylors Creek Road.

The Tarago to Bungendore Road will provide partial views of the wind farm, but at many points along the road, trees and topography will provide some or complete screening. The section of the Federal Highway on the western side of Lake George will have direct views to the site but at distances exceeding 9 kilometres.

Where the wind farm is visible, the varying topographic heights of the turbines within each group may avoid the appearance of a geometric layout and may appear more natural with the turbine positions following the contours of the land.

In addition, the effect of turbines trailing out of sight along a ridge line or being partially screened by topography can introduce an element of 'depth' to some views. Visual impact studies indicate this to be a preferred visual outcome. The spacing of the turbines can also affect the visual impact. The minimum spacing used is in excess of 200 m.

The rotation of the turbine blades will add an element of movement in the view and could invoke varying responses including visual attraction. It may also increase visibility. The three bladed wind turbines rotating in random phase should avoid introducing unnecessary geometry into the rural landscape. The relatively slow rotation speed of the turbines, approximately 15.4 revolutions per minute, may not be unduly disturbing to most people. Observers at the Crookwell wind farm have expressed surprise at the slow rotation speed, which in that case is of the order of 28 revolutions per minute.

A further aspect of wind farms is the novelty aspect. The Capital Wind Farm will be visible from the Federal Highway lookout adjacent to Lake George. As wind turbines are still a relatively new type of electricity generation in New South Wales, the Wind Farm will represent an additional point of interest for many locals, visitors and travellers passing through the region.

2.4 Landscape Character

Hull and Revell (1989) define landscape and scenes as follows:

Landscape – “the outdoor environment, natural or built, which can be directly perceived by a person visiting and using that environment.”

Scene – “A scene is the subset of a landscape which is viewed from one location (vantage point) looking in one direction ...”.

Scenes may be further classified as close, distant, panoramic or corridor views. In the case of distant views, it is less easy to distinguish the detail of the objects in the scene. Corridor views are those which are constrained by lateral features.

Landscape descriptors can include physical (natural and cultural) and artistic or psychological descriptors. The physical elements of the landscape (natural and cultural) of the proposed wind farm

locality are described in the following two sections, while Section 2.5 discusses the subjective elements of landscape preference.

2.4.1 Natural Features of the Landscape

The landscape of the Tarago/Bungendore area comprises typical Southern Tablelands rural land, with Lake George being a locally distinctive feature of the landscape.

The Great Dividing Range on which the wind farm is located has its highest point within the project area at about 935 metres at Hammonds Hill. The Range is visible from the Federal Highway about 9 kilometres to the west and also contrasts with the flat expanse of Lake George at an elevation of about 680 metres. Both the Range and the Lake are distinct features of the landscape.

The landscape of the wind farm site comprises mostly cleared pastoral land with small areas of uncleared woodlands adjacent to parts of the wind farm. Mature trees both dead and alive are scattered through the landscape. In addition to the scattered remnant native trees, there have been localised plantings of exotic trees such as pines near residences or former residence sites and as windbreaks. Use of thick screening around residences is a feature of the locality.

Areas of remnant woodland can relate to areas of steep slopes, poor soils or simply different priorities of the owners of the land. There are extensive areas of wooded ranges to the north and east of the site that contrast with the mostly cleared ridges of the wind farm site. The tracts of woodland close to the wind farm will not be affected significantly by the development and they will still be present in views after the wind farm has been installed.

In some places, there are areas with outcropping rock features, such as the granitic tors. For the wind farm site, this mainly applies for the Hammonds Hill-Big Hill ridgeline. In general, the tors are relatively small and will not be evident in distant views. It is not envisaged that any significant rock visual features will be disturbed. As far as possible, rock features will be avoided or relocated nearby to preserve habitat for reptiles which can also maintain the appearance of the location.

Watercourses on the upper slopes of the range are intermittent. Drainage from the site is to Lake George, to the west of the site. Disturbance of watercourses will be minimised.

Overall there is a high proportion of vegetation in most views, varying from cleared paddocks with varying degrees of exotic grass, to patches of woodlands.

2.4.2 Cultural Features of the Landscape

Cultural elements of the existing landscape for the purpose of this assessment, include the built features such as roads, residences, farm buildings, fences and overhead power lines. In general, these features are a minor part of the rural scenes.

The style of farming of the land could also be regarded as a cultural element, with the large, mostly cleared, grazing paddocks that exist over much of the site having been created over the last 180 years of farming in the area.

Residences and farm buildings (e.g. shearing sheds and barns) are scattered throughout the rural land at varying densities mostly in lower, more sheltered locations. The ridges on which the turbines are located have been chosen because they have suitable wind energy resources

and also because they are free from residential settlement. In some places there are clusters of small acreage farms with residences, for instance along Taylors Creek Road.

It is common for residences in this Southern Tablelands Region to be surrounded by trees as a means to protect the residence from winds. While the visibility of the residences may be reduced in these cases, they are identifiable as such in the mostly cleared landscape. Fencing is a common visual element of the landscape, while exotic trees and shrubs are associated with some of the residences and rural buildings.

Roads in the vicinity of the wind farm include:

- the sealed Tarago to Bungendore Road which passes east of the Hammonds Hill Group of turbines being about 2 kilometres away at its closest point;
- the sealed Collector Road about six kilometres to the north of the project area;
- the mostly unsealed Taylors Creek Road that passes to the north east of the wind farm;
- minor property access tracks which are common in the area; and
- the Federal Highway is the nearest road to the west of the wind farm at more than nine kilometres distance.

Traffic volumes on the local roads within 5 kilometres of the site appear to be low. The Goulburn to Canberra rail line also passes several kilometres to the east and south of the site. The rail line has a low level of usage but would provide some views of the development to travellers on the railway.

An existing generally east west trending 330,000 volt transmission line, comprising steel lattice structure towers passes to the south of the Hammonds and Ellenden Groups of turbines. An existing 66,000 volt overhead line trends north-south and passes to the east of the Grose Hill Group and between the Ellenden and Hammonds Hill Groups of turbines.

Due to topographic screening, the wind farm site will not be visible from the Tarago township some 10 kilometres to the north-east of the wind farm. Parts of Bungendore will have distant (about 10 kilometres) views of the wind farm. However, many views of the wind farm from Bungendore township will be limited by tree screening or aspect of the viewpoint.

There are no public places such as community halls or churches close to the wind farm apart from the Taylors Creek Rural Fire Service Station.

The proposed wind farm will be an additional cultural element in the landscape. Some viewers would describe it as an industrial element of the landscape while many others would see it as an expression of sustainable energy generation.

2.4.3 Types of Views and Landscape Elements

Overall, the landscape character comprises pastoral scenes with moderate size properties scattered throughout the area. Components of the views in the wind farm locality are primarily grass covered paddocks, scattered trees, occasional rural residences, farm buildings and associated fencing and tracks.

Ridges forming the Great Dividing Range and Lake George are significant visual features within the wind farm locality. The ridges also obstruct the extent of views from many viewpoints. Viewpoints may in places also be constrained by vegetation. Topography, vegetation and aspect may provide partial or full screening of the wind farm from some viewpoints.



The main landscape elements present at the wind farm locality are shown in Table 2.2 below and in the accompanying Plates.







Table 2.2 – Representative Local Landscape Elements

Reference Plate	Landscape element	Main Features Present in the Landscape
1	Groses Hill	Cleared rural land with planted pine wind breaks. Occasional settlement.
2	Taylors Creek Catchment	Cleared rural land with rural settlement. Taylors Creek Road and scattered buildings including Bonnie Doon residence and Rural Fire Service building
3	Red Hill	Rolling, grassed hills with rock outcrop. Lake George in background
4	Governors Hill	Steep ridgeline with occasional clumps of trees.
5	Hammonds Hill Grassland	Broad grassed ridgetop, mostly devoid of trees
6	Hammonds Hill Woodland	Remnant woodland on western side of Hammonds Hill and grasslands
7	Bungendore Rural Plain	Relatively flat plain north of Bungendore comprising grassland and pockets of woodland (natural and plantation) and scattered settlement.
8	Lake George Plain	Broad flat grassland plain with Great Dividing Range in background. Viewed from Federal Highway

In addition to the views of landscape elements below, the appended photomontages in Viewpoints 1 to 10 taken from representative viewpoints also include a range of elements of rural scenes together with the proposed wind turbines. The representative viewpoints have been selected for their maximum visual exposure of the wind farm and many locations where views of the wind farm were constrained (by either topography or trees), were not chosen for the production of photomontages.

Plates 1 to 8 - Capital Wind Farm Locality – Landscape Elements

	
Plate 1 Groses Hill Cleared rural land with planted pine wind breaks. View to Groses Hill	Plate 2 Taylors Creek Catchment Rural land with Taylors Creek Road and scattered buildings.

	
Plate 3 – Red Hill Cleared grazing land with small wind break	Plate 4 – Governors Hill Cleared grazing land with farm buildings
	
Plate 5 – Hammonds Hill grassland Cleared grazing land and scattered trees	Plate 6 – Hammonds Hill Woodland Semi-cleared land with woodland remnant
	
Plate 7 Bungendore Plain Cleared grazing land with patches of woodland – View north from Bungendore	Plate 8 Lake George Landscape Viewed from Gearys Gap lookout towards Governors Hill in the distance

2.5 Subjective Aspects of Landscape Preference

The preceding sections have described the visual aspects of the turbines, the layout of the wind farm and the main natural and cultural features of the landscape. A viewer's perception of these natural and cultural elements and the values assigned to them is more difficult to define than the physical aspects of the scene and it is likely that a variety of responses will be obtained from those potentially affected by the development.

2.5.1 Aspects Affecting Viewing Experiences

Aspects which singularly, or in combination, may affect a viewer's response to the development, include:

- the viewer's relationship to the area, e.g. resident or visitor;
- in the case of a local resident, proximity to the wind farm and extent of change arising from the development ;
- the viewer's experience, values or attachment to the character of the existing view;
- the viewer's preference for the status quo;
- impressions/associations invoked in the viewer by the development;
- the perceived extent of change to an existing view and contrast with the existing landscape;
- any uncertainty in the mind of the viewer as to actual impact when implemented; and
- the viewer's response to sense of movement in the landscape.

The above aspects, and perhaps others, may influence how a viewer perceives various scenes and their acceptance, like or dislike of the scene. A variety of responses is possible and it is unlikely that there will be a consistent response.

2.5.2 Consultation with Landowners

It is possible that some people within the visual catchment may feel a degree of concern regarding the impact on their longer term enjoyment of the locality. Such concern is likely to be heightened by any uncertainty regarding the extent of actual impact.

With the above consideration in mind, Renewable Power Ventures has undertaken consultation with the community and has provided details of the proposed development and contact details to enable further discussion with interested or concerned locals.

The initial consultation was carried out by explaining details of the proposed development. The impression gained from the initial consultation was that many neighbours are supportive of wind energy developments in general, while others have expressed concerns regarding proximity of the development. As far as possible, RPV has modified the wind farm layout to mitigate visual impacts with the aim of addressing concerns raised by some neighbours.

The presence of the Crookwell Wind Farm within 30 km to the north-west of Goulburn allows neighbours to the development to investigate first hand the impact of a wind farm in the rural landscape, albeit a smaller development than the proposed Capital Wind Farm. Neighbours have also been exposed to community consultation in relation to the Woodlawn Wind Farm.

This report aims to assist stakeholders by providing a basis for potential viewers, including local residents, to reach their own conclusions as to the potential visual impacts of the proposed development, using realistic representations of the wind farm in the form of photomontages. It

also aims to provide a relative ranking of visibility of the wind farm from the selected viewpoints and a description of the changes to the scenes at those viewpoints.

2.5.3 Crookwell, Blayney and Gunning Experience

The prior establishment of a wind farm on a grazing property at Crookwell provides a useful local reference to gauge community reaction to such installations. In that instance, the broader community has been supportive of the development, and have mostly indicated very positive responses since construction of the wind farm.

A quote in the Crookwell Gazette, May 12, 1998 reads as follows, “ *They are simply stunning and beautiful white structures which blend well into the natural environment.* ”

On the other hand, the owner of an adjoining property, was quoted (Sydney Morning Herald, 25th August, 1998) as saying the wind turbines are, “ *a desecration of beautiful country* ”.

Another letter from a Crookwell local (26th August 1998) in the Sydney Morning Herald included the following statement “ *And I have yet to meet anyone who has seen the new wind farm – both locals and visitors – who have not remarked on the beauty and elegance of the structures* ”.

In the case of the Blayney Wind Farm there was a broad acceptance of the wind farm development by the Blayney community. However, instances of anxiety and opposition were encountered from neighbours to the development. Correspondence with those neighbours following the installation of the wind farm has indicated a significant reduction in the neighbours’ concerns.

It is recognised that there are differences between the setting and scale of the Capital Wind Farm development and the Crookwell and Blayney wind farms and that residents in these areas may have different values. Indeed, as noted above, differences were found in the Crookwell area, with some neighbours expressing support and others voicing concern about the development.

In the case of the Gunning Wind Farm, for which consent was gained in November 2004, there was general community support but some objection from immediate neighbours. That wind farm has not yet been built and the reaction to the constructed wind farm is not available.

From the above examples, it can be seen that widely differing views can be held regarding the acceptability or otherwise of the visual impact of a wind farm.

On this basis it serves little purpose to make categoric assertions regarding the likely visual impact of the development. Rather, the likely spectrum of opinion reinforces the approach of providing realistic impressions of the completed wind farm to enable the Consent Authority and other interested parties to make their own assessments of visual impact.

2.5.4 Association with Environmentally Friendly Technology

The overall strong community support received from the Crookwell, Blayney and Gunning communities may be related to the fact that wind farms utilise an environmentally friendly energy source while allowing continuity of existing land use. In short, many people have embraced the notion of ecologically sustainable development and are likely to form a positive mental association with the wind turbine structures. However, not all of the people resident in the local area can be expected to have this outlook and some may prefer the existing rural vistas without imposition of the wind turbines.

3. Methodology

The methodology adopted for this review of the visual impact of the proposed development includes both an assessment of the wind farm's visibility and an overview of subjective aspects. The review entailed the following steps:

- Determination of visibility criteria (Section 4);
- Identification of the wind farm's visual catchment (Section 5);
- Compilation of a list of assessment sites (Section 5.1 and Table 5.1);
- Photography at assessment sites (Section 6.1);
- Computer modelling of topography & generation of perspective views of the wind farm (Section 6.2);
- Photomontage compilation (Section 6.3);
- Review of photomontages against the visibility criteria (Section 7);
- Review of visual aspects of ancillary works (Section 8).

More detailed descriptions of these stages are provided in the following sections.

Shadow flicker analysis has been assessed separately and is reported in Appendix D.

4. Visibility Assessment Criteria

In order to facilitate objective assessment of visibility, a set of key assessment criteria was developed. The key criteria against which the visibility of the proposed development was assessed are:

- the distance from the wind farm;
- the spatial extent of the wind farm (view field angle); and
- the number of visible turbines.

The **distance** of each assessment site from the closest turbine was used as a principal factor to rank visual prominence which decreases with distance. Scenic impact has also been shown to decrease rapidly with distance in a reciprocal relationship (Hull and Bishop 1988). Distance can also be used to classify whether the wind farm would be viewed in the:

- foreground (0 to 1 km), the zone of greatest reduction in scenic impact with distance,
- mid-ground (1 to 3 km) or
- background (more than 3 km).

The Capital Wind Farm development is spread over a wide area, with the separation between the eastern and western turbines being about 6 kilometres and about 10 km from north to south. Accordingly, in some views the closest turbines may be in the mid-ground, while the more distant turbines are in the background. In this situation, it is the closest turbines that are regarded to have the most visual impact. In some cases the more distant turbines may be obscured by topography and/or trees.

Neighbouring residences are all set back more than one kilometre from the wind farm and there are no public viewpoints apart from short sections of local roads that are located in the foreground.

The **view field angle** can be described as the angle subtended by the wind farm at the observer's location. This angle varies for different viewpoints and is influenced by the distance from the wind farm, the number of turbines, the layout and its orientation relative to the viewer and the effect of intervening topography. In some cases, only part of the wind farm will be visible. The angle between the left and right hand edge of the view field of the wind farm defines the affected proportion of the viewpoint. A person normally sees about 100° at any point and can easily see a much broader field by scanning from side to side.

As noted above, the angle subtended by the wind farm is, in part, dependent on distance in that, as the distance from the wind farm increases the view field angle for the same width of wind farm will decrease. For a layout such as the Capital Wind Farm, the greatest angular decrease in the view field with distance occurs from 0 to 1 kilometres. Beyond about 3 kilometres, there is only a small decrease in the view angle as distance increases.

The **number of visible turbines** was determined for each assessment site from inspection of photomontages (Plates 1 to 10) and review of layouts relevant to the viewpoints and is shown in Table 7.1.

Although not specifically taken into account in ranking the visibility of the wind farm, the number of visible turbines is also likely to contribute to overall visibility. To some extent it can affect the view field angle and has indirectly affected the visibility ranking described below.

4.1 Visibility Ranking

The above factors have been used to assign a simple relative ranking of the visibility of scenes into three classes, high, moderate and low, as described below and shown graphically in Figure 4. For the purpose of this assessment, the following descriptors were adopted.

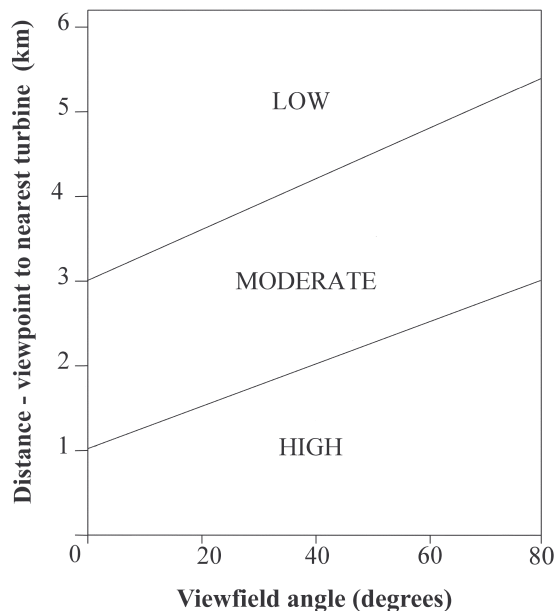
High Visibility: Scenes having high visibility include viewpoints within 1 kilometre and viewpoints up to 3 kilometres depending on the wind farm view field angle.

Low Visibility: Low visibility is assigned to all viewpoints beyond 5 kilometres and viewpoints between 3 and 5 kilometres depending on the wind farm view field angle. It should be noted, however, that low visibility does not necessarily correspond to low visual impact.

Moderate Visibility: This classification is applied to viewpoints intermediate between the low and high classes.

While the above classification scheme is somewhat arbitrary, it does serve to rank visibility for the respective viewpoints and enable comparison between them. It is stressed that visibility rankings do not represent the visual impact which, as indicated in Section 2.5, is subject to a range of other considerations. Similarly, the visibility ranking does not indicate whether the visibility is adverse or favourable.

Figure 4 – Classification of Wind Farm Visibility



4.2 Backdrop of the Wind Farm Views

Whether the wind turbines are seen against the sky or land features can also be relevant to the assessment of visual impact. Most views of the wind farm will have a background of sky. In clear weather, the turbines are likely to be more clearly defined against the blue sky, whereas they may be less noticeable with a backdrop of clouds. Photomontages have been enhanced to make the turbines more prominent.

5. Visual Catchment and Assessment Sites

The visual catchment of a wind farm is the area of surrounding land from which the wind turbines may be wholly or partly visible. Areas not included in the visual catchment are those where the view of the wind farm is obscured by topography, vegetation, human made structures or even just distance (Robotham & Quillesh).

The wind farm will be visible at distances of the order of 10 km or more in some directions. The view of the wind farm across Lake George from the Federal Highway is unimpeded, while topography is a limiting factor in other directions, particularly to the east as described in the following sections. Visual impacts decrease with distance and this assessment has been focussed on distances less than 10 kilometres.

For this study, the approximate visual catchment of the wind farm was computed using a Geographic Information System (GIS) and digital topographic data that was sourced from commercially available map sheet data for the Sutton, Lake George, Lake Bathurst and Boro 1:25,000 map sheets.

Because data on the heights of vegetation was not readily available over the study area, its affect on view-field extent has not been used for the computation of the visual catchment. The result of the GIS view field computation shown in Figure 5 is therefore conservative with the areas from which the wind farm would actually be visible being less than is shown in Figure 5.

The representation of the wind farm visual catchment shown in Figure 5 shows locations within 10 kilometres of the nearest turbine where part, or all, of the wind farm is visible. Due to the difference between the location of the three groups of turbines, differences in the elevation of turbines and topographic variations across the locality, the visibility of the respective turbine groups varies for different viewpoints. Accordingly, while areas shown green in Figure 5 identify the visual catchment of the wind farm, the extent of visibility varies between different view points within the visual catchment.

Due to variation in visibility of the turbine groups, the visual catchments of each group have been separately assessed and are shown in Figures 6, 7 and 8. The visibility of the more western and lower elevation groups is limited to the east by the Great Dividing Range. The more elevated Hammonds Hill Group is visible further to the east of the Great Dividing Range, but its visibility further to the east, in the vicinity of the Tarago to Braidwood Road is limited by an elevated ridgeline south of Tarago. As can be seen in Figure 5, Tarago is beyond the wind farm catchment while the visual catchment extends to Bungendore.

An inspection of the area surrounding the wind farm was also undertaken as part of the assessment to verify the visual catchment and is described in Section 5.2.

5.1 Selection of Representative Viewpoints for Visibility Assessment

Within the Wind Farm's visual catchment, 10 specific sites were identified, from which the visibility of the wind farm was assessed and for which photomontages were prepared. All include views of the wind turbines and one also includes the substation. The basis for the selection of the 10 assessment sites was to include representative views of the various turbine groups from various directions at locations where the public would be able to view the wind farm. All the selected viewpoints are on public roads surrounding the site, some of which are close to private residences and are generally representative of the views from those residences. Five of these viewpoints are in the Taylors Creek Road, where neighbouring residences are the closest to the wind farm. The distance of the viewpoints varies from one kilometre (Viewpoint 6), the closest public viewpoint for the wind farm, to nine kilometres (Viewpoint 1), the most distant.

The viewpoints were also selected as far as possible, to provide a clear view of the wind farm. Locations that were affected by tree and/or topography screening, although a common characteristic,

were generally avoided. Photomontages were not prepared for specific residences as often tree screens around the residences limited views of the wind farm and because locations nearby on public roads were generally representative of the views from the residences. The photomontages for the locations nearest to such residences should enable the respective residents to visualise the changes arising from development of the wind farm relative to their property (Table 7.2).

The locations of the 10 viewpoints are shown in Figure 5 and are listed in Table 5.1.

Only three viewpoints are beyond the range of 5 kilometres from the nearest turbine. Due to spacing between the turbines and lateral extent of the wind farm, there may be a distance of up to 5 kilometres or more between the nearest turbine and the most distant turbine. The visual impact from more distant viewpoints is regarded as being less significant.

Viewing experiences from the nominated locations are generally representative of a range of locations at similar distances.

Table 5.1 – Details of Viewpoint Assessment Sites

Ref	Viewpoint Location (see also Figure 5)			View Details				
	Easting AMG m	Northing AMG m	Description of Location	Distance, nearest turbine (km)	Direction of view	Turbine Group in view Y = 'Yes'		
						GH	EL	HH
1	716293	6112780	Gearys Gap Lookout, Federal Highway	9	East	Y	Y	Y
2	727854	6115570	Taylor's Creek Road West Leg (Lakoona)	2.2	South-east	Y	-	-
3	729436	6118615	Taylor's Creek Road (2.8 km North of West Leg intersection)	5	South	Y	Y	Y
4	729580	6112322	Taylor's Creek Road, North.	3.5	South	-	Y	Y
5	730507	6110486	Taylor's Creek Road, Mid	2.8	North-west	Y	-	-
6	732127	6108856	Taylor's Creek Road, Mid (near Nardoo)	1.5	South	-	-	Y
7	734257	6107246	Taylor's Creek Road, East	3	South West	-	-	Y
8	732415	6104190	Intersection Mt Fairy and Tarago Roads	3.2	West	-	-	Y
9	729692	6101346	Tarago/Bungendore Road	2.7	North	Substation		Y
10	724444	6099265	Hope Drive, Bungendore	6.6	North	Y	Y	Y
Note: GH – Grose Hill, EL – Ellenden, HH – Hammonds Hill								

The Tarago township is approximately 10 km from the closest turbine location. As the township is surrounded by low hills, the town will not have views of the wind farm.

Bungendore is some 10 kilometres to the south of the wind farm. Due to trees and low hills around Bungendore there would be limited distant views of the wind farm from parts of the town. However, residential subdivisions to the north of Bungendore are about 6 to 8 kilometres from the southern part of the Wind Farm and where the aspect and lack of tree screening permits, they may have views of the Wind Farm. The initial residential development appears to be associated with tree planting that will screen much of the views of the Wind Farm once the trees have matured.

Figure 5 shows the location of the wind farm together with lines representing 5 and 10 kilometres distance from the nearest turbine. The lines shown on Figures 5 to 8 will assist individuals to gauge the distance to their respective points of interest and to select viewpoints at similar distance for comparison purposes.

5.2 Review of Visibility from Areas Surrounding the Wind Farm Site

In addition to the computation of the Visual Catchment shown in Figure 5, the following provides a commentary on potential wind farm visibility from the various directions from which it may be viewed.

More detail of the visual features of each Group is provided in Section 5.3 and discussion of visibility of the Wind Farm is provided in Section 7. A discussion of the views from the representative viewpoints and potential views of the site from other points such as residences and public places is also included. Due to the distribution of turbines in three separate groups, the discussion in Section 7 refers to the visual features of the turbine groups as appropriate.

5.2.1 Views to the Site from the South

The visual catchment to the south of the wind farm is in part limited by the extension of the Great Dividing Range to the south, particularly to the east of the Tarago to Bungendore Road.

Distant views of the development will be obtained for northbound traffic on the Bungendore to Tarago Road up to 10 kilometres to the south of the Wind Farm and beyond. Viewpoint 10 is located at Hope Drive a new subdivision about 4 kilometres north of Bungendore and some 6.5 kilometres south of the Wind Farm.

The closest residence to the south of the Wind Farm is Werriwa at slightly more than 3 kilometres distance. It may have partial views of the Hammonds Hill Group of turbines with partial screening by trees. A photomontage has been prepared for Viewpoint 9, about one kilometre east of Werriwa which has a closer view of the Hammonds Hill Group and includes the substation locality.

Other residences to the south of the Wind Farm and south of Werriwa may not have direct views of much of the site, due to various degrees of screening by topography and trees.

5.2.2 Views to the Site from the West

The large low level uninhabited expanse of Lake George to the west of the wind farm means that views of the wind farm will be obtained from the Federal Highway and locations on the scarp on the western side of Lake George.

The western side of Lake George is mostly more than 10 kilometres from the wind farm and there are no residences within Lake George. While some locations on the western side of Lake George with an easterly aspect may have views of the site, these will be distant views with low visual impact. The density of rural settlement on the western side is generally low but is higher at the southern end of Lake George closer to Bungendore.

A photomontage has been produced for a viewpoint at Gearys Gap Lookout on the Federal Highway to the west of the wind farm (Viewpoint 1) where the highway diverges westward from Lake George. From this viewpoint, many of the turbines are visible, with those on the western ridges of the wind farm site being clearly visible while some further to the east are partly screened by topography. No turbines are planned for the prominent ridgetop that forms Governors Hill.

5.2.3 Views to the Site from the North-West

The topography in the area to the north-west of the Grose Hill Group ranges in elevation from about 700 metres for extensive lowland adjacent to Lake George, to 900 metres for the more distant range of hills on the north-east of Lake George. This area has a low density of settlement.

Views of the wind farm from the Collector to Tarago Road to the north-west of the site are limited to the north of a ridge that is about 8 km north of the wind farm.

Much of the lowland area between Lake George and Taylors Creek Road south of Allianoyonygo Creek remains unsettled presumably due to its potential for flooding. Residences that are located within 5 km to the north west of the site are Lakoona, Luckdale and Kullingrah. These residences are close to the foot of Grose Hill Ridge and will have close views of the wind farm. A photomontage (Viewpoint 2) has been prepared for a location at the entrance to Lakoona.

5.2.4 Views to the Site from the North

The wind farm may be partly visible at locations to the north as indicated in Figure 5. An inspection of the area to the north indicates that it is sparsely settled and that distance and topography, together with screening by trees will in many places, limit views of the wind farm and its visual impact. Viewpoint 3 located on Taylors Creek Road to the north of the Wind Farm shows the sparse settlement density of this location.

Views of the Wind Farm from the Collector to Tarago Road in the area of the Woodlawn Bioreactor will be limited by topography.

Viewpoint 5 located on Taylors Creek Road about one kilometre south of Taylors Creek Road provides views to the north west toward Grose Hill Group as shown in the respective photomontage.

5.2.5 Views to the Site from the North-East

The land to the north-east in the vicinity of Tarago is some 10 km distant from the wind farm and will not have direct views of the wind farm due to topographic screening by the large elevated features of the Great Dividing Range.

There will be partial views of the wind farm for vehicles on the Tarago to Bungendore Road. There are also several residences along this road, some of which may have views of the wind farm although most views will be screened by trees, topography or an aspect that will limit views of the wind farm. A photomontage has been prepared for a location on Taylors Creek Road with a south-west view toward the Hammonds Hill and Governors Hill (Viewpoint 4).

A second photomontage representing the view to the south west from Viewpoint 6, on Taylors Creek Road near Nardoo, shows part of the Hammonds Hill Group of turbines. The viewpoint is

close to three residences but is also close to a creek line and has a less expansive view than other residences such as Bonnie Doon.

The wind farm will not be visible to most residences at the eastern end of Taylors Creek Road. Viewpoint 7 is located at the eastern end of Taylors Creek Road several hundred metres west of the intersection with the Tarago to Bungendore Road. The top parts of two turbines are visible in the photomontage while the rest of the wind farm is concealed predominantly by topography. As will be evident in the photomontage, the residences will have a lesser view of the turbines.

5.2.6 Views to the Site from the East

The extent of the visual catchment to the east will, in places, be limited by topographic features and trees. Views to the west from many parts of the Tarago to Braidwood Road will not extend to the wind farm due to topographic and/or tree screening.

The general locality where the Mt Fairy Road joins the Tarago to Bungendore Road is an elevated area where residences at this locality may have varying degrees of visibility of the wind farm. The aspect of the residence will affect the potential to have views to the wind farm. These residences are about 3 kilometres or more from the wind farm. A photomontage has been prepared for the above-mentioned intersection (Viewpoint 8) which indicates the effect of topographic screening for the northern part of Hammonds Hill Group.

5.2.7 Views to the Site from Public Roads and the Goulburn to Canberra Rail Line

Sections of the wind farm will be visible from parts of the Tarago to Bungendore Road, Collector to Tarago Road, Taylors Creek Road and Mt Fairy Road. Of these, Taylors Creek Road provides the closest views and six viewpoints have been chosen along this road. Distant views will occur from parts of the Federal and Kings Highways and may represent a point of interest for some tourists and highway travellers.

Views of the wind farm at distances of 3 to 5 kilometres or more will be available from parts of the Tarago to Bungendore Road that are not shielded by topography or trees. Those views may have foreground consisting of cleared rural paddocks or scattered trees providing a filtered view of the wind farm. Parts of this road have substantial areas of trees that will provide screening of the wind farm.

The Goulburn to Canberra Rail Line is located within the eastern part of the site and at various locations between Tarago and Bungendore there will be glimpses of the wind farm from the railway. Due to the speed of passenger trains on this line, the views will only be seen for a short period. Part of the visual impact may be that the wind farm provides a point of interest for passing travellers in addition to the rural landscape.

5.3 Visual Features of each Turbine Group and Surrounding Viewpoints

This section provides a description of the visual features of the three turbine groups and the substation. It also identifies the main viewpoints that surround the respective Groups.

5.3.1 The Groses Hill Group

The Groses Hill Group of turbines comprises 17 turbines that are spread across a number of low rounded and cleared hills located within four kilometres of Lake George and at the north-western

extent of the Wind Farm. Twelve turbines are located on the Grose Hill ridge that forms the bulk of the Group. Five turbines are located on two low hills adjacent to Lake George on the western side of the Group. The visual catchment of the Grose Hill Group is shown in Figure 6. The density of rural settlement varies around this group, with most neighbouring residences being close to Taylors Creek Road and Western Leg Road and about one to three kilometres from the wind farm.

Photomontages for Viewpoints 2, 3 and 5 provide relatively close views of the Ellenden Group. The Grose Hill is also evident at considerable distance in photomontages for Viewpoints 1 and 10.

5.3.2 The Ellenden Group

The Ellenden Group of turbines comprises 17 turbines on low level rounded and generally cleared hills. All turbines are located south of the main peak of Governors Hill. The Group is wholly within the Osborne family properties and distant from neighbouring properties and residences. Due to the elevated feature of Hammonds Hill to the east of the Ellenden Group turbines, the Ellenden Group will have a low visual impact on neighbouring properties. The visual catchment of the Ellenden Groups is shown in Figure 7.

Photomontages for Viewpoints 1, 3, 4 and 10 include part or all of the Ellenden Group.

5.3.3 The Hammonds Hill Group

The Hammonds Hill Group comprises 29 turbines on elevated ridgelines in the south east of the wind farm development. The Group has two identifiable sub-areas.

- Sixteen turbines are located on the Hammonds Hill to Big Hill ridgeline that runs approximately north-south and is the most elevated part of the Wind Farm.
- Thirteen turbines are dispersed across a large broad area of rolling hilltops and ridges to the north-east of Hammonds Hill and at slightly lower elevation.

The Group will be visible to varying extents from some residences along Taylors Creek Road, Tarago to Bungendore Road, some in the area of Mt Fairy Road and in views from the south in the area north of Bungendore. The visual catchment of the Hammonds Hill Group is shown in Figure 8.

All photomontages except Viewpoint 2 and 5 include turbines of the Hammonds Hill Group.

The visual catchment for a single turbine, Number 49, the most elevated turbine is shown in Figure 9 and illustrates the difference between the visual catchment assessed based on an 80 metre hub height and for the top of the blade sweep at 124 metres. As can be seen it would serve little purpose to reduce the turbine height at this location to reduce its visibility.

5.3.4 The Substation Site

The Substation site is located to the south of the Hammonds Hill Group of turbines within a broad cleared valley. The surrounding residences will have limited visibility of the substation development partly due to topographic screening and in some cases due to screening by trees. There will also be limited visibility from the Tarago to Bungendore Road.

A photomontage has been prepared for Viewpoint 9 looking north towards the Hammonds Hill Group. The substation location is behind a line of trees that is likely to effectively screen it.

5.4 Factors which may Restrict the Visibility of the Wind Farm

The wind farm will be visible to varying degrees from many locations during the day time. Depending on requirements of the Civil Aviation Safety Authority it may be necessary to have lighting on the turbine structures. If so the Wind Farm will be partly be visible at night.

At certain times weather conditions involving low cloud, fog and heavy rain may limit daytime views of the wind turbine structures. Visibility of the Wind Farm will be at a maximum on fine sunny days with blue skies and a clear dust free atmosphere. Considerable effort was made to obtain photos that show these conditions, so that the photomontages would represent the Wind Farm at a time when it is most visible.

6. Photomontages

To assist the assessment of visual impact at each of the selected assessment sites, photographic representations (photomontages) of the modified landscape were prepared (Plates 1 to 10).

The use of pictures as surrogates for real landscape has been criticised in that photographs are less complex, less multi-dimensional and offer less interaction than do real scenes (Abello et al 1986). However, the use of photomontages derived from on-site landscape photographs can be valid if viewers rank pictures in approximately the same way as they rank the actual scenes. A number of researchers have reported high correlations between photo-based judgements and on-site judgements of scenic beauty (Hetherington et al, 1993).

Given the variable topography around the wind farm site, viewing experiences at different locations can be quite variable. The photomontages serve to indicate the proportion of the wind farm that will be visible and also the relationship of the proposed wind turbines to the landscape features with which the local residents are familiar.

The preparation of these photomontages involved photography and computer modelling to integrate the wind farm structures with the topography. These stages of photomontage preparation are described in the following sections.

6.1 Photographs

Colour photographs were taken at each of the 10 selected viewpoints providing representative views of the wind farm site. The photographs were taken to achieve a perspective of sizes as realistic to the eye as possible. This required consideration of both the camera focal length and the width of the field of view. For a negative size of 35 mm, a focal length of 65 mm gives the most realistic representation of distance and size (Tindal and Garrad). While a 100 degree view is the most natural to the eye (Robotham & Quillesh), a viewer is able to scan a wider field of view. Accordingly, at most sites, a series of photos was taken and then joined together to gain a field of view that extended beyond the wind farm site. Fewer photographs were required for the more distant viewpoints where the wind farm occupied only a narrow view field.

A Nikon F65 single lens reflex camera with Nikon AF Nikkor 28 to 80 mm zoom lens was used to take the photographs. The 65 mm setting was marked on the lens case and maintained for each photo. Kodak 100 Film was used for most of the photography. A tripod with two spirit levels was also used to obtain the series of photos to ensure that each series of photos was in a horizontal plane. A series of visits to the locality were required to obtain photographic images for all locations that displayed suitable clear sky weather conditions.

6.2 Computer Modelling and Perspective Views

The 'Windfarmer' software program was used to produce a three dimensional model of the wind farm site. The model was then used to generate perspective views of the proposed wind farm based on the horizontal and vertical position of each turbine with respect to each of the viewpoints.

In all of these views, the turbines were shown generally facing the viewer in order to show the maximum visual impact. In practice, the turbines will predominantly face east or west into the predominant wind directions.

The resultant perspective views from each of the selected viewing points provide accurate representations of the turbines in relation to topography.

6.3 Production of the Photomontages

To illustrate the appearance of the wind farm from specific locations, the photos and computer generated perspective views were combined to create photomontages.

The computer model generated scaled graphical displays of the wind turbines to allow their incorporation into the photo images for each of the selected viewpoints. The resultant photomontages provide an accurate simulation of the appearance and scale of the wind farm on the existing landscape. The presence of existing monitoring towers and other identifiable features within the views provided important reference points against which the accuracy of turbine location in the photomontage was verified.

The landscape photos were scanned into a computer for production of photomontages of each of the selected 10 visual assessment sites as shown in Plates 1 to 10. The photomontages have been printed at natural scale to represent as realistically as possible the actual view seen by the human eye at the various viewpoints. The collection of photomontages portrays viewing experiences from the 10 sites around the area and forms the principal resource for visual impact assessment of the project.

Due to limitations of the equipment used to produce the photomontages, it can be difficult to precisely match the colours on the computer generated images with those on the original photographs. These differences were not considered to be such as to prevent an effective visual assessment and, in some instances, the visibility of the turbines has been accentuated due to increased contrast against the sky.

Considerable effort was made to ensure that the photomontages are an accurate simulation of the proposed wind farm.

7. Visibility Assessment Results

An assessment of the likely visibility of the proposed development is provided in the following sections. Section 7.1 provides the assessment of visibility undertaken for each of the ten representative viewpoints (1 to 10) shown in Figure 5. In addition, Section 7.2 contains a visibility assessment from residences located surrounding the wind farm site as well as other relevant locations.

7.1 Visibility Assessment for the 10 Representative Viewpoints

The assessment was based on:

- review of relevant photomontages for each location;
- visits to each of the viewpoints to assess visibility of the wind farm site (i.e. assessment of the proportion of wind farm that may be visible from the viewpoint);
- observation of factors that may reduce the visibility (e.g. topographic features, tree screening); and
- reference to GIS based view field analysis that takes into account the height of the turbines.

The key visibility criteria and the resulting visibility classifications (based on the assessment criteria in Section 4) are shown in Table 7.1. In addition, the number of turbines in various distance ranges (1-3 km, 3-5 km and >5 km) from the viewpoint are shown. No viewpoints are located closer than one kilometre to the nearest turbine. It can be seen that only Viewpoints 2, 6 and 8 have turbines in the range less than 3 kilometres which for visual impact studies is generally regarded as mid-ground.

Table 7.1 – Visibility Assessment Results for the 10 Representative Viewpoints

Ref No.	Viewpoint Location (see also Figure 5)	Number of Visible Turbines			Visibility Criteria		
		Mid-ground	Background	Background	Distance to Nearest Turbine	View Angle	Visibility Class (see Appendix C)
		1 – 3 km	3 - 5 km	> 5 km	km	degrees	
1	Gearys Gap Lookout	0	0	63	9	45	Low
2	Lakoona entrance	7	10	0	2.2	75	High
3	Taylors Creek Road, north of West Leg Intersection	0	2	41	5	45	Low
4	Taylors Creek Road, north	0	11	22	3.5	75	Mod
5	Taylors Creek Road, mid	9	5	3	2.8	40	Mod
6	Taylors Creek Road, mid (near Nardoo)	9	6	1	1.5	20	High
7	Eastern end Taylors Creek Road	1	1	0	3	5	Mod
8	Mt Fairy Road/Tarago Road	0	18	0	3.2	55	Mod
9	Tarago Road	3	13	11	2.7	30	Mod
		Substation – Low visibility due to low height and tree screening					
10	Hope Drive, Bungendore	0	0	55	6.6	45	Low

In Table 7.1, a turbine is regarded as visible even if only partially visible.

Of the 10 sites assessed, two are ranked as having high visibility, five as moderate visibility and three as low visibility. Visibility of the substation is regarded as low due to low height and screening by trees.

The view from the selected distant site, Site 1 (at about 9 km from the wind farm) was assessed as being subject to low visibility. It can be seen from the respective Plate 1 that, due to the effects of distance (and to some extent topographic screening) visibility from Viewpoint 1 is indeed low, but the turbines are nevertheless discernible in the landscape.

There are limited trees on the ridges where the wind farm is located and therefore little to reduce or soften the proposed structures. Visibility of the proposed structures in these cases will therefore relate to the contrast provided by the background scene. Many views of the Wind Farm will be from a lower elevation and the backdrop to the turbines is likely to be the sky. Some viewpoints may contain portions of the turbines in front of more distant ridges. In such cases, even though the wind turbines are noticeable features they will not significantly mask the scenes but rather they may impact upon the character of the scenery.

At many residence locations other than the representative viewpoints, trees close to the residence are likely to reduce the portion of the wind farm which is visible. In such cases, more expansive views of the proposed development may be available at short distances from the residences and from beyond tree stands surrounding the residence. Section 7.2 provides an indicative guide to visibility considerations for residences and public places surrounding the wind farm site.

7.2 Other Potential Viewing Points

The visibility of the Capital Wind Farm is demonstrated in the photomontages that have been prepared for the 10 representative viewpoints surrounding the wind farm. Section 5.2 also provides a review of the general visibility of the wind farm when viewed from each of the localities in each direction around the wind farm.

In addition, specific viewpoints have been assessed for the potential visibility of the wind farm. Table 7.2 provides a listing of indicative visibility parameters, predominantly for the main residences that occur within 5 kilometres of the wind farm. Residences beyond 5 kilometres will have low visibility and have not been included in Table 7.2.

In preparing Table 7.2, the visibility parameters for each viewpoint have been estimated and should be regarded as indicative only. In some cases, the actual residences have not been visited and the assessment is based on a review of the local terrain, the aspect of the particular site and the impression of the extent of tree screening, generally gained from observation of the residence's setting from a nearby roadside vantage point.

During consultation with the wind farm neighbours, Renewable Power Ventures has provided neighbours with an indication of the visibility at their residences using photomontages and discussions on the ground.

Table 7.2 – Review of Indicative Visibility for Viewpoints from Neighbouring Residences within 3 km of the Wind Farm Site, other than the 10 representative viewpoints.

Ref No.	Location	W – Wind farmer N – Neighbour	Nearest turbine	Approx. no. of potentially visible turbines	Distance to residence to nearest turbine (km)	View field angle degrees	Estimated Visibility Class L, M, H	Screening by trees (Yes/No/Partial)	Nearest Photo-montage	Comment on potential visibility factors
A	Groses Hill Group									
	Luckdale	N	WTG 4	14	1.2	130	H	Yes		View to turbines 1-3 blocked by ridge surrounding residence south-west
	Lakoona	N	WTG 6	17	2.3	80	H	Partial		
	Bernallah	N	WTG 6	12	2.0	15	M	Yes		Screening by trees and topography
	Widgemore	N	WTG 6	12	1.3	15	M-H	No		Screening by topography
	Torakina	N	WTG 6	0	2.4	0	L	Partial		No visibility, residence visibility blocked by ridgelines
	La Granja	N	WTG 15	17	1.6	55	H			
	G11	N	WTG 15	17	1.9	55	H			
	Narine Green	N	WTG 15	17	1.8	50	H			
	G13	N	WTG 15	17	2.4	40	M			
	G14	N	WTG 15	17	2.3	45	M			

Ref No.	Location	W – Wind farmer N – Neighbour	Nearest turbine	Approx. no. of potentially visible turbines	Distance to residence to nearest turbine (km)	View field angle degrees	Estimated Visibility Class L, M, H	Screening by trees (Yes/No/Partial)	Nearest Photo-montage	Comment on potential visibility factors
	G15	N	WTG 15	17	2.4	45	M			
	G17	N	WTG 15	17	2.6	45	M			
	G16	N	WTG 15	17	2.6	40	M			
B	Ellenden Group									
	E7	N	WTG 32	17	1.5	70	H	Yes		In valley and partial tree screening
C1	East of Hammonds Hill									
	Storeys	N	WTG 51	Up to 20	2.8	65	M	Minor		On ridgeline, ridge screens view to NW
	The Patch	N	WTG 57	25-29	2.6	90	H	In progress		Tree planting undertaken
	Substation entrance	N	WTG 63	25-29	2.1	60	H	Yes		Native vegetation screening
C2	NE of Hammonds Hill Taylors Ck Rd									
	Wroxham	N	WTG 39	<4	1.5	55	M	Yes	6	Partial topographic screening and extensive screening by trees
	Bonnie Doon	N	WTG 39	29	1.8	55	H	Partial	6	
	Rosehill	N	WTG 39	29	1.9	60	M	Yes	6	Extensive screening by trees

Ref No.	Location	W – Wind farmer N – Neighbour	Nearest turbine	Approx. no. of potentially visible turbines	Distance to residence to nearest turbine (km)	View field angle degrees	Estimated Visibility Class L, M, H	Screening by trees (Yes/No/Partial)	Nearest Photo-montage	Comment on potential visibility factors
	Hill Top	N	WTG 39	29	2.1	55	H	Partial	6	
	H8	N	WTG 39	Up to 29	1.6	60	H	Partial	6	
	Taylor's Creek Road East End residences on southern side of road	N	WTG 39	0	>1.5	<10	L to Nil	topography	7	Residences have topographic screening
C3	Taylor's Creek East residences northern side of road	N	WTG 39	Depend on location	>1.5	Mostly low to nil	L	Trees and topography	6,7	Residences at lower levels unlikely to have views to wind farm. More elevated residences may have views to wind farm with various degrees of screening.
C4	Mt Fairy Road residences	N	WTG 57	Up to 29 but expected to be less	>3.4	80	L	Topography and trees	8	Low impact due to distance, aspect and tree screening
C5	South of Big Hill	N	WTG 63	25 HH Group 5 Ellenden	>3 >5	<20 10	M	Partial	9	Limited views of wind farm. Part due to orientation and also due to screening.
D	North of Bungendore Hope Drive	N	WTG 32	17 Ellenden 26 HH Group	>5 >5	40	L	Partial	10	Distant views, greater than 5 km, Many residences have tree screening.

8. Visual Aspects of Ancillary Works

The main considerations in relation to visual impact of ancillary works are discussed in the following sections. The location of these works is shown in Figure 2. Construction works including areas of earthworks and soil stockpiles at foundation excavations will be temporarily visible. These areas will be progressively restored following completion of the construction works at each turbine site.

8.1 Access Tracks

In general, permanent tracks can be designed and located to minimise visual impact. Most of the access tracks to turbines will be near the top of the ridges and not visible from the surrounding countryside. In cases where new tracks are located on the sides of slopes, their visibility will be minimised by the revegetation of batters following construction works.

The access track to the Grose Hill ridge is from Western Leg Road and will not be visible to much of the public using Taylors Creek Road. Access to the Hammonds Hill Group will be visible from Taylors Creek Road, but in the gentle slopes will have low visual impact. Upgrading of the existing tracks and formation of new tracks may be readily visible from a range of viewpoints.

Any temporary tracks will be removed and re-grassed after construction works are completed and will not have a long term visual impact.

8.2 Facilities Building and Substation

The facilities building and substation will be located in a valley south of the Hammonds Hill Ridge. Their location is such that they will only be partly visible at distance from the south in areas where no residences are located. Their visual impact is assessed as minor. If considered beneficial, further tree planting could be undertaken along a ridge to the south of the substation, to further mitigate the substation visibility.

8.3 Transmission Lines

A ten kilometre section of the internal aboveground 33,000 volt wood or concrete pole transmission line is proposed to link the north-western and western groups of turbines to the facilities building and substation. The route of the overhead line has been chosen to minimise its visibility from surrounding residences, local roads or public areas. The visibility of such lines at distances of 3 kilometres or more in rural landscapes is minimal.

There will be limited views of the substation, facilities building or new overhead line from the public roads and these will be minor visual elements compared to the turbines themselves.

8.4 Temporary Construction Office and Batch Plant Facilities

The temporary Construction Site Office and a Batch Plant Facility will be located adjacent to Taylors Creek Road at the entrance to the Hammonds Hill Group. A temporary Batch Plant will also be located toward the southern end of Western Leg Road

8.5 Summary of Impact for Ancillary Works

Having regard to the foregoing, the visual impacts of the ancillary works will be minor and insignificant compared to that of the wind turbines because:

- Most of the elements of the ancillary works are low level aspects compared to the turbines;
- Many will not be visible to the public; and
- Significant distances exist to public vantage points and residences.

Screening for the ancillary features could also be applied if required. However, the factors above are likely to achieve satisfactory mitigation of the visual impact and screening of ancillary works is unlikely to be warranted.

9. Cumulative Visual Impacts

The land on which the wind farm will be developed is extensively cleared. There will be minimal additional clearing and negligible change to the vegetation that comprises the current landscape.

The development will add a new feature to the landscape that will affect views from points surrounding the wind farm to varying extents. The turbines will not mask the existing landscape or reduce the natural elements of the landscape but may change the viewer's point of focus. As described in previous sections, the wind farm may occupy varying degrees of a particular view and the turbines may be partially or fully visible from various viewing points.

Much of the broader region, particularly the lower land, is considered unsuitable for wind farm development and the extent of future similar developments is limited. Furthermore, the low level expanse of Lake George will limit any wind farm developed to the immediate west of the Capital Wind Farm. The low level terrain extends south around Bungendore and to the north of Grose Hill and such areas are also considered unsuitable.

More elevated areas with potentially higher energy resource are located to the north and east and some could be suitable for wind farm development at some stage in the future. However, the rugged and vegetated terrain and limitation on grid access will lower their potential for development. It is also understood that the western side of Lake George has restrictions on development of wind farms.

In October 2005, development consent was granted for the nearby Woodlawn Wind Farm and the two wind farms, while separate by at least 5 kilometres, cover a wide area south west of Tarago. It is noted that for the photomontages prepared for 10 representative viewpoints selected around the Capital Wind Farm, that only two of these will include views to the Woodlawn Wind Farm. Similarly many other viewpoints in the local area are likely to have only partial views of one or both wind farms and a limited number of residences will have unimpeded views to both wind farms.

Travellers on the Tarago to Bungendore Road will have filtered to expansive views of the one or both of the two wind farms at a number of locations along the road.

Other wind farm developers are known to be investigating sites in the region and it is conceivable that Development Applications for other sites could be lodged in the future, although these are likely to be more distant from the Capital Wind Farm than the Woodlawn Wind Farm. Residences located between the two wind farms will experience the greatest visual impact, as a small number will have views of both wind farms.

The presence of the Great Dividing Range running through the locality limits the visual catchments of the individual developments as indicated in Figures 6 and 8.

10. Mitigating Options

The planning of the Capital Wind Farm has considered a range of options for mitigating the project's visual impact.

In response to the concerns raised by neighbours, the layout for the wind farm submitted for the Development Application contains a lesser number of turbines than has been considered during the planning stage. Turbines included in the initial plan and since removed have included:

- Nine at the Mt Fairy locality
- Thirteen between Hammonds Hill and Tarago/Bungendore Road
- Three on the northern end of the Grose Hill ridge

The changes to the layout have been associated with increased setbacks from many nearby residences. While some additional turbines have been added in these are at locations where they will have a lesser visual impact.

Other mitigation measures that have been implemented or which will be incorporated in the project include:

- Clearing of vegetation will be minimal
- Earthworks will be restored as soon as possible
- Underground cables will also be installed between turbines within each of the turbine groups.
- Trenches that house the cables will be backfilled so that once restored they will have no visual impact. The choice of underground cables for the ridge top turbine locations instead of above ground transmission lines has been made to minimise the visual impact of the development.
- The colour of the turbines is that commonly chosen to create a more desirable visual outcome. Visual amenity was the only factor considered in the choice of the colour. If an alternative colour were considered to be more favourable, its use would be considered subject to discussions with key stakeholders.
- Tree planting has been undertaken on some neighbouring properties with agreement of the relevant landowners to screen parts of the development. The preferred types of plants for screening are local native varieties but it may be necessary to plant non-natives that are fast growing where expediency is essential or where property owners would prefer non-natives.
- The design and location of ancillary works will incorporate measures to reduce their visual impact. Screening of certain ancillary works, if required, can utilise vegetation planting at the location of the ancillary works
- Restoration of any earthworks will be an important component of the construction works.

The number of blades, blade diameter and height of the turbines are determined by technical and commercial considerations. Consideration has been given to the selection of the hub height in respect of visual impact. For the type of turbines being considered, an assessment of capital costs, energy output, commercial return and net greenhouse gas emission savings indicated that a hub height of about 80 metres is required. On balance, it is considered that the benefits of an 80 metre hub height versus lesser hub heights are justified when compared to the marginal increase in visibility of the wind farm.

As noted in Section 1.1, some minor relocation of turbines within the site may occur during the implementation phase. However, such changes are unlikely to significantly alter the overall visual impact.

11. Conclusions

The proposed wind farm is a sustainable energy development that involves the installation of large structures in a rural landscape. Various numbers of wind turbines will be clearly visible from a range of viewing points including some of the surrounding rural residences, parts of the local roads and various distant viewpoints.

The characteristics that can affect the visual impact of wind farm developments include:

- sensitivity of the location
- visibility of the development for neighbours and the general public
- layout and size of wind turbine equipment
- colouring of the wind turbines
- visibility of ancillary works.

The Capital Wind Farm development is located on a number of large grazing properties in sparsely settled rural land. Public roads are set back from the wind farm and the community will mostly have distant views of the project. However, there are small groups of rural residences located within 1 to 3 km of the wind farm, where some of the residents may have concerns regarding visual impact.

The visual catchment of the wind farm is extensive but is restricted in several directions by topography and in some cases due to screening by trees. The main visual impact will primarily occur within a radius of about 5 kilometres and the extent of visual impact will progressively decrease with distance.

A process of visibility ranking was applied to each of 10 selected viewpoints. The findings were:

- Two sites were assessed as being subject to high visibility
- Five sites, were assessed as being subject to moderate visibility, and
- Three sites were assessed as being subject to low visibility

The above rankings provide a basis for comparison of the viewpoints and do not necessarily reflect the actual visual impact.

The representation of the potential visual impact of the proposed development is primarily based on the provision of photomontages created for views from the 10 selected assessment sites.

To rank or categorise potential visual impacts is subjective and, in the end, it is the individuals of the affected community who will judge the visual impact of the wind farm. Individuals' perceptions of what is intrusive, and what is not, may differ as do their opinions on the attractiveness of the wind turbines.

This report should be seen as a tool to assist the individual in examining the photomontages and making a more informed decision as to the wind farm's appearance. It also provides recommendations for mitigation of the project's visual impact as described in Section 10.

12. References

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Appendix A1

Extract from PlanningNSW, 2002 – NSW Wind Energy EIA Guidelines

APPENDIX A – Guideline for Landscape and Visual Issues assessment

Issues which may need to be considered include:

- (a) describe the existing landscape setting and the key features contributing to its character including its heritage values. Identify the likely risk that the landscape setting or surrounding land use will change in the short, mid or longer term.
- (b) identify the visual catchment(s) of the wind farm or any associated infrastructure:
 - (i) consider the visual quality and significance of the landscape including unique visual aspects and the extent of any existing visual degradation;
 - (ii) identify areas (in particular public area) with the high visual impacts from the fore, middle and background;
 - (iii) consider the visual absorption capacity of the area (particularly if towers protrude beyond the ridge line) including the compatibility of the proposal with the existing visual environment and scale of the proposal relative to existing land uses;
 - (iv) outline the community's views on whether the project is likely to become a visual asset or liability to the landscape quality of the area. In this context, consider the impacts on the landscapes quality or particular features of local or regional significance or sensitivity from key vantage points;
- (c) identify the potential for reflective light and shadow flicker from the blades of the wind turbine/s at residences, road or other public places outline any risks to road safety, and evaluate their significance
- (d) outline measures to mitigate visual impacts including:
 - (i) location, layout, surface treatment and colour of structures;
 - (ii) any landscaping and the rehabilitation of constructions areas
 - (iii) ongoing community consultation measures
- (e) discuss the acceptability of impacts and the adequacy of the mitigation strategies to manage visual impacts;
- (f) consider the risks associated with managing visual impacts if the surround land use changes; can contingencies be built into the project if the risks are high.