Onshore wind turbines

Snapshot: Since Planning Advice Note 45 was published in 2002, the number of onshore wind farms and the scale of individual onshore wind turbines has grown substantially. Planning authorities have been preparing spatial frameworks for wind farms over 20 Megawatts (MW) capacity. Nationally there are now approximately 80 operational wind farms with turbines up to 140/150m high. Onshore wind power on December 17, 2010 had an energy generation capacity of 2550.06MW (Scottish Renewables). The latest trends indicate that feed in tariffs are driving applications for groups of wind turbines and single wind turbines below 5MW. Planning authorities are also more frequently having to consider turbines within lower-lying more populated areas, where design elements and cumulative impacts need to be managed. In a wider context, electricity grid reinforcements are supporting renewable energy potential (See National Planning Framework 2).

Suggested areas of focus for planning authorities:

- Provide greater clarity on where groups of wind turbines can be located by ensuring that a spatial framework for wind farms > 20MW has been set out in the development plan and addressing the potential below 20MW where appropriate
- Detail criteria to be applied in assessing wind turbine applications
- Establish protocol and key consultees for involvement in spatial planning, policy making, pre-application work and applications for wind turbines
- Identify proportionate levels of information to service pre-application discussions and to assess applications on wind turbines
- Secure support from local communities, wind power operators and other stakeholders on policies and procedures
- Ensure planning conditions and agreements for wind turbine approvals are reasonable and proportionate

Opportunities within Planning Processes for Planning Authorities:

Stage in Planning Process	**Actions for Wind**
Monitoring and Evidence Base and Main Issues Report	• Ensure map based records of operational and consented wind turbines in area are up to date [check out Scottish Natural Heritage (SNH) 6-monthly maps] • Using information from consultees, collate information on localised impacts of wind turbines, such as impacts on birds, communities, cumulative impacts • Consider whether existing spatial frameworks and policies are consistent with Scottish Planning Policy o Determine if they proactively respond to the Renewable Energy Action Plan and current national targets for electricity from renewable sources; o Factor in potential areas of greatest activity resulting from changes in Feed in Tariffs. • Involve key consultees for wind (including SNH, Scottish Environmental Protection Agency (SEPA),The Royal Society for the Protection of Birds (RSPB), Ministry of Defence (MOD), Civil Aviation Authority (CAA), National En Route Ltd (NERL) and National Air Traffic Services (NATS) ideally at draft Main Issues Report stage

	• For Strategic Development Plan Authorities, consider if cumulative impacts of wind turbines across planning authority areas merit inclusion as a main issue / sub-topic of a main issue.
Spatial Planning	• Assess whether existing spatial plans provide sufficient clarity to *'support the development of wind farms in locations where the technology can operate efficiently and environmental and cumulative impacts can be satisfactorily addressed (SPP)'* • If not, follow guidance for preparing wind farms of over 20MW generating capacity, • Taking into account wind farm potential at different scales locally, consider whether spatial guidance for groups of wind turbines lower than 20MW would be appropriate • Ensure that full consultations have been carried out with key consultees to secure sufficient data on matters such as designated sites, ecology, aviation and defence • If a spatial framework for onshore wind farms of over 20MW generating capacity has not been developed, provide a timeline for its preparation or a reasoned justification why it is not intended to prepare a spatial framework • Ensure that the Strategic Environmental Assessment (SEA) Environmental Report assesses the individual and cumulative significant environmental effects arising from wind energy development areas

Drafting Development Plan Policy	• Ensure that wind policies provide clear guidance for applicants and:
	  o cover design, including the number and height of turbines, location and supporting infrastructure
	  o take into account the scale and character of the landscape
	  o safeguard ecological, community, historic environment, aviation and defence interests
	  o consider cumulative impacts and decommissioning
	• Ensure that policies for all new developments consider wind (and other renewables) as energy options where impacts can be managed
	• Ensure guidance is provided on considering the cumulative effect of wind turbines
	• Consult key consultees at an early stage on the drafting of wind energy policies
	• Ensure the public are offered an 'early and effective' opportunity to engage in policy development and their environmental effects as part of the SEA process.

Development Plans Action Programmes	• Consider selecting an action officer to take forward development plan objectives for wind power. Typically this might involve setting up a wind power working group involving key consultees and landowners, producing a project plan to decide on focus and priorities, preparing local design guidance, development briefs and considering local solutions to local problems.

Securing Sufficient Information to Determine Planning Applications	• Establish if supporting guidance adequately details typical and proportionate information needs for pre-application discussions: o Determine whether visual representation information is consistent with SNH's national standard for windfarm representation. o Ensure that any supplementary information used to inform the visual representation of wind farms is necessary in order to deal with local circumstances, is proportionate and does not conflict with SNH's national standard for windfarm visualisation o For wind turbines proposed on peatland, a method for preparing carbon calculations is available . • Ensure that design statements are submitted for national and major wind turbine proposals over 20MW • Ensure that guidance highlights the potential need for seasonal bird surveys, which may significantly affect development project timetables
Pre-Application Stage	• Ensure that key consultees are given adequate opportunity to be involved in pre-application meetings / site visits • Ensure that early advice is given on whether schemes require an EIA
Determining Planning Applications	• Ensure that key consultees for wind are involved in meetings and site visits to help ensure that constraints are overcome where possible. • Technical information and guidance on typical issues associated with onshore wind turbines are provided below, which planning authorities should draw upon in determining applications and designing appropriate local solutions.

Technical information for Onshore Wind Turbines

Types of Turbines: There are commonly two types of wind turbine, vertical and horizontal axis machines. The horizontal axis, three bladed turbine is more common in Scotland.

Power of Turbines: The rated generating capacity of single onshore commercial turbines typically extends up to around 3MW, and 5MW models are under development.

Components of a Wind Turbine: The turbines usually have steel or concrete towers supporting the nacelle, which houses the mechanical machinery and a device known as "the yaw mechanism", which allows the machine to turn itself towards the prevailing wind. The majority of rotor blades are made of glass reinforced plastic or wood epoxy but can be of aluminium or steel.

Foundations: Turbine towers are fixed to a concrete foundation up to 15 metres in diameter, depending on the size of the turbine, whose surface will normally be flush with the surrounding ground. On land normally used for agricultural purposes, agricultural use can continue up to the edge of and over the foundations. With some ground conditions, such as peat, piled foundations have been used to minimise disturbance and the generation of waste material.

Separation Distances Between Turbines: The improved productivity of the current generation of wind turbines is partly as a result of advances in the micro-siting of turbines, along with higher hub heights and improved technology. Grouped turbines need to be positioned to allow a separation distance of around 3-4 rotor diameters between turbines. This is to limit energy loss through wind shadowing from upstream machines. Operators may have to balance the benefits of a compact site, which can minimise construction cost, and the gains from maximising energy capture from greater separation distances. The planning system should support the optimal arrangement where this does not lead to unacceptable visual impacts.

Control Unit: A group of wind turbines will require a central computerised monitoring system, which controls the operation of the turbines. This usually consists of an on-site building linked electronically to a headquarters and operatives off-site. The control unit is essential as turbines shut down when wind speeds are too great to avoid damage to equipment and when wind speeds are too weak to be commercially viable. For some larger sites, larger control facilities may be required to provide suitable facilities for on site operational staff.

Connection to the electricity distribution grid: Apart from turbines intended solely for private use, access to the electricity transmission and distribution system is required.

Power Lines: Power lines within the site connecting the individual turbines to the on-site substation will always be underground. Beyond that, careful consideration should be given to the relative merits of underground versus overhead lines from the substation to the electricity distribution system.

Access: Wind turbines will normally require adequate means of vehicular access, capable of taking articulated vehicles carrying machinery, both during constructional and operational phases.

Anemometers and Wind Vanes: Most sites require a slender mast with anemometers and wind vanes to provide control information for the site. This may be the same mast erected to provide pre-construction wind speed information. Masts may be free standing or require guying.

Wind Speed: The power produced by wind turbines depends on two key factors - the strength of the wind, and the area swept by the rotor. Assessing whether a particular site will harness sufficient wind power satisfactorily usually entails using historical meteorological data, with annual mean wind speed data available from the Meteorological Office, and obtaining information from anemometers on site for about 12 months. Advances in technology now allow turbines to operate efficiently at lower wind speeds than previously. The data secured also helps to identify the best positions for wind turbines within the site.

Equipment Safety: Companies supplying products and services to the wind energy industry operate to a series of international, European and British Standards. Site operators also tend to have rigorous and computer aided maintenance regimes and control rooms can detect icing of blades in which cases turbines are not operational. Danger to human or animal life from falling parts or ice is rare and appropriate lightning protection measures are incorporated in wind turbines to ensure that lightning is conducted harmlessly past the sensitive parts of the nacelle and down into the earth.

Typical Planning Considerations in Determining Planning Applications for Onshore Wind Turbines

Landscape Impact: Wind turbines can impact upon the landscape by virtue of their number, size or layout, how they impact on the skyline, their design and colour, any land form change, access tracks and ancillary components anemometers, substations and power lines. The ability of the landscape to absorb development often depends largely on features of landscape character such as landform, ridges, hills, valleys, and vegetation. This can also be influenced by careful siting and the skills of the designer. Different layouts of turbines may be more or less suited to particular landscape types and the physical form and /or colour of turbines may also be relevant. Selecting an appropriate route for access, considering landform change, surfacing and vegetation can also influence to what extent proposals are integrated into the landscape setting.

In considering wind farm visibility it should be noted that in some locations and clear weather, turbines may be visible over long distances, though this will depend on elevation, the angle of the sun and other factors. It is important to emphasise, however, that visibility and distance do not follow a linear relationship. Factors including the backcloth (or skyline) against which turbines are seen, turbine colour and typical weather conditions require careful consideration.

As more areas of search are taken up and as more sites are proposed within or near sensitive landscapes, landscape protection and designing appropriate mitigation through conditions and/or legal agreements, will become a more routine consideration alongside maximising the potential of wind energy. In relation to landscape impact, a cautious approach is necessary in relation to particular landscapes which are rare or valued, such as National Scenic Areas.

Landscape Assessment: Analysis of landscape impact normally requires the preparation of a zone of theoretical visibility map, to show where the windfarm may be seen from, a viewpoint analysis based on key viewpoints throughout the surrounding area, computer modelling and photo or video montages.

SNH is the Scottish Government national agency and statutory advisor on landscape matters. Their guidance is expected to be followed in the first instance in respect of landscape character appraisal, landscape and visual impact analysis and wind farm design. SNH and its partners have carried out a comprehensive national programme of Landscape Character Assessment which will assist in identifying landscape characteristics that are particularly sensitive to wind farm development. There is also a range of guidance available from SNH which can help in the design, visualisation and assessment of impacts within the landscape (see below).

Any supplementary information used to deliver local solutions to local problems must not conflict with national standards and must be a proportionate and reasonable burden on the applicant.

Impacts on Wildlife and Habitat, Ecosystems and Biodiversity: Wind turbine developments have the capacity to have both positive and negative effects on the wildlife, habitats, ecosystems and biodiversity of an area. For example, the effects of climate change are known to have damaging effects on wildlife, habitats, ecosystems and biodiversity, and the production of renewable energy counters this. There are also many opportunities for wind turbine developments to introduce environmental improvement through land management, land restoration and habitat creation, as part of a development scheme.

At the same time, there is also the potential for negative environmental effects, with possible loss of or damage to valuable habitat resulting from construction of turbine bases, access tracks or other works. Such impacts can be significant particularly if they relate to habitats that are difficult to replicate. There is also the potential of collision risk, displacement or disturbance by forcing birds or bats to alter flight paths. Wind farms should not adversely affect the integrity of designated sites protected under EU and UK legislation (Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Sites of Special Scientific Interest (SSSIs)) or wider conservation interests outlined in the SPP.. Negative effects can also be at a distance from the turbines if works alter the hydrology of an area or if access roads create barriers to movement of protected species. Again, there is scope for mitigation in the location of wind turbines, construction techniques, design measures and management.

Assessing Impacts on Wildlife and Habitat, Ecosystems and Biodiversity: In carrying out an assessment of impacts on wildlife and habitat, risk needs to be quantified. One such approach has been developed to calculate the impact of wind turbine developments on the soil carbon stocks held in peats. Guidance on the carbon calculator method is available. Additionally, although many bird and their habitats are largely unaffected by wind turbine developments, wind farm wild bird collision, displacement and disturbance risk needs to be quantified. Wild birds in flight would often be expected to take action to avoid obstacles but this will depend on species, numbers, and relevant seasonal / breeding patterns. Notable resources for planners are included below.

Buffer zones: Buffer zones should not be established around areas designated for their natural heritage importance and proposals should be considered on their merits.

Impact on Communities: There are a number of impacts on communities that require consideration as follows:-

- Shadow Flicker: Under certain combinations of geographical position, time of day and time of year, the sun may pass behind the rotor and cast a shadow over neighbouring properties. When the blades rotate, the shadow flicks on and off; the effect is known as "shadow flicker". It occurs only within buildings where the flicker appears through a narrow window opening. The seasonal duration of this effect can be calculated from the geometry of the machine and the latitude of the potential site.

  Where this could be a problem, developers should provide calculations to quantify the effect. In most cases however, where separation is provided between wind turbines and nearby dwellings (as a general rule 10 rotor diameters), "shadow flicker" should not be a problem. However, there is scope to vary layout / reduce the height of turbines in extreme cases.

- Noise*:* Technically, there are two quite distinct types of noise sources within a wind turbine - the mechanical noise produced by the gearbox, generator and other parts of the drive train; and the aerodynamic noise produced by the passage of the blades through the air. There has been significant reduction in the mechanical noise generated by wind turbines through improved turbine design.

  The Report, "The Assessment and Rating of Noise from Wind Farms" (Final Report, Sept 1996, DTI), (ETSU-R-97), describes a framework for the measurement of wind farm noise, which should be followed by applicants and consultees, and used by planning authorities to asses and rate noise from wind energy developments, until such time as an update is available. This gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable burdens on wind farm developers, and suggests appropriate noise conditions.

  Circular 10/1999 sets out Government policy on the role of the planning system in controlling noise and the PAN on Planning and Noise provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise.

  The most conclusive summary of the implications of low frequency wind farm noise for planning policy is given by the UK Government's statement regarding the findings of the Salford University report into Aerodynamic Modulation of Wind Turbine Noise. The report concludes that there is no evidence of health effects arising from infrasound or low frequency noise generated by wind turbines.

- Electro-magnetic Interference to Communications Systems: Wind turbines (in common with all electrical equipment) produce electro-magnetic radiation which can interfere with broadcast communications and signals. The Radiocommunications Agency (RA) register of all civil radio communications installations in the UK can identify any radio installations in the neighbourhood of a wind farm site, but will not identify their owners. Applicants should make direct contact with any authorities or bodies likely to have an interest, in particular, the local emergency services, local authority services departments, gas and electricity companies.

- Ice Throw: The build-up of ice on turbine blades is unlikely to present problems on the majority of sites. When icing occurs the turbines' own vibration sensors are likely to detect the imbalance and inhibit the operation of the machines. However, warning signage may be a useful precaution.

Separation Distances: Paragraph 190 of the SPP refers to a guideline separation distance of up to 2km between areas of search for groups of wind turbines and the edge of towns, cities and villages, to reduce visual impact. However, this 2km separation distance is a guide not a rule and decisions on individual developments should take into account specific local circumstances and geography. There is no guide distance between established and proposed groups of wind turbines. Primarily this matter is a local authority development plan issue based on the policy set out in SPP paras 187-191. Further details on separation distances can be found on the Scottish Parliament website.

Aviation Matters: UK Airspace is important for both civilian and military aviation interests. It is essential that the safety of UK aerodromes, aircraft and airspace is not adversely affected by new wind power infrastructure. As such, planning authorities should take the following into account:-

- Wind turbines can have implications for the flight paths of aircraft due to the height of turbines and anemometers. In particular, planning authorities are requested to encourage potential developers to consult relevant aviation interests regarding the siting of anemometer masts. Due to their structure, anemometer masts are particularly difficult to see in the aviation environment and can cause safety concerns as a result.

- Planning authorities are requested to supply the CAA with information about approved new wind power developments involving obstructions as soon as permission has been granted, as the CAA is responsible for recording all air navigation obstructions in the UK for air safety.

- Depending on the wind turbine and anemometers' size, shape, construction materials and location, together with the amount of electromagnetic interference, there may be implications for airport radar and communications systems. Planning authorities should consult the MOD and NERL who have a statutory duty to safeguard certain communication, navigation and surveillance (CNS) sites (including radars) from interference to signals caused by wind turbines in the interests of national security, and the continued safe operation of passenger and military aviation.

- Planning authorities receiving applications affecting the areas identified in safeguarding maps, will be required to consult the relevant aerodrome operator or, for en route technical sites, NATS. Further guidance on military aviation matters are covered below along with other defence matters.

Military Aviation and Other Defence Matters: Whilst civilian aviation is largely confined to designated corridors of controlled airspace using set approaches at airports, military aviation may be over extensive areas of the UK in airspace outside 'controlled airspace'. The approaches and flight patterns to military aerodromes are not necessarily routine and can be irregular owing to the performance characteristics of military aircraft.

A considerable amount of military flying for training purposes is conducted at low altitude - sometimes as low as 100 feet in the Tactical Training Areas (TTA). In addition, military helicopters may operate down to ground level. New energy infrastructure may cause obstructions to MOD low flying operations. Planning authorities should see Low Flying Zones.

The MOD also operates military training areas, military danger zones (offshore Danger and Exercise areas), military explosives storage areas and Tactical Training Areas (TTA). There are extensive Danger and Exercise Areas across the UK Continental Shelf Area (UKCS) for military firing and highly surveyed routes to support Government shipping that are essential for national defence. Other operational defence assets may be affected by new development, e.g. the Seismological Monitoring Station at Eskdalemuir and maritime acoustic facilities. The MOD also operates Air Defence radars and Meteorological radars which have wide coverage over the UK (onshore and offshore). It is important that new energy infrastructure does not significantly impede or compromise the safe and effective use of any defence assets.

The MOD is a statutory consultee for some of the operations/facilities mentioned above. For wind energy, MOD needs to be consulted on turbines of 11m in height (agl) and above or rotor diameter of 2m or above. Outwith the lighting of structures (150m in height and above) in accordance with the Air Navigation Order, MOD may request lighting of turbines when it deems it necessary for military aviation purposes including low flying training. A map depicting low flying consultations zones and other spatial data referred to above is available on the RESTATS website.

The MOD has committed to work with developers to identify mitigation where possible. The following websites will be of use and should be accessed:

- MOD has some useful constraints maps/data.
- A summary of Defence Estates Safeguarding interests can be found on the MOD website

Road Traffic Impacts: In siting wind turbines close to major roads, pre-application discussions are advisable with Transport Scotland's Trunk Roads Network Management (TRNM). This is particularly important for the movement of large components (abnormal load routing) during the construction period, periodic maintenance and for decommissioning. Although wind turbines erected in accordance with best engineering practice should be stable structures, it may be advisable to achieve a set back from roads and railways of at least the height of the turbine proposed, to assure safety. Driver distraction my in some circumstances, be a consideration.

Cumulative impacts: Assessing the cumulative impact of a number of wind turbines or a number of wind farms involves considering the combined effects of siting proposals in proximity to each other. In areas approaching their carrying capacity the assessment of cumulative effects is likely to become more pertinent in considering new wind turbines, either as stand alone groups or extensions to existing wind farms. In other cases, where proposals are being considered in more remote places, the thresholds of cumulative impact are likely to be lower, although there may be other planning considerations.

In assessing cumulative landscape and visual impacts, the scale and pattern of the turbines plus the tracks, power lines and ancillary development will be relevant considerations. It will also be necessary to consider the significance of the landscape and the views, proximity and inter-visibility and the sensitivity of visual receptors.

Relevant guidance on assessing cumulative impacts include "A Guide to Assessing the Cumulative Effects of Wind Energy Development" (W/14/00538/REP ETSU 2000) and SNH guidance 'Cumulative Effects of Windfarms' (April 2005).

The issue of cumulative impact on MOD operations and facilities also needs to be considered. Wind turbines cause clutter on radar displays which consequently impact on MOD operations and air safety. Proliferation of turbines will exacerbate the problem. If not managed, the cumulative impact could have extremely significant detrimental affects on MOD operations and air safety. Wind turbines can also have a cumulative effect upon the operation of facilities such as the seismological monitoring station at Eskdalemuir owing to the combined vibratory emissions of turbines in the vicinity of such installations. It should not be assumed that MOD can continue to meet its current operational requirements in cases where there is a further proliferation of turbines.

Good Practice During Construction: Planning authorities should generally encourage developers to appoint Ecological Clerks of Works to ensure that agreed designs and construction techniques are followed following planning approval.

Decommissioning: In many cases, wind turbines can be decommissioned and sites cleared and restored easily and rapidly. Turbine bases tend to be left 'in situ' to avoid damage taking place through removal. Planning authorities should ensure via conditions and/or legal agreement that site restoration takes place either on the expiry of the consent or in the event of the project ceasing to operate for a specified period. Prior to the expiry of consents, proposals may come forward to extend the life of the project by re-equipping or replacing the original turbines with new ones. While there are obvious advantages in utilising established sites, such cases will have to be determined on merit and in the light of current policy considerations.

Useful References:

Scottish Natural Heritage:
Renewables Trends in Scotland 2010
Good practice during wind farm construction (Oct 2010)
Siting and designing windfarms in the landscape (Version 1) (2009)
Visual representation of wind farms. Good Practice Guidance (February 2007)
Visual assessment of windfarms best practice (2002)
Survey methods for assessing the impacts of onshore wind farms (2005 – revised 2010)
TIN051 – Bats and onshore windfarms: interim guidance (2009)
Natural heritage assessment of small scale wind energy projects which do not require formal Environmental Impact Assessment (EIA) 2008