2 Design Evolution & Alternatives

Introduction

2.1 In this chapter a description is given of the site selection process and design strategies that have been adopted to arrive at the Proposed Development described in Chapter 3: Proposed Development. Firstly, the general design principles adopted by RES are outlined and potential key issues which have affected the design are identified. Thereafter, a description is given of how the turbine layout and infrastructure design have evolved in response to constraints identified through the EIA process.

2.2 Figures 2.1 – 2.4 are referenced in the text where relevant.

Current land use and site context

2.3 The location of the Proposed Development is shown in Figure 1.1: Site Location and Figure 1.2: Planning Application Boundary. The total planning application area is 384 ha.

2.4 The Site extends to 362 ha and is centred on the summit of Werfa (568m). From this high point the plateau slopes gently down in all directions, though only marginally to the northern boundary which follows the administrative boundary across the upland. On the other sides the plateau drops sharply at the valley edges. Small watercourses drain the site to south-east and south-west.

2.5 Land cover consists of upland grassland, used as rough grazing. The boundary adjoins coniferous plantations to east, west and north, but there is no woodland on site (except along the forestry access track). The only enclosures are in the eastern part of the site and comprise post and wire fencing. The summit of Werfa features an OS trig point and two communications masts within a fenced compound. The compound is accessed via a track from the A4107 and is serviced by a low-voltage overhead power line on wood poles which runs from the Garw Valley. A series of vertical axis wind turbines were formerly located to the south of the masts, but only the foundations now remain. The turbines of Llynfi Afan Wind Farm are located to the west and north of the Site.

2.6 There are several public rights of way crossing the site, including a bridleway linking Cwmparc with the Garw Valley, and footpaths linking the other surrounding valleys, and following the ridge of Mynydd Llangeinwyr south. Being unenclosed upland grazing, most of the site is open access land, with the exception of the enclosed pastures in the east.

2.7 The north-east boundary follows the A4107, which connects the Afan Valley with the A4106, which in turn connects the Ogmore Valley with the Rhondda Valley. The planning application boundary also includes 3.6 km of forestry

track, with an area of 22 ha, to the north of the Proposed Development site, which will be used as part of the abnormal load access route. This existing forest track runs between stands of commercial conifer plantation and is managed by Natural Resources Wales (NRW).

Key Issues and Constraints

2.8 The design of a wind farm is optimised to produce a layout that maximises the use of the land available for wind power generation balanced against the overall environmental impact of the development. The optimal layout of a wind farm depends on a range of technical, economic and environmental criteria. The following are site specific factors determining the viability of a wind farm:

- Wind Speeds/Energy Yields: Sufficiently high wind speeds to ensure energy production from the wind turbines that would yield an adequate return on investment;
- Planning: A site which complies with planning policy and in particular, avoids unacceptable effects on areas that have been designated by statutory agencies; maintains appropriate distances from dwellings to avoid unduly impacting local amenity; and avoids impeding or interfering with major electromagnetic transmission and airport communication systems;
- Area of Site: A site must have sufficient area to accommodate the number of wind turbines required for economic viability;
- Access: Adequate vehicular access to a site using existing roads wherever possible to minimise the amount of civil works, particularly during the construction phase;
- Local Terrain and Topography: Terrain and topography affect wind flow across a site and need to be considered in relation to turbine performance, specification and life-span;
- Ground Conditions: A site must have suitable ground conditions for the construction of wind turbine foundations, erection of the turbines and the provision of access tracks and cables.

2.9 There are additional factors which also influence the scale and viability of a wind farm including:

- Turbines must be separated by specific distances both perpendicular to, and in line with, the prevailing wind direction to minimise turbulent interaction between the wind turbines (i.e. wake effect). This needs to be considered to balance turbine performance with energy extraction, and to protect the life-span of the turbines. Spacing requirements vary between turbine manufacturers and are also subject to wind conditions;

- Wind turbines have to be located at a distance sufficiently far from occupied residential property to ensure adherence to relevant noise criteria and to ensure that shadow flicker impacts are minimised;
- The implications of locating turbines near environmentally sensitive features and areas (ecology, archaeology, hydrology etc.) need to be carefully considered; and
- Landscape and visual design considerations need to be taken into account.

2.10 The apportioning of weight to each element is a site-dependent consideration and results in bespoke design approaches and strategies for each site. The following sections identify potential issues and outline how these have been addressed through appropriate design.

2.11 The basis of the design process is the evaluation of the various constraints and design recommendations that have been identified through the environmental surveying. The constraints identified through these surveys, along with other technical constraints and appropriate buffers are presented in **Figure 2.1**: **Key Constraints and Infrastructure**.

Potentially significant effects

2.12 Following consultation and baseline characterisation of the Site, the following key environmental issues have been identified:

- Landscape and visual
- Geology, hydrogeology and hydrology
- Archaeology and cultural heritage
- Noise and shadow flicker
- Ecology and ornithology
- Socioeconomics
- Traffic and transport.

2.13 The issues listed above have been considered during the iterative design process with the aim of designing out significant effects. Where it is not possible to mitigate these effects through design, the issues are considered further as part of the Environmental Impact Assessment process (EIA) which is described in this Environmental Statement (ES).

Consultation

2.14 As part of the EIA process, RES and the consultant project team consulted with various stakeholders, the outcome of which has been considered in the design process where relevant and incorporated into the appropriate chapters of this ES, to ensure that the scope of the ES fully, but concisely, addresses all potentially significant issues.

2.15 A table detailing where the ES addresses issues raised in the Scoping Decision received from the Planning Inspectorate (PINS) can be found in Technical Appendix 1.3. Any further consultation undertaken by the consultant project team is detailed in the specific chapter.

Public Consultation

2.16 RES is committed to finding effective and appropriate ways of consulting with all its stakeholders, including local residents and community organisations, and believes that the views of local people are an integral part of the development process. RES began the engagement process in November 2017, approximately 33 months prior to the submission of the planning application, to facilitate a constructive consultation process which helped RES to understand and address any concerns as the project developed. Public exhibitions were held on 28th and 29th November 2017 to introduce RES and the Proposed Development to the communities.

2.17 Further public exhibitions were held on 4th and 5th September 2018 which included detailed maps and information about the proposals, including the following:

- Background information about RES as a company;
- Map of the proposed layout;
- Photomontages representing how the proposed layout would appear from a range of viewpoints;
- Zone of Theoretical Visibility (ZTV) diagrams. (A ZTV is a map-based diagram illustrating where and how many wind turbines, or wind farms, would theoretically be visible from all parts of a given area. The methods for preparing ZTVs and their uses within the EIA process are described in Chapter 5: Landscape and Visual Impact Assessment;
- Other information about the project and the development process, including the secondary application for common land consent under Section 16 of the Commons Act 2006;
- RES staff were available to answer questions and feedback was encouraged.
- A Pre-Application Community Consultation (PACC) Report, which includes details of consultation completed to date with the public and with statutory consultees, accompanies the planning application and Environmental Statement.

Alternatives

2.18 RES considers a range of potential options when selecting and designing wind farm sites. The following sections outline the broad design alternatives that have been considered in terms of the EIA Regulations.

Do-Nothing Alternative

2.19 The "do-nothing" scenario is a hypothetical alternative considered as a basis for comparing the potential significant effects of a development proposal. In the case of the Development the "do-nothing" scenario would be for the Site to continue to be managed for agricultural rough grazing by the landowners. It is likely that current land management activities would continue.

Alternative Sites

2.20 RES has a robust site selection methodology, using a Geographical Information System (GIS) to aid identification of potential wind farm sites and this site was selected based on that methodology.

2.21 The Proposed Development site meets the criteria listed in section 2.8 of this chapter. The GIS model was used to identify potential constraints which could restrict development or would need to be addressed in the design process.

Alternative Layout Designs

2.22 There have been several iterations of the turbine and infrastructure layouts. From the outset the following design principles have been employed when making design decisions:

- Mitigation by design should be the principal method of reducing potential environmental impacts.
- Utilisation of existing infrastructure should be implemented whenever possible to avoid unnecessary development.
- All site infrastructure should be designed as efficiently as possible to reduce the overall extent of development whilst maximising the renewable energy generation potential.

2.23 A key tool in the design process is the key constraints drawing which integrates all potential constraints that need to be considered in the design process. The finalised key constraints drawing is shown as Figure 2.1: Key Constraints and Infrastructure.

2.24 The key constraints drawing is iteratively updated where required through the EIA process as new information from surveys, site visits and consultation is received. The following surveys and assessments informed the key constraints drawing:

- Breeding and wintering bird survey
- Ornithological vantage point survey
- National Vegetation Classification (NVC) Phase 2 survey
- Terrestrial fauna surveys
- Peat probing
- Hydrology assessment

- Archaeology and cultural heritage surveys
- Landscape field survey
- Aviation
- Transport and traffic
- Geology and mining
- Noise
- Shadow flicker
- Technical and engineering site walkovers.

2.25 The final site layout for the Proposed Development (Figure 3.1: Infrastructure Layout) balances the need to optimise the energy yield whilst paying due regard to environmental and technical sensitivities. Wind farm design is an iterative process and is influenced by potential environmental effects identified throughout the EIA process, policy recommendations, environmental, technical, engineering and landscape design considerations, and as a result of feedback from consultees.

2.26 The following sections describe the evolution of the turbine and infrastructure layouts.

Design Evolution

Turbine Layout

2.27 The final proposed turbine layout is shown in Figure 2.2: Turbine Layout. There were three principle iterations of the turbine layout, shown in Figure 2.3: Turbine Layout Evolution, which were developed at the following stages in the project process:

- Initial feasibility stage, when turbines were located based on preliminary constraints;
- Revised turbine layout, following completion of mining and geological site investigations and incorporating increased tip heights and rotor diameters to maximise efficiency;
- Final constraints and refinement stage, following the completion of environmental surveys and more detailed assessments on any potential issues identified.

Layout 1 - Initial Feasibility Stage

2.28 At the beginning of the development process an initial layout was produced to show the maximum potential extent of the development within the developable area. The developable area was defined as the land with slopes of less than 15% on which it would technically be feasible to install large wind turbines. The initial layout was prepared in accordance with design principles, prior to baseline surveys being completed, informed by the following:

- 10 x rotor diameter separation from housing
- Provisional buffer around the existing transmitter at Werfa as a precautionary measure prior to consultation
- Tip height plus 10% buffer to public roads
- Slope

2.29 This identified that the Site could potentially accommodate 17 turbines with a 125 m tip height. This is shown in Layout 1 of Figure 2.3: Turbine Layout Evolution.

Layout 2 - Revised Turbine Layout

Mining and geology

2.30 The key risk addressed through the second layout iteration was potential geological instability due to historic mining activities and active geological faults.

2.31 A specialist consultant was appointed to carry out a geotechnical ground investigation, which followed a two-stage process. The first stage investigations identified two fault lines crossing the site and resulted in the categorisation of the site into zones at high, medium or low risk of geological instability. Following this the turbine layout was revised to ensure all turbines were located outwith zones of high risk of instability. This resulted in a significant decrease in turbine numbers from 17 to eight.

2.32 The second stage of the investigation examined the turbines that were provisionally located in medium risk areas. Detailed site investigations were performed to examine potential instability at the specific turbine locations, with the result that the instability level was able to be reduced to low at all turbine locations.

Turbine size

2.33 Wind turbine manufacturers continue to develop larger turbines because small increases in turbine geometry result in significant increases in energy generation. For example, a 20% increase in tip height could increase output by 90% due to taller turbines with longer blades capturing more wind.

2.34 To maximise energy capture at the Proposed Development, the tip height was provisionally increased from 125 m to 149.9 m, subject to design review by the landscape and visual consultants following their baseline assessments.

2.35 The above studies resulted in a layout of eight turbines of up to 149.9 m tip height, as shown in Layout 2 of Figure 2.3: Turbine Layout Evolution.

Layout 3 - Final Constraints and Refinement

2.36 The final major iteration of the turbine layout took place following the completion of environmental surveys. Detailed environmental and technical

surveys were carried out to characterise the baseline environmental conditions on the Site and associated study areas, as described in more detail in chapters five to 13 of this ES. Any constraints to development resulting from the baseline surveys were added to the key constraints drawing and design recommendations were taken into account as the layout evolved.

Landscape and Visual

2.37 As described in Chapter 5: Landscape and Visual Impact Assessment, ZTV diagrams were prepared to indicate from where all, or parts of, the Proposed Development were likely to be visible. These were used primarily to assist the identification of areas with theoretical visibility and the location of Preliminary Viewpoints as part of the baseline Landscape and Visual Impact Assessment (LVIA), and later to assist in the detailed analysis of the potential visibility of the Proposed Development throughout the Study Area that was used for the LVIA.

2.38 The Proposed Development is designed to be seen as an extension to the operational Llynfi Afan Wind Farm. To this end, the Landscape Consultants reviewed the heights of the proposed turbines and concluded that six of the eight turbines would be acceptable with maximum tip heights of 150 m and turbines T1 and T2 would be acceptable with maximum tip heights of 130 m.

2.39 Further consultation with the operators of the Werfa communications mast provided more detailed information on the radio links across the Site. This information required some turbines to be relocated and one of these, turbine T8, could only be sited at the eastern extremity of the Site to avoid the radio links. At that location, the Landscape Consultants advised that it would appear incongruous with the layout of the other seven turbines. It was therefore decided to remove turbine T8 from the development.

2.40 Feedback from the public exhibitions included comment that turbine T6 appeared too tall when viewed from Nantymoel. Whilst the LVIA advice was that this turbine would be acceptable at a tip height of 150 m, a development decision was made to reduce the tip height of turbine T6 to 130 m (the same height as turbines T1 and T2), even though this would result in a loss of some energy generation from the project. The final proposed turbine layout is shown as Layout 3 on Figure 2.3: Turbine Layout Evolution.

Ecology and biodiversity

2.41 Following the baseline surveys and characterisation of the site no additional layout constraints were proposed by the ecological consultant.

Cultural Heritage

2.42 As described in detail in Chapter 7: Cultural Heritage, following site surveys a number of scheduled monuments and non designated assets were identified

within the Site. These were added to the key constraints drawing and avoided with all infrastructure and turbine positions.

Hydrogeology and Hydrology

2.43 As recommended in Chapter 8: Hydrogeology and Hydrology, turbine centres are located a minimum of 50 m from significant watercourses. A significant watercourse is defined as a watercourse that appears on 1:50,000 Ordnance Survey mapping.

Geology & Mining

2.44 A series of ground investigations have quantified the geological and mining hazards relating to the site. As described earlier in this chapter the layout of the Proposed Development has been iteratively developed to take account of the results; to avoid geological and mining hazards as well as areas of deep peat. On this basis, and as confirmed in the Scoping Direction, RES has scoped out a detailed impact assessment chapter for geology and mining from the Environmental Assessment.

2.45 The potential impact on sensitive habitats associated with peat is considered as part of the ecology and biodiversity assessment, and an assessment of peat hydrology is considered as part of the hydrology and hydrogeology assessment.

2.46 Two sets of ground investigation were carried out during the turbine layout evolution due to changes in the layout, to ensure all final turbine positions had been assessed. The resulting reports are included in Appendix 2.1 and 2.2:

- Appendix 2.1: Upper Ogmore Wind Farm Ground Investigation Report, N A Brown, March 2016. (This report includes an assessment of previous locations of T3, T4 and T5, which subsequently moved due to other constraints.)
- Appendix 2.2: Upper Ogmore Wind Farm Ground Investigation Report, RSK, Project no. 371718-01 (01), August 2018. (This report includes the final locations of T3, T4 and T5.)

2.47 Further geotechnical investigations will be commissioned prior to the construction of the development to provide the parameters for detailed design of the turbine foundations and associated civil infrastructure.

Acoustic

2.48 One of the key turbine layout design constraint considerations was the minimisation of impacts at the nearest residential receptors and as such the turbine layout was designed to ensure that there is an adequate separation distance between any of the proposed turbines and the nearest residential property.

2.49 As described in detail in Chapter 10: Acoustic Assessment, background noise surveys were carried out to establish baseline conditions and the wind turbine layout was assessed for acoustic impact. No further mitigation measures are

required for the operation of the proposed turbines as the layout complies with relevant noise criteria.

Shadow Flicker

2.1 Whilst there is no specific standard for the assessment of shadow flicker in the UK, planning requirements of shadow flicker are contained within Parsons Brinckerhoff (2011) which states: "the 10 rotor diameter rule has been widely accepted across different European countries, and is deemed to be an appropriate assessment area".

2.50 A separation distance of 10 x the rotor diameter (1050 m) has been applied to the key constraints drawing. There are no inhabited houses within ten rotor diameters of any of the proposed turbines. Chapter 12: Shadow Flicker and Reflected Light provides more information.

Electromagnetic Interference, TV and Radio

2.51 Wind turbines can potentially interfere with communication systems that use electromagnetic waves as the transmission medium, primarily television, radio or point to point electromagnetic (PtP EM) links. Wind turbines therefore may cause interference to television reception in the proximity of a wind farm, causing loss of picture detail, loss of colour or loss of audio. Microwave links can also be affected by the reflection, scattering, diffracting and blocking of the electromagnetic signal caused by wind turbines. Potential impact on PtP EM links and TV/Radio signal are addressed separately in the following paragraphs and table.

2.52 For PtP EM links, RES has consulted with all organisations operating microwave links which could be affected by the Proposed Development and these are listed in **Table 2.1** below. The final turbine layout complies with the required set back distances for all the links crossing the site and as such no impacts are expected.

2.53 Should interference to TV reception occur as a result of the Proposed Development, a range of viable mitigation measures can be considered, with the most suitable method chosen on a case by case basis. Any necessary work would be undertaken in a timely manner following receipt of a valid complaint, and would be funded by the wind farm operator.

Table 2.1: PtP EM Consultation Summary

Operator/Organisation	Response & Status
OFCOM	Contacted to provide a list of operators to be contacted regarding the project. BT, Airwave and the nationwide consultees JRC and Atkins were identified.
BT	Following consultation turbines have been moved to positions with no impact on operations. The submitted layout is expected to have no impact.

Airwave	Following consultation turbines have been moved to positions with no impact on operations. The submitted layout is expected to have no impact.
JRC	Responded with no objection.
Atkins	No response. Atkins are known to respond when they have operations in an area; it is thus concluded that the layout is expected to have no impact on Atkins operations.

Aviation

2.54 Wind turbines can potentially interfere with aviation operators by either physically affecting the safeguarding of an aerodrome by the close proximity of the turbines or through interference with the Air Traffic Control (ATC) radars that direct aircraft in flight. RES consulted with all relevant organisations which could be affected by the Proposed Development including the Defence Infrastructure Organisation (DIO) and Cardiff Airport.

2.55 The DIO responded in September 2018 to confirm that they had no concerns with the Proposed Development. In their response they stated that if planning permission was granted they would want to be informed of the date construction starts and ends, the maximum height of construction equipment and the latitude and longitude of every turbine.

2.56 As detailed in **Table 2.2**, pre-submission consultation was undertaken with airports located within 30 km of the Proposed Development. Cardiff Airport is just beyond 30 km from the closest turbine and there is no radar line of sight due to terrain shielding. Nevertheless, consultation was undertaken as a courtesy.

2.57 Based on public aviation procedures the turbine layout does not breach safeguarding distances.

Table 2.2: Aviation Consultation Summary

Operator/Organisation	Response & Status
Defence Infrastructure Organisation	No concerns with the proposal (September 2018).
Cardiff Airport	No issue with obstacle safeguarding.

Public Roads

2.58 165 m buffers were applied to nearby public roads in line with the best practice guidance which recommends a setback distance of at least tip height plus 10% between turbines and roads.

Public Rights of Way and Common Land

2.59 A number of public footpaths and a bridleway cross the site. Following consultation with Bridgend County Borough Council the Proposed Development includes a proposal for permanent diversions to bridleway BW64GWV and footpath FP103GWV in order to maintain a suitable distance from the wind

turbines. In addition, a temporary diversion during the construction period to footpath FP31 OGV is proposed to maintain a suitable set back distance from the borrow pits.

2.60 The Proposed Development also includes the provision of 16.81 ha of new common land to replace the common land that will be occupied by the Proposed Development infrastructure and construction area footprint.

2.61 Further information on common land and the proposed diversions to public rights of way are provided in Chapter 12: Socioeconomics, Land Use and Public Access.

Final Turbine Layout

2.62 As a result of the surveys and assessments outlined above and from feedback received during consultation, the following key changes were proposed for the final turbine layout:

- Removal of T8 due to EMI interference and landscape and visual effects;
- Reduction of tip heights of T1, T2 and T6 to 130 m due to landscape and visual effects;
- Repositioning of T3 to avoid electromagnetic links, and in response to feedback from the public exhibitions about its proximity to Blaengarw.

2.63 This resulted in the final seven turbine layout, including four turbines up to 149.9 m tip height and three turbines up to 130 m tip height. This is shown in Layout 3 on Figure 2.3: Turbine Layout Evolution and shown at a larger scale with the turbine coordinates in Figure 2.2 Turbine Layout.

2.64 Prior to the layout being finalised RES engineers undertook site visits to check that there were no remaining physical characteristics on site that may impact upon the turbine performance such as topography and the proximity and height of forestry in relation to the turbines and to agree principles for the design of the onsite infrastructure based on the constraints determined. No further revisions to the turbine layout were proposed and the turbine layout was fixed.

Infrastructure Design Evolution

Engineering considerations

2.65 Key infrastructure considerations and design alternatives in response to constraints are summarised in the following sections.

Site Entrance Location

2.66 Three alternative locations for the site entrance were considered through the design evolution. These are shown on Figure 2.4: Site Access Options Plan.

- Option 1: Existing Llynfi Afan Wind Farm entrance
- Option 2: Existing Werfa mast entrance

- Option 3: Existing field entrance.

2.2 Whilst options 1 and 2 are more substantial existing access points they were discounted due to their proximity to a scheduled monument, as detailed in Chapter 7: Cultural Heritage. Option 1 would pass close to the scheduled monument and pass directly through the unscheduled extent of the monument; Option 2 would pass directly through the scheduled monument, as illustrated on Figure 2.4: Site Access Options Plan.

2.67 Option 3 was selected as the optimum location as it is further away from the scheduled monument and has increased visibility onto the public highway. The existing access will be upgraded to provide suitable access with appropriate visibility splays, which are readily achievable in both directions. Site entrance details are discussed in Chapter 9: Traffic, Transport and Access and shown on Figure 3.9: Site Entrance.

Track

2.68 The Proposed Development track was designed in accordance with the following principles:

- Avoidance of environmental and technical constraints (as shown in Figure 2.1: Key Constraints and Infrastructure);
- Follow natural contours as far as possible, in order to avoid unnecessary amounts of excavation;
- Minimisation of the overall length of access track;
- Minimisation of the number of watercourse crossings;
- Avoidance of steep slope areas to minimise earthworks.

2.69 A key constraint in relation to the track was the avoidance of areas of deeper peat as far as possible, identified through two peat probing surveys. The vast majority of the track is located in areas of peat depth less than 0.5 m. Where this wasn't achievable a very short section passes over depths up to 0.8 m. A floated construction method will be used here in order to minimise impacts and Natural Resources Wales have been consulted on the proposed track layout.

Control Building and Substation

2.70 The buildings will be centrally located on the site which will allow ease of access from both the public road network and turbine locations. The substation is located away from the identified environmental constraints, on shallower gradient to minimise excavation, and respects existing field boundaries.

Temporary Construction Compound / Energy Storage

2.71 The temporary construction compound is required to be located close to the site entrance and turbine locations for logistical reasons. The location is away from any identified environmental constraints, on shallower gradient to minimise excavation, and respects existing field boundaries.

2.72 Following construction, a portion of the construction compound will be used to house energy storage containers on a permanent basis. The remainder of the compound will be re-instated.

Borrow pits

2.73 The Proposed Development incorporates two temporary borrow pits to make use of site-won stone and reduce the requirement for the transportation of materials to the Site. The borrow pits are located close to the site entrance, in order that maximum benefit can be gained for the construction of the site tracks. The location of the borrow pits avoids deep peat and all other identified constraints. The location of the borrow pits was also confirmed as acceptable by the noise assessment.

Final Infrastructure Layout

2.74 The final infrastructure layout in relation to the combined constraints is shown in Figure 2.1: Key Constraints & Infrastructure.

Summary

2.75 The final layout of the Proposed Development reflects the need to optimise the energy yield whilst minimising potential effects on environmental sensitivities. Wind farm design is an iterative process and the design has been influenced by potential environmental effects identified through the EIA process. The proposed layout has evolved in response to policy recommendations, environmental, technical, engineering and landscape and visual design considerations and as a result of feedback from key consultees.