



**WRITTEN SCHEME RELATING TO
CONDITION 21 DEN BROOK WIND FARM
IMPLEMENTATION OF CONDITION 20
FOR THE IDENTIFICATION OF
GREATER THAN EXPECTED
AMPLITUDE MODULATION**

5 FEBRUARY 2014

Appeal Decision No: **APP/Q1153/A/06/20
17162/AD2**

Date of Approval: **11th December 2009**

Site of Proposed Development: **Land to the South East of North Tawton**

Description of Proposal: **Nine 3-bladed horizontal axis wind turbines, electricity transformers, access tracks, crane hard standings, control building, sub-station, met mast, temporary construction compound and met masts**

Applicant: **RES Developments Ltd**
Applicant Address: **Beaufort Court
Egg Farm Lane
Kings Langley
Herts
WD4 8LR**

INTRODUCTION

This written Scheme has been prepared by RES Developments Limited to satisfy Condition 21 of the planning permission granted on the 11 December 2009 for a wind farm known as 'Den Brook' located on farm land to the south-east of North Tawton.

As specified in Condition 21, the objective of this Scheme (which shall be implemented as approved) is to evaluate compliance with Condition 20 over a range of wind speeds and directions.

DEFINITIONS

Amplitude Modulation	(AM) means the modulation of the level of broadband noise emitted by a wind turbine at blade passing frequency, fc ¹⁶
Greater Than Expected AM (GTE-AM)	means amplitude modulation as defined in Condition 20 imposed on the Planning Permission – see Appendix 1
the Development	means the Den Brook Wind Farm located to the South East of North Tawton for which the Planning Permission has been granted
the Operator	means RES Developments Limited or any successor operator in title for the life of the Development
the LPA	means the Local Planning Authority, West Devon Borough Council, or any successor authority in title
the Planning Permission	means the planning permission granted on appeal for the Development on 11 December 2009 (Appeal Decision: APP/Q1153/A/06/2017162/AD2)
the Approved Consultant	an approved consultant employed by the Operator and tasked with implementing the requirements of this Scheme
the Assessment Period	the period of time during which the pre-requisites for investigation of an AM complaint are active
the Monitoring Period	the period of time during which measurements are made to determine whether GTE-AM is present

¹⁶ Where fc is in hertz. For most modern wind turbines, fc is typically ~ 1 Hz.

Date of First Electricity Generation	the date that all the wind turbines, of which the Development comprises, first generate electricity to the grid
the Scheme	the Scheme required under Condition 21 of the Planning Permission, i.e. this Scheme.

THE SCHEME

The Scheme follows six stages, as follows:

- STAGE 1** Appointment of Approved Consultant
- STAGE 2** Residents Noise Diary, Recordings and Consultant's Initial Opinion
- STAGE 3** Site Monitoring
- STAGE 4** Assessment
- STAGE 5** Mitigation
- STAGE 6** Compliance Verification

The Operator shall implement the Scheme set out below.

STAGE 1

Prior to the Date of First Electricity Generation, the Operator shall submit the name, qualification and experience of an Approved Consultant to the LPA for its approval in writing. Following approval, which shall occur within 7 days from submission, the Operator shall, at the Operator's expense, appoint, within 7 days of the approval by the LPA, the Approved Consultant to implement Stages 2 – 6 of this Scheme.

Where possible, the same Approved Consultant shall be appointed as that person appointed to implement the Scheme agreed under Condition 19 of the planning permission.

STAGE 2

Two alternative approaches are possible to fulfil the requirements of Stage 2.

Alternative 1

Where the LPA suspect that GTE-AM is present in the noise immissions at the complainant's property so as to be, at least in part, a contributor to a noise complaint, the following pre-requisite for investigation of the complaint must first be fulfilled:

- a) the Approved Consultant shall request the complainant to keep a noise log indicating those times at which possible GTE-AM is deemed by them to be unreasonably intrusive, in accordance with the LPA's general practice. The noise

log shall be maintained until at least 5 separate incidences of possible GTE-AM have been recorded. Separate occurrences recorded in any one 24 hour period shall be counted as a single incidence. The noise log shall also set out the location(s) (internal or external to the property) where the possible GTE-AM most affects the complainant(s).

If the complainant refuses or fails to keep or maintain a noise log then no further action shall be required of the Operator under this Scheme in relation to the complaint.

- b) If the noise log provided for under step a) fails to identify 5 incidences of possible GTE-AM then the existence of GTE-AM as a significant contributor to the noise complaint shall be excluded and no further action is necessary. This should be confirmed in writing by the Approved Consultant to the LPA.
- c) If the noise log provided for under step a) identifies at least 5 separate incidences of possible GTE-AM then the Approved Consultant shall proceed to Stage 3, Alternative 1.

Alternative 2

Where long-term, continuous recordings have been made at a property in the vicinity of the wind farm and suggest the presence of GTE-AM, the following pre-requisites must be fulfilled:

- a) the long-term, continuous recordings shall have been made by a suitably qualified person as defined in Stage 1 above
- b) the long-term, continuous recordings shall have been made with a measurement system of EN 60651/BS EN 60804 Type 1, or BS EN 61672 Class 1 quality, or the equivalent UK adopted standard in force at the time of the measurements, with the audio recording facility having a minimum 16 bit resolution and 48 kHz sample rate recording audio files in uncompressed format, in an external amenity area of the complainant's property consistent with the requirements of Condition 20, (not further than 35m from the relevant building, and not closer than within 3.5 m of any reflective building or surface, or within 1.2 m of the ground)
- c) rainfall shall be assessed by use of a rain gauge that shall log the occurrence of rainfall and be situated in the general vicinity of the sound level meter.
- d) the occupants of the property must have made a formal complaint to the LPA about the noise immissions at their property and have indicated that, at least in part, they consider GTE-AM to be a contributor to the disturbance
- e) there must be a proven history of complaint at the property. This requirement may be satisfied if the occupants of the property keep a noise log indicating those times at which possible GTE-AM is deemed by them to be unreasonably intrusive, in accordance with the LPA's general practice. The noise log shall comprise at least 5 separate incidences of possible GTE-AM, where separate occurrences recorded in

any one 24 hour period shall be counted as a single incidence. The noise log shall also set out the location(s) (internal or external to the property) where the GTE-AM most affects the complainant(s).

- f) If:
- i. the complainant fails to provide a noise log, or
 - ii. the noise log provided for under step d) fails to identify 5 incidences of possible GTE-AM, or
 - iii. the 5 incidences of possible GTE-AM within the noise log do not broadly coincide with the periods of recordings indicating the possible presence of GTE-AM

then the existence of GTE-AM as a significant contributor to the noise complaint shall be excluded and no further action shall be required of the Operator under this Scheme in relation to the complaint. This should be confirmed in writing by the LPA.

- g) If:
- i. the noise log provided for under step d) identifies at least 5 incidences of possible GTE-AM; and
 - ii. the 5 incidences of possible GTE-AM within the noise log broadly coincide with the periods of recordings indicating the possible presence of GTE-AM made by the equipment provided under step b)

then the Approved Consultant shall proceed to Stage 3, Alternative 2.

STAGE 3

Depending on the approach taken in Stage 2, one of the following alternatives must be pursued:

Alternative 1

If GTE-AM is potentially present the Operator must arrange for the Approved Consultant to measure noise from the Development at the complaint's property against the criteria set out in Condition 20. The Approved Consultant shall install an audio recording system comprising a measurement system of EN 60651/BS EN 60804 Type 1, or BS EN 61672 Class 1 quality, or the equivalent UK adopted standard in force at the time of the measurements, with the audio recording facility having a minimum 16 bit resolution and 48 kHz sample rate recording audio files in uncompressed format, in an external amenity area of the complainant's property consistent with the requirements of Condition 20, (not further than 35m from the relevant building, and not closer than within 3.5 m of any reflective building or surface, or within 1.2 m of the ground) within 14 days of the notification as under Stage 3 of this Scheme, unless otherwise agreed with the LPA.

The said equipment shall remain on site and functioning during the Monitoring Period. This Monitoring Period should include weather conditions which closely replicate those pertaining during the noise log of GTE-AM in Stage 2. Wind speed, wind direction and power generation data for each wind turbine shall be continuously logged and provided to the Approved Consultant within 14 days of a request. 'Closely replicate' shall be interpreted as weather conditions which the LPA accept are as similar as possible to those pertaining during the noise log.

If at least 4 valid 60 min periods fail to be identified within 1 month of the deployment of the noise measuring equipment this instance of implementation of the scheme shall be postponed until such time as more closely replicated weather conditions are likely to be experienced.

Valid data periods are those that remain after all periods during rainfall or additional atypical data as identified by the Approved Consultant have been excluded. Rainfall shall be assessed by use of a rain gauge that shall log the occurrence of rainfall and be situated in the general vicinity of the sound level meter.

Alternative 2

If GTE-AM is potentially present the Approved Consultant shall obtain noise data from the Development at the complaint's property using the long-term, continuous equipment referred to in Stage 2, Alternative 2. At least 4 valid 60 min periods are required and are regarded as the Monitoring Period.

Valid data periods are those that remain after all periods during rainfall or additional atypical data as identified by the Approved Consultant have been excluded.

STAGE 4

The Approved Consultant shall determine if GTE-AM is present in the data collected during the Monitoring Period using the methodology set out below and provide the results of this analysis to the LPA within 14 days from the end of the Monitoring Period.

The determination shall proceed as follows:

- a) for each hour of the 4 or more such periods of audio data collected in Stage 3, a time series of 60 items of LAeq,1min data shall be obtained, either by means of software or directly from a sound level meter
 - i. for each 1 min period, the LAeq,1min noise level shall be determined. If the LAeq,1min noise level is < 28 dB(A) then that particular 1 min period requires no further analysis
 - ii. for those periods where the LAeq,1min noise levels are ≥ 28 dB(A), each period shall be split into 6, consecutive 10 sec periods of audio data
 - iii. for each 10 sec period:

- 1) the LAeq,100msec turbine noise levels shall be determined, either by means of software or directly from a sound level meter, resulting in a time series of 100 values
- 2) the time series shall be de-trended by subtracting the mean value
- 3) a single-sided power spectral density function, using a Rectangular window, shall be calculated using the de-trended data. A frequency resolution, Δf , of 5/128 Hz shall be used, and the modulation spectrum shall comprise 128 lines, with a maximum frequency of 5 Hz
- 4) wind farm SCADA for that period shall be obtained and used to verify that variation present in the modulation spectrum, at f_c , is consistent with the rotational speeds of the turbines. If this is not the case then that particular 10 sec period requires no further analysis
- 5) the energy in the band from $0.9f_c$ to $1.1f_c$, centred on f_c , shall be calculated, E_c
- 6) the objective measure of the level of AM is then derived as A , where:

$$A = 2 \cdot \sqrt{2 \cdot \Delta f \cdot E_c}$$
- 7) if the value of A is less than the threshold value, 4 dB, then no further analysis is required
- 8) if the value of A is greater than or equal to the threshold value, 4 dB, then the Approved Consultant shall listen to the 10 sec of audio noise data and judge whether the AM derives from the wind farm and not another noise source at the blade passing frequency of the wind turbine (f_c) or any other frequency. Some external sources of noise, for example crows and other birds, bird scarers, pile driving operations etc. can have a noise signature which 'looks' like amplitude modulation, but does not in fact derive from wind turbines. If, in his judgement, the AM may not derive from the wind farm then that particular 10 sec period requires no further analysis
- 9) if the value of A is greater than or equal to the threshold value, 4 dB, and the Approved Consultant judges that the AM derives from the wind farm then:

iv. if at least 6 separate 10 sec periods fulfil condition iii. 8) then:

- b) the entire hour of audio data for that period shall be assessed using the methodology defined in Condition 20

- c) if this assessment indicates that GTE-AM is present, then the LAeq,125msec data required by Condition 20 shall be band pass filtered, from $0.9f_c$ to $1.1f_c$, and the application of the Condition 20 methodology repeated. This is essential to ensure that the variation causing apparent non-compliance with Condition 20 derives solely from that occurring at the blade passing frequency, f_c
- d) if this assessment indicates that GTE-AM is present proceed to Stage 5.

STAGE 5

If GTE-AM is not found to exist when assessed in accordance with Stage 4 then the operation of the Development shall be regarded as complying with Condition 20. Once satisfied with such an assessment as provided by the Approved Consultant, the LPA shall indicate in writing to the Operator and the complainant that this instance of implementation of the scheme has been satisfactorily completed and no further action is necessary.

If GTE-AM is found to exist and require mitigation then the LPA shall provide notification in writing to the Operator and the complainant. Unless otherwise agreed with the LPA, the Operator shall thereafter propose within 28 days of notification a mitigation scheme which shall be designed to prevent the generation of GTE-AM in the conditions identified in Stage 2. Once approved by the LPA, the mitigation scheme, which may or may not require turbines to be disabled, shall be implemented within 28 days, unless otherwise agreed with the LPA.

STAGE 6

Once mitigation is implemented, the Operator is required to verify that the noise immission from the wind farm complies with the requirements of Condition 20, as follows:

- a) Within 7 days of the mitigation scheme being implemented, the Approved Consultant shall install long-term, continuous recording equipment at the complainant's property
- b) long-term, continuous recordings shall have been made with a measurement system of EN 60651/BS EN 60804 Type 1, or BS EN 61672 Class 1 quality, or the equivalent UK adopted standard in force at the time of the measurements, with the audio recording facility having a minimum 16 bit resolution and 48 kHz sample rate recording audio files in uncompressed format, at the same location used in Stage 2 Alternative 2 or Stage 3 Alternative 1
- c) rainfall shall be assessed by use of a rain gauge that shall log the occurrence of rainfall and be situated at the same location used in Stage 2, Alternative 2 or Stage 3, Alternative 1
- d) the Approved Consultant shall request the complainant to keep a noise log indicating those times at which possible GTE-AM is deemed by them to be unreasonably intrusive, in accordance with the LPA's general practice. This noise

log may assist the Approved Consultant in determining whether the mitigation scheme has been effective

- e) the said equipment shall remain on site and functioning during the Monitoring Period. This Monitoring Period should include weather conditions which closely replicate those pertaining during the measurement of GTE-AM in Stage 2. Wind speed, wind direction and power generation data for each wind turbine shall be continuously logged and provided to the Approved Consultant within 14 days of a request. 'Closely replicate' shall be interpreted as weather conditions which the LPA accept are as similar as possible to those pertaining at the time/period of complaint.
- f) If at least 4 valid 60 min periods fail to be identified within 1 month of the deployment of the noise measuring equipment this instance of implementation of the scheme shall be postponed until such time as more closely replicated weather conditions are likely to be experienced.
- g) valid data periods are those that remain after all periods during rainfall or additional atypical data as identified by the Approved Consultant have been excluded. Rainfall shall be assessed by use of a rain gauge that shall log the occurrence of rainfall and be situated in the general vicinity of the sound level meter.
- h) the Approved Consultant shall determine if GTE-AM is present in the data collected during the Monitoring Period using the methodology set out in Stage 4 and provide the results of this analysis to the LPA within 14 days from the end of the Monitoring Period.
- i) If GTE-AM is not found to exist then the mitigation scheme shall be regarded as effective and the wind farm as complying with Condition 20. Once satisfied with such an assessment as provided by the Approved Consultant, the LPA shall indicate in writing to the Operator and the complainant that this instance of implementation of the scheme has been satisfactorily completed and no further action is necessary.
- j) If GTE-AM is still found to exist and require further mitigation then the LPA shall provide notification in writing to the Operator and the complainant. Unless otherwise agreed with the LPA, the Operator shall thereafter propose within 28 days of notification a revised mitigation scheme which shall be designed to prevent the generation of GTE-AM in the conditions identified in Stage 2. Once approved by the LPA, the mitigation scheme, which may or may not require turbines to be disabled, shall be implemented within 28 days, unless otherwise agreed with the LPA.
- k) Stage 6 is then repeated.

Appendix 1: Conditions 20 & 21 of the Planning Permission

CONDITION 20

At the request of the local planning authority following receipt of a complaint the wind farm operator shall, at its expense, employ a consultant approved by the local planning authority, to assess whether noise immissions at the complainant's dwelling are characterised by greater than expected amplitude modulation. Amplitude modulation is the modulation of the level of broadband noise emitted by a turbine at blade passing frequency. These will be deemed greater than expected if the following characteristics apply:

- (a) A change in the measured LAeq, 125 milliseconds turbine noise level of more than 3 dB represented as a rise and fall in sound energy levels each of more than 3 dB) occurring within a 2 second period.
- (b) The change identified in (a) above shall not occur less than 5 times in any one minute Period providing the LAeq, 1 minute turbine sound energy level for that minute is not below 28 dB.
- (c) The changes identified in (a) and (b) above shall not occur for fewer than 6 minutes in any hour.

Noise immissions at the complainant's dwelling shall be measured not further than 35 m from the relevant building, and not closer than within 3.5 m of any reflective building or surface, or within 1.2 m of the ground.

CONDITION 21

No wind turbine shall generate electricity to the grid until the local planning authority, as advised by a consultant approved by the local planning authority at the expense of the operator, has approved in writing a scheme submitted by the wind farm operator providing for the measurement of greater than expected amplitude modulation immissions generated by the wind turbines. The objective of the scheme (which shall be implemented as approved) shall be to evaluate compliance with condition 20 in a range of wind speeds and directions and it shall terminate when compliance with condition 20 has been demonstrated to the satisfaction of and agreed in writing by the local planning authority.