NOISE

A wind farm development (Yellow River Wind Farm), consisting of thirty two turbines is proposed for an area in Co. Offaly located between Rochfortbridge and Rhode. Each turbine can have a hub height up to 110m, a rotor diameter up to 113m and an overall height up to 166m.

Noise and Vibration Consultants Ltd. were commissioned were contracted by Jennings O'Donovan & Partners to undertake a Noise Impact Assessment to consider the impact of the proposed development on the surrounding area and in particular on the nearest residential properties.

Noise is unwanted or undesirable sound, it does not accumulate in the environment and is normally localised. Environmental noise is normally assessed in terms of A-weighted decibels, dB (A), when the 'A weighted' filter in the measuring device elicits a response which provides a good correlation with the human ear. The criteria for environmental noise control are of annoyance or nuisance rather than damage. In general a noise level is liable to provoke a complaint whenever its level exceeds by a certain margin the pre-existing noise level or when it attains a level. A change in noise level of 3 dB (A) is the minimum perceptible under normal circumstances while an increase in noise level of 10 dB (A) is perceived as a twofold increase in loudness. A noise level in excess of 83 dB (A) gives a significant risk of hearing damage.

Construction and industrial noise sources are normally assessed and expressed using equivalent continuous levels, L_{Aeq}[1]. L90 dBA is the background noise and is the level equalled or exceeded for 90% of the measurement interval. The table below gives a comparison of noise levels in our environment.

Comparison of noise levels in our environment

Source/Activity	**Indicative noise level dBA**
Threshold of hearing	0
Rural night-time background	20-50
Quiet bedroom	35
Wind farm at 350m	**35-45**
Busy road at 5km	35-45
Car at 65km/hr at 100m	55
Busy general office	60
Conversation	60
Truck at 50km/hr at 100m	65
Inside a typical shopping centre	70-75
Inside a modern car at around 90km/hr	75-80
Passenger cabin of jet aircraft	85
City Traffic	90
Pneumatic drill at 7m	95
Jet aircraft at 250m	105
Threshold of pain	140

Source: Fact sheet published by the Australian Greenhouse Office and the Australian Wind Energy Association

[1] L_{Aeq} is defined as being the A-weighted equivalent continuous steady sound level during the sample period and effectively represents a type of average value.

Noise Limits
The noise limits suggested by the *Wind Energy Development Guidelines* have been derived with reference to the following, and other, points:

- Existing standards and guidance relating to noise emissions
- Society's need for renewable energy sources to reduce harmful greenhouse gas emissions in pursuance of government energy policy
- The ability of manufacturers and developers to meet these noise limits
- The research of Noise Working Groups in the UK, Denmark, Holland and Germany.

The following are a number of key extracts from the *Wind Energy Development Guidelines* in relation to noise impact:

General Noise Impact
"*Noise impact should be assessed by reference to the nature and character of noise sensitive locations*."

"*Separate noise limits should apply for day-time and for night-time*"

"Noise limits should be applied to external locations, and should reflect the variation in both turbine source noise and background noise with wind speed."

"In general, noise is unlikely to be a significant problem where the distance from the nearest turbine to any noise sensitive property is more than 500metres."

Measurement Units
"*The descriptor [$L_{A90\ 10min}$] which allows reliable measurements to be made without corruption from relatively loud transitory noise events from other sources, should be used for assessing both wind energy development noise and background noise."* The relationship between Leq and L90 for wind farms is generally given as L90 = Leq -2dBA.

Specific Noise Limits
"Noise limits should be applied to external locations, and should reflect the variation in both turbine source noise and background noise with wind speed."
"In general, a lower fixed limit of 45dB(A) or a maximum increase of 5dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours. However in very quiet areas, the use of the margin of 5dB(A) above the background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments. Instead in low noise environments where background noise is less than 30 dB(A), it is recommended that the day time level of $L_{A90,10min}$ of the wind energy development noise should be limited to a level within the range 35-40dB(A)".
"Separate noise limits should apply for day-time and for night-time. During the night the protection of external amenity becomes less important and the emphasis should be on preventing sleep disturbance. A fixed limit of 43dB (A) $L_{A90,10min}$ is deemed to protect sleep inside properties during the night"

The proposed noised limits for this development are:

- A fixed lower limit of 45dB (A) $L_{A90,10min}$ or 5dBA above background, whichever is the greater, at all residents.
- A fixed lower limit for night-time 43dB (A) $L_{A90,10min}$ or 5dBA above background, whichever is the greater.

(The derived background noise levels were above 30dBA at all monitoring locations during day time).

Existing Environment
The locations of noise sensitive location within were identified through map searches, visits to the site. In order to represent the prevailing background noise in the area continuous noise monitoring was set up at 10 locations for an extended period from 12th to 30th May 2013.

The land in the proposal area is a flat rural farming landscape. The local environment is predominately controlled by wind influence on vegetation, agricultural activity and road traffic on the local road network. The higher background levels were recorded from monitoring locations which were closer to the higher traffic flow roads (Regional roads) and Motorway. Background noise levels from a motorway at up to 5km can be increased by anything up to 7dBA depending on wind direction and traffic flow.

The prevailing background noise level has been calculated based on the methodology contained in the UK document ETSU-R-97 and referenced in the Guidelines for Planning Authorities issued by the Department of Environment, Heritage and Local Government.

NOISE IMPACT

Characteristic of Proposal

There are two quite distinct types of noise sources within a 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 rotor blades through the air. Over the last number of years there has been a significant reduction in the mechanical noise generated by wind turbines, and it is now generally less than the aerodynamic noise.

Aerodynamic noise is a low level noise generated as a result of the turbine rotor blades moving through the air. Turbine noise is generally classed as broadband in nature, not unlike wind blowing through vegetation but modulated with a regular swishing sound. With distance from a turbine this blade swish normally decreases as the sound decays into the background. Because of the low level of noise generated from a turbine it is very difficult to measure at distance as the sound generated masks into the background noise. In very low wind speeds turbines do not operate. As the wind speed increases so too does the sound generated by the turbine along with the sound generated by the action of wind on vegetation and objects.

With continuing improvements in design, lower rotational speeds produce higher rated outputs. Low rotational speeds reduce the probability of any audible tonal or impulsive components.
The audibility of noise from wind turbines will generally be greatest at lower wind speeds, less than 6 m/s. At receptor ground level and at average wind speeds of around 7-8 m/s and above, it generally becomes quite an abstruse issue to discuss sound emissions from modern wind turbines since background noise (wind on vegetation / objects) will generally mask any turbine noise.

The proposal for the site is for 32 no. wind turbines. The final turbine selection for the site will be made during the design and procurement phase. The candidate turbine used in this assessment is a Siemens SWT-3.0-113, however, there are other turbines in the market place (Enercon E82 E3 and

Vestas V112-3) which have hub heights up to 110m and can operate within the same sound power level of emission.

Assessment Methodology
The assessment was carried out according to the guidance given in ETSU-R-97 taking into account The Wind Energy Development Guidelines, *'Guidelines for Planning Authorities',* June, 2006 and recommendations in '*The Prediction and Assessment of Wind Turbine Noise'*, published in the Institute of Acoustics *'Acoustics Bulletin.*' and '*A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise,'* May 2013.

Predicted Wind Turbine Noise

There are numerous models for predicting noise from a point source and some of these models are specifically used for the prediction of noise from wind farms. In this instance a version of WindFarm by Resoft wind energy development software package was used to determine the noise levels at the prediction locations. Noise predictions have been carried out using International Standard ISO 9613, Acoustics – Attenuation of Sound during Propagation Outdoors. The propagation model described in Part 2 of this standard provides for the prediction of sound pressure levels based on either short term down wind (ie. worst-case) conditions or long term overall averages. Only the worst-case down wind condition has been considered in this assessment; that is for wind blowing from each turbine directly to each house.

The following conservatism has been employed in the propagation modelling;

- down-wind propagation is modelled in all directions so predicted values are over-estimated, upwind and cross wind. In practice dwellings cannot be down-wind of all turbines simultaneously.
- although in reality the ground is predominately porous it has been modelled as mixed corresponding to a ground absorption coefficient of 0.5
- trees and other topography features have not been considered
- all dwellings were modelled at a receptor height of 4m. Using a 4m receptor height results in a more conservative result than using a 1.5 receptor height with the difference being more than 1dBA.
- the effects of wind shear has been taken into account in deriving the background noise levels with respect to wind speed

Cumulative Impacts
There are no permitted wind farms within 2km of this proposal

Assessment of Noise Levels
The predicted noise levels in shows that the predicted noise levels at all wind speeds are within the day time lower limit of 45dBA and night-time lower limit of 43 dBA at all receptors. The predicted noise level at H138 assumes down wind conditions simultaneously from turbines to the north-west and south-east, a condition that cannot occur in practice. The noise levels at H138 (and all of the nearby houses) will have noise levels more than 1dBA below that predicted in the model.

The modelled prediction is a worst case scenario with the prediction assuming that the wind will be downwind from all turbines at the same time which is an occurrence that cannot happen in practice.

Aerodynamic Modulation

Aerodynamic modulation (AM) is a highly complex field, and whilst general principles are understood there are still unanswered questions. AM is defined as aerodynamic noise which displays a greater degree of fluctuation than usual, which can occur in some circumstances much more than normal blade swish. A study carried out by the University of Salford in 2007 into operating wind farms found that the incidence of wind farm noise and AM in the UK is low and AM was considered to be a factor in 4 of the 133 operating sites.

The recent; *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* published in May 2013 by the Institute of Acoustics gave no guidelines with respect to AM

Assessment of Construction Noise

It is not possible to specify the precise noise levels emissions from the construction equipment until such time as a contractor is chosen and construction plant has been selected however,

The construction activity at 500m from the operating point with attenuation by distance, ground absorption and air attenuation is 34 dB(A)] for distance and 4 dB(A) ground absorption and air attenuation) will result in typical noise levels of between 35 and 48 dB L_{Aeq} with maximum levels of 52 dB L_{Aeq} during intensive activity. The maximum levels will pertain for no longer than two weeks-equivalent at any residence. The main construction activity will be the construction of the wind turbine bases. The nearest turbine to any resident is more than 500 metres away.

Mitigation Measures for Construction Noise

All construction will be carried out in accordance with BS 5228-1: 2009 *Code of Practice for Noise and Vibration Control on Construction and Open Sites.* Accordingly all construction traffic to be used on site should have effective well-maintained silencers. Operators of all mobile equipment will be instructed to avoid unnecessary revving of machinery. Where possible the contractor will be instructed to use the least noisy equipment. With efficient use of well-maintained mobile equipment considerably lower noise levels than those predicted can be attained. The Project Engineer will closely supervise all construction activity. Construction activity due to its nature is a temporary activity and thus any impacts will be short term. All construction works will be carried out during the day-time period. Construction plant will be throttled down or turned off when not in productive use.

Low Frequency Noise and Vibration

The frequency range of audible sound is in the range of 20 to 20,000Hz and low frequency sound / noise is generally from about 2 to 200Hz. Low frequency sound is considerable audible at high amplitudes above 20Hz. Infrasound is sound that is generally inaudible to the human ear, at less than20Hz, however it may still interact with the body or structures and may be felt as vibrations (examples could be blasting or a window vibrating when a large truck passing nearby at low speed).

Researchers such as Leventhall have studied low frequency noise and found that levels were found to be below the hearing threshold of most people, and the research concluded noise from the proposed wind farm installation in the low frequency (10 to 200Hz) range was unlikely to be a problem. However, significant research has also been carried out into low frequency noise in the area of blasting vibrations (air overpressure) which falls into the same frequency range, although with considerably higher magnitude. There appears to be little or no agreement about the biological effects of low frequency noise on human health and there is evidence to suggest that no serious consequences result to human health, from infrasound exposure from wind turbines.

There is always low frequency noise present in an ambient quiet background. It is generated by natural sources such as wind effects on vegetation, surf, water flow in streams and rivers and there are also emissions from many sources found in modern life, such as household appliances (e.g. washing machines, refrigerators, fans etc.). It can also be found in water flowing through pipes within your home and in water flow from municipal water supply. Vibration of structures can also be found in local activity in ones home by way of normal routine activity like climbing stairs, closing doors, walking on floors, etc.

A study of low frequency noise (infrasound) and vibration around a modern wind farm was carried out for ETSU and reported in ETSU W/13/00392/REP – '*Low Frequency Noise and Vibration Measurements at a Modern Wind Farm'*. The results showed levels of infrasound to be below accepted thresholds of perception even on the wind farm site. A recent study by the EPA in South Australia on low frequency noise near wind farms and in other environments found that 'Overall, the study demonstrates that low frequency noise levels near the wind farms in the study are no greater than levels in urban areas at comparable rural residences away from wind farms'. A paper presented at the 159th meeting of the Acoustical Society of America outlined the results of sound measurements from Siemens SWT-2.3 MW -93 turbines and concluded 'that at more than1000ft (305m) the turbine model does not pose a low frequency noise or infrasound problem as it meets standards published by the American National Standards Institute (ANSI) for indoor levels for low frequency sound for bedrooms, classrooms and hospitals'.

Mitigation Measures

When the wind farm is commissioned noise monitoring of the operation over a range of wind speeds and direction can be used to demonstrate compliance with the noise limits. The wind turbines have noise control systems in place whereby the noise emission of a turbine can be reduced by a number of means e.g. by wind direction, by time of day, by reducing power outputs. Noise impacts from the construction and operation of the proposed development will not be significant.

Conclusion

An assessment of the likely noise impact of the proposed wind farm development has been carried out. Baseline noise levels measured at ten locations representative of the nearest residential properties to the proposed thirty two turbines, and noise levels were predicted based on a maximum hub height of 110m. The predicted noise levels are within the adopted 45dBA lower noise limit for day time and 43 lower limit for night-time and accordingly within the Wind Energy Development Guidelines, *Guidelines for Planning Authorities*, June 2006. The noise emissions from the wind farm is continuous in the main, however the emissions depends on wind speed. In very calm to low wind speed (,3m/s), the turbines will not operate resulting in zero emissions.

The modelled prediction is a worst case scenario with the prediction assuming that the wind will be downwind from all turbines at the same time which is an occurrence that cannot happen in practice. Furthermore the houses along the road north-west of T23 and T24 and south-east of T20, T23 and T22 will have noise levels of more than 1dBA below the predicted levels as the wind cannot be blowing simultaneously in opposite directions at the same time.

The low frequency noise and vibration from the turbines of the proposed Yellow River Wind Farm is predicted to have a negligible impact on all residences in the locality.

Any impacts associated with the construction of the Yellow River Wind Farm will be of a temporary nature, associated with the site preparation works and erection of the wind turbines.