



A NEW METHODOLOGY FOR INVESTIGATING ILFN COMPLAINTS

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General Approach

Environmental Noise

- at residential receptor $L_{Aeq, 15 \text{ min}} \leq$
Rating Background Level + 5 dB(A)
- If noise contains tonal, impulsive or low frequency characteristics (or is intermittent at night) then add 5 dB for audible characteristics.
- Rating Background Level is the median of 5 – 7 individual day results of the lowest 10 percentile of all $L_{A90, 15 \text{ min}}$ results for the day (7am – 6pm), evening (6pm – 10pm) and night (10pm to 7am the next day).

General Approach

Licensed Premises:

- LA10 contribution (in octave bands 31.5 Hz – 8 kHz inclusive) not to exceed LA90 Background + 5 dB between 7am – midnight at any affected residential boundary
- LA10 contribution (in octave bands 31.5 Hz – 8 kHz inclusive) not to exceed LA90 Background + 5 dB between midnight and 7am at any affected residential boundary
- Noise to be inaudible inside any habitable room of any residence between midnight and 7am

New Methodology

(well not that new really)

- Questions as to disturbance, times, how long, how often, effects
- Undertake preliminary investigations
 - Full spectrum recordings
 - Resident Diaries
 - Plant Operations
 - Bio-metric monitoring
- Combine results of preliminary investigations and look for PATTERNS – try different parameters and analyses
- Develop hypothesis and re test
- Other disciplines?
- Develop noise control solutions

Cape Bridgewater Wind Farm Study

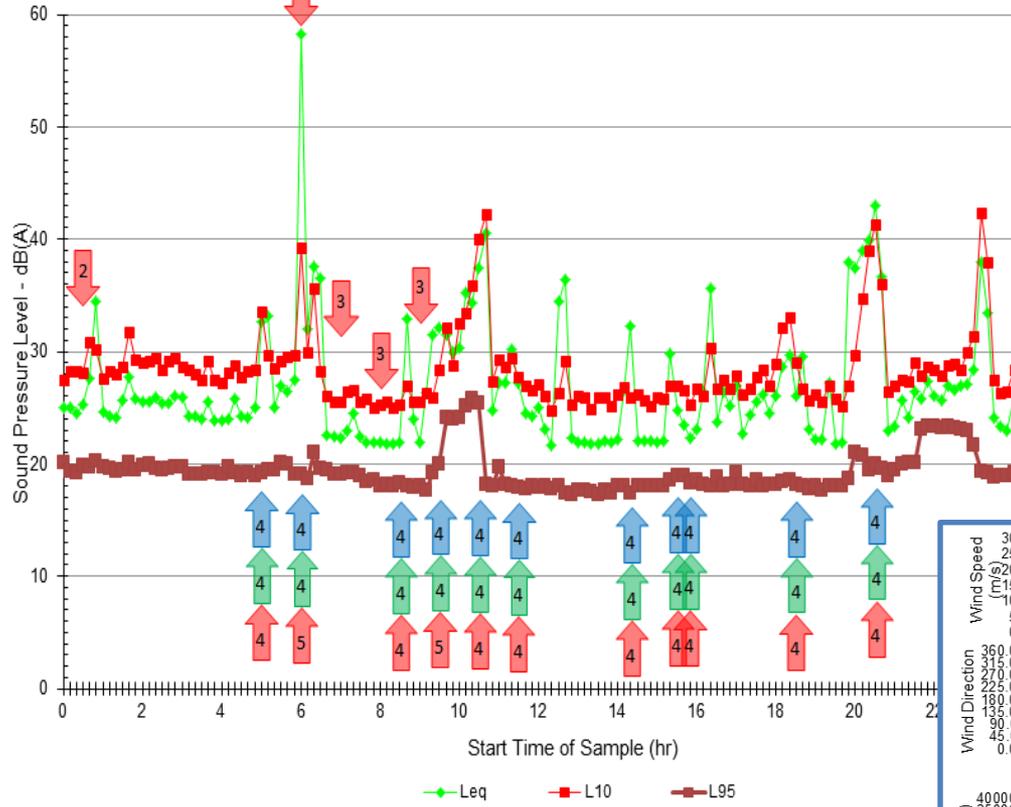
Specific brief by the wind farm operator to:

Undertake sound and vibration measurements to ascertain certain wind speeds and certain sound levels that related to disturbances reported by specific local residents.

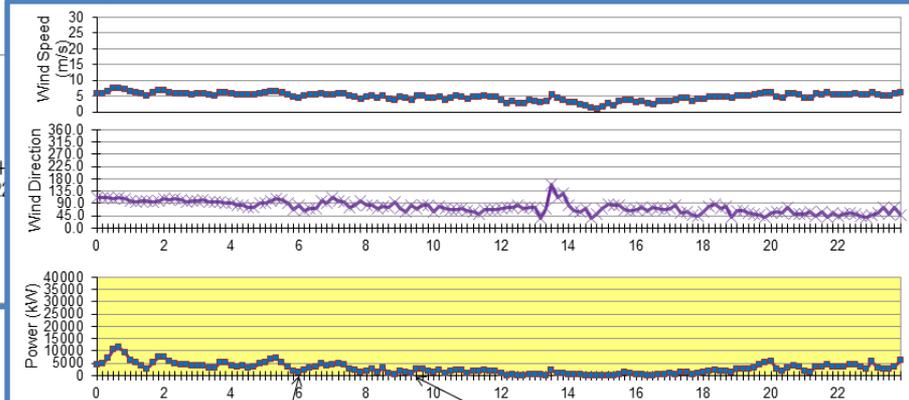
The specific local residents were six people who had been identified as complaining to be adversely affected by the operation of the wind farm for a number of years.

Ambient Measurements

Sunday, 8 June 2014

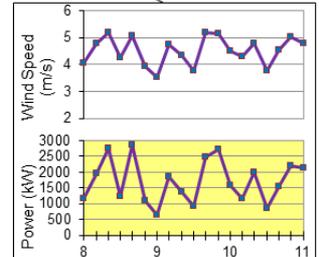
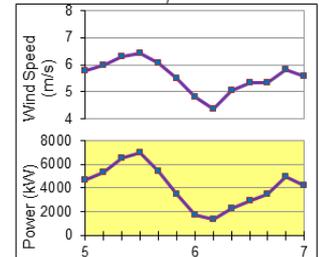


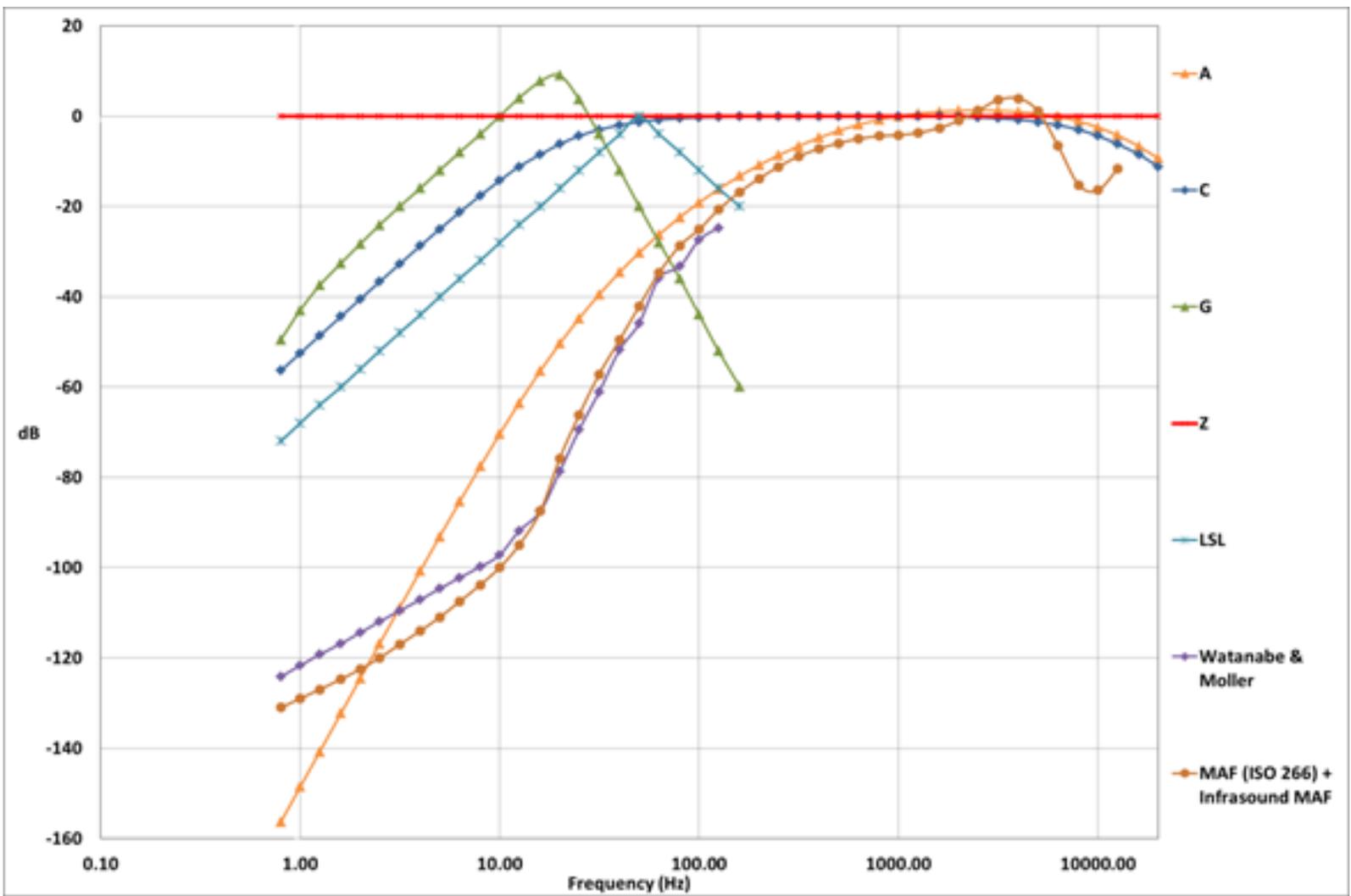
Cape Bridgewater



Cape Bridgewater
SVAN 979 27164

House 88 Inside





dB(A), dB(C) dB (Z/Lin) all full range

dB(A), dB(C), dB (Z/Lin) LF covering 10 Hz – 160 Hz

dB(A), dB(C), dB(Z/Lin) LF (ext) covering 0.8 Hz – 160 Hz

dB(Z) dB(Z) Infra covering 0.8 Hz – 5 Hz

dB(G)

LSL (Kelley curve)

0.8Hz, 2.5Hz and 4 Hz individual 1/3 octave band

Leq (A) – L95 dB(A)

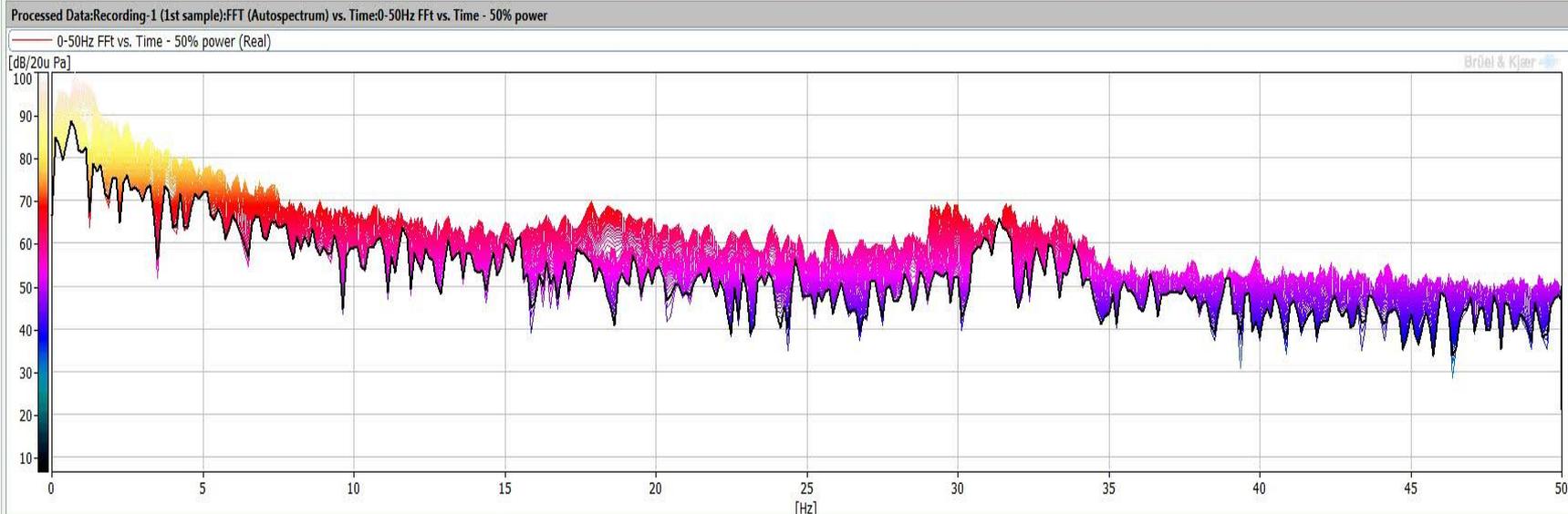
Leq (C) – Leq (A)

Watanabe & Moller (extrapolated to 0.8Hz)

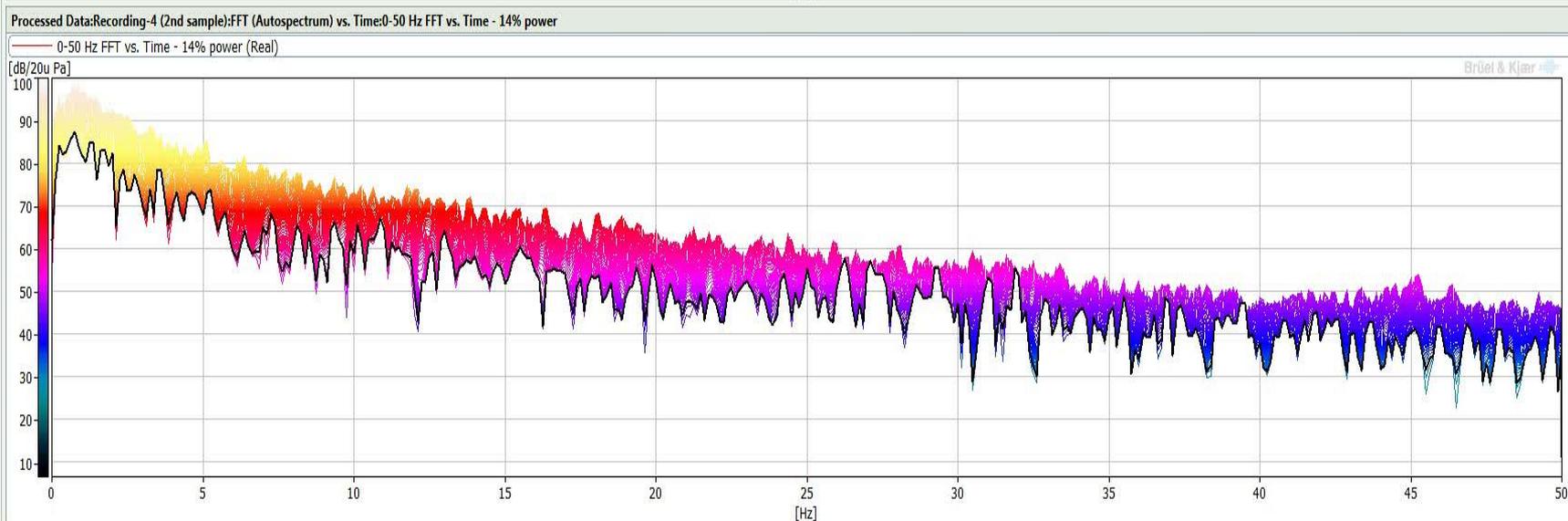
Minimum Audible Field (ISO 266 for audible range) + proposed Infrasound MAF

Minimum Audible Field (ISO 266 for audible range)

Proposed Infrasound MAF



Cursor values
X: 50.000 Hz
Y: 46.765 dB/20u Pa
Z: 8.400 s

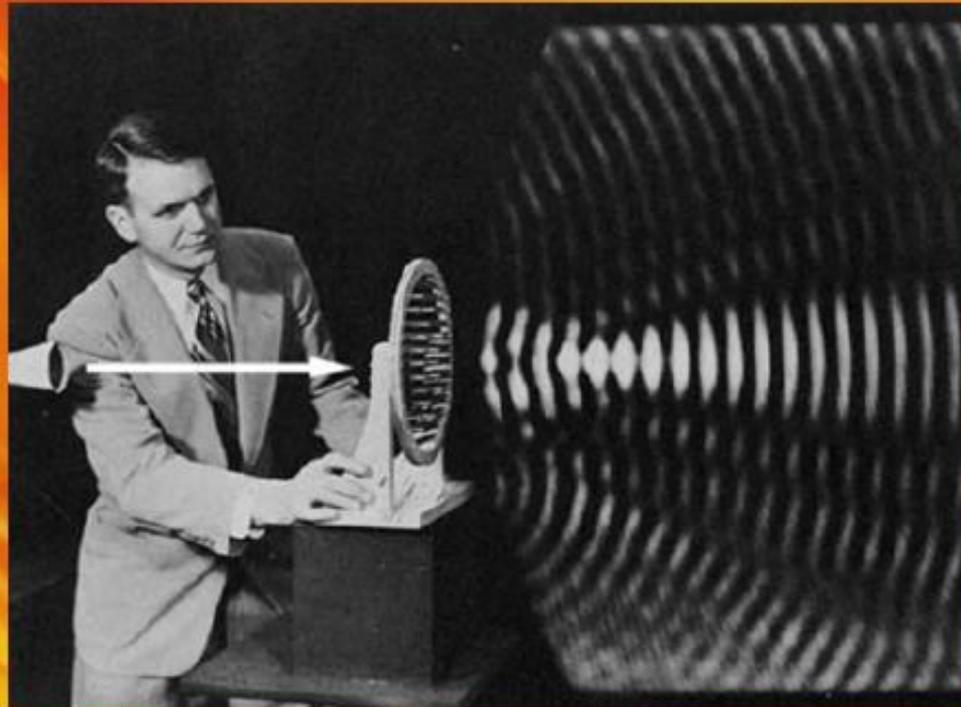


Cursor values
X: 50.000 Hz
Y: 37.747 dB/20u Pa
Z: 8.400 s

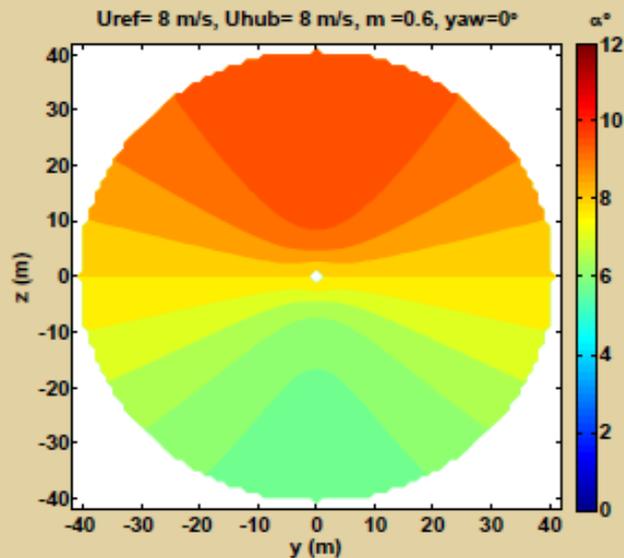
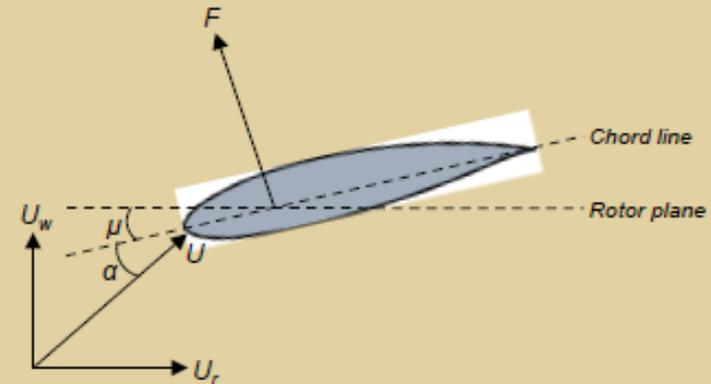
Wind Turbine Noise - from Source to Receiver Far-field Noise Issues - AM, Tonality & Impulses

Dr Jeremy H Bass, MIOA, MInstP
SENIOR TECHNICAL MANAGER

11 - 12 December 2012 - EWEA Noise Workshop, Session 3



3c THEORY 3 - OAM Caused by Blade Stall in High Shear



- in periods of high wind shear the wind speed increases rapidly with height
- pitch setting appropriate for hub height, but too low for blade tip when at 12 am (TDC)
- stall may occur around the tip of the blade at TDC
- sudden increase in noise (~10 dB) until flow re-attaches

Underground Coal Mine Exhaust Fan/Coal Fired Power Station

Brief from mine

- To review previous investigations by another consulting firm and EPA (referenced to dBA compliance levels)
- Undertake full spectrum testing at two residences and two underground coal mines.
- No correlation with operations
- ILFN complaints

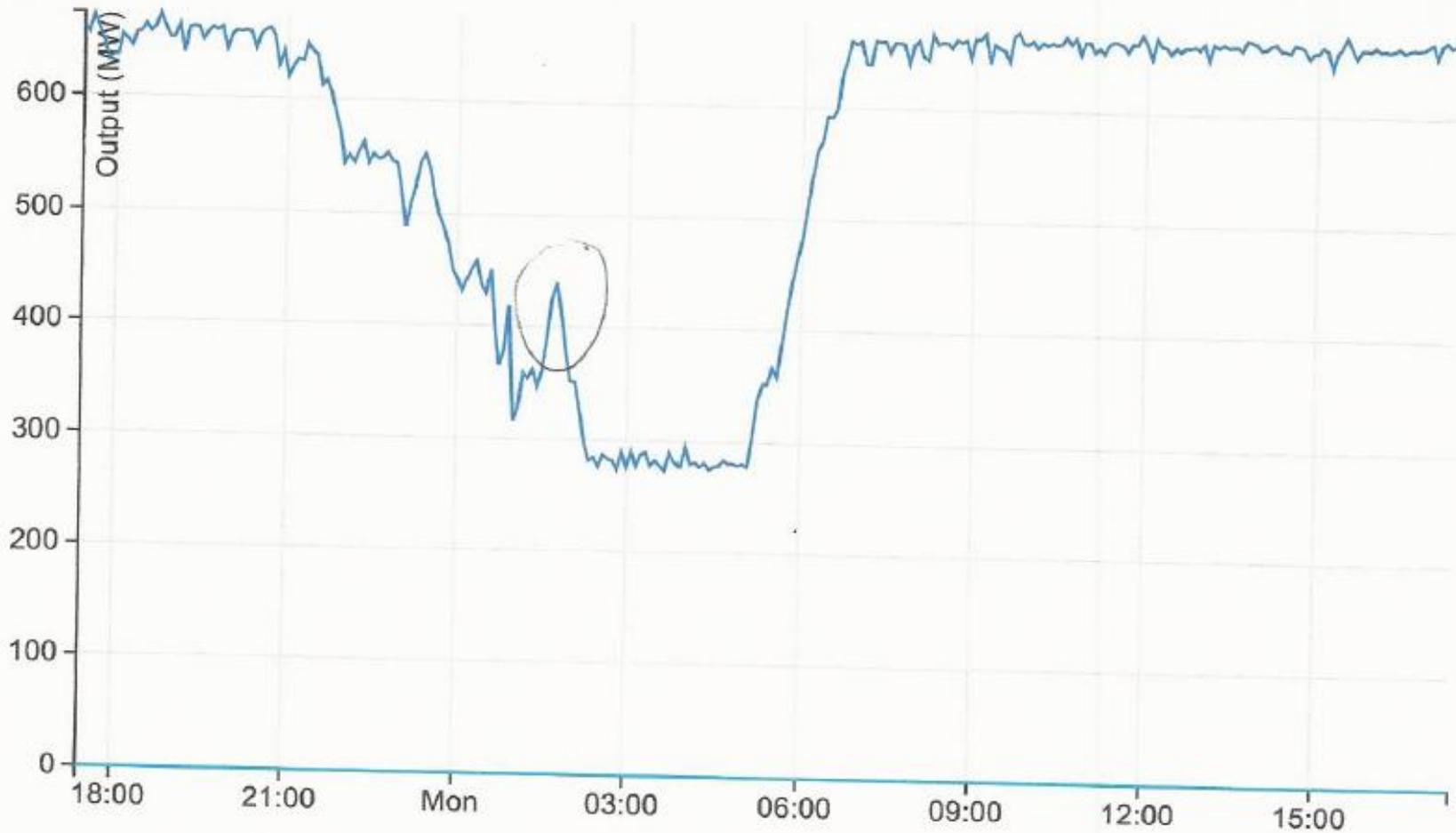
Findings

Coal Fired Power Station as main source (dependent on variations of load) with Amplitude Modulation of Exhaust Fan from mine as a secondary source dependent weather.

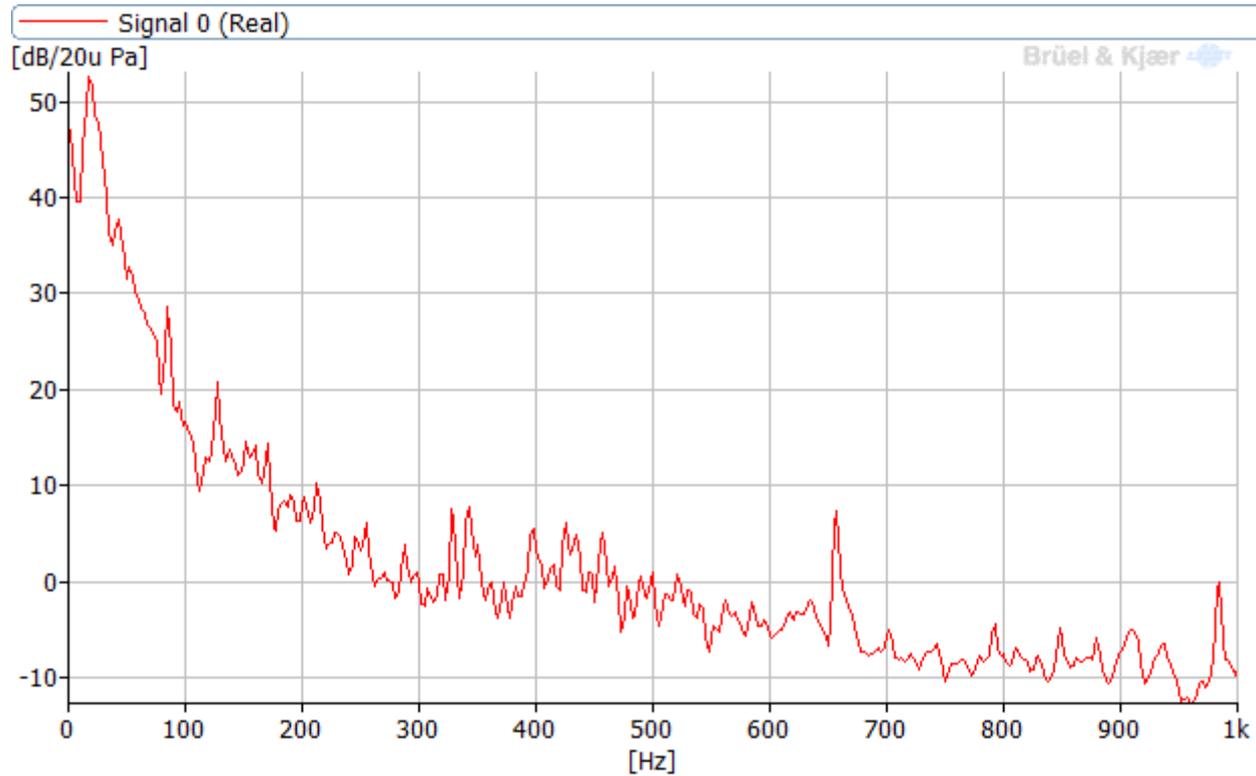
Coal Fired Power Station Output

11/2016

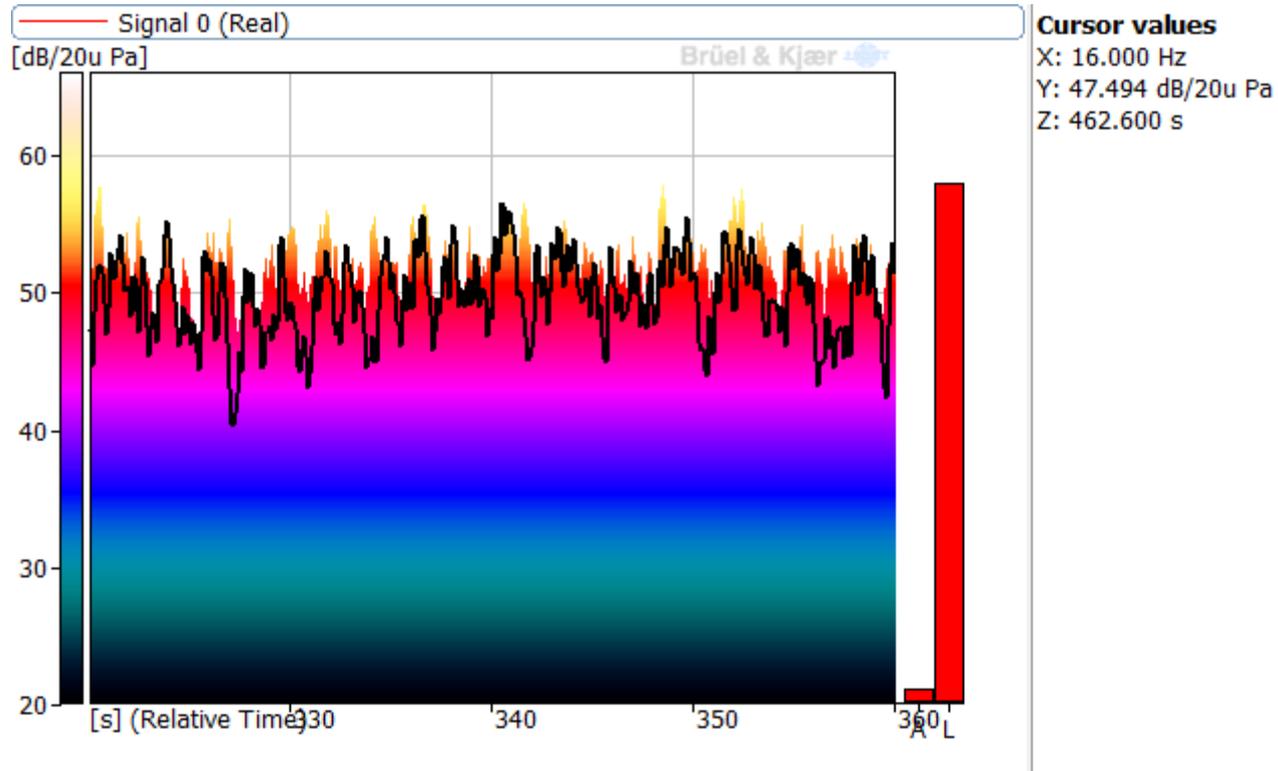
Fossil Energy in Australia | Aneroid



Reported Sleep Disturbance



Reported Sleep Disturbance

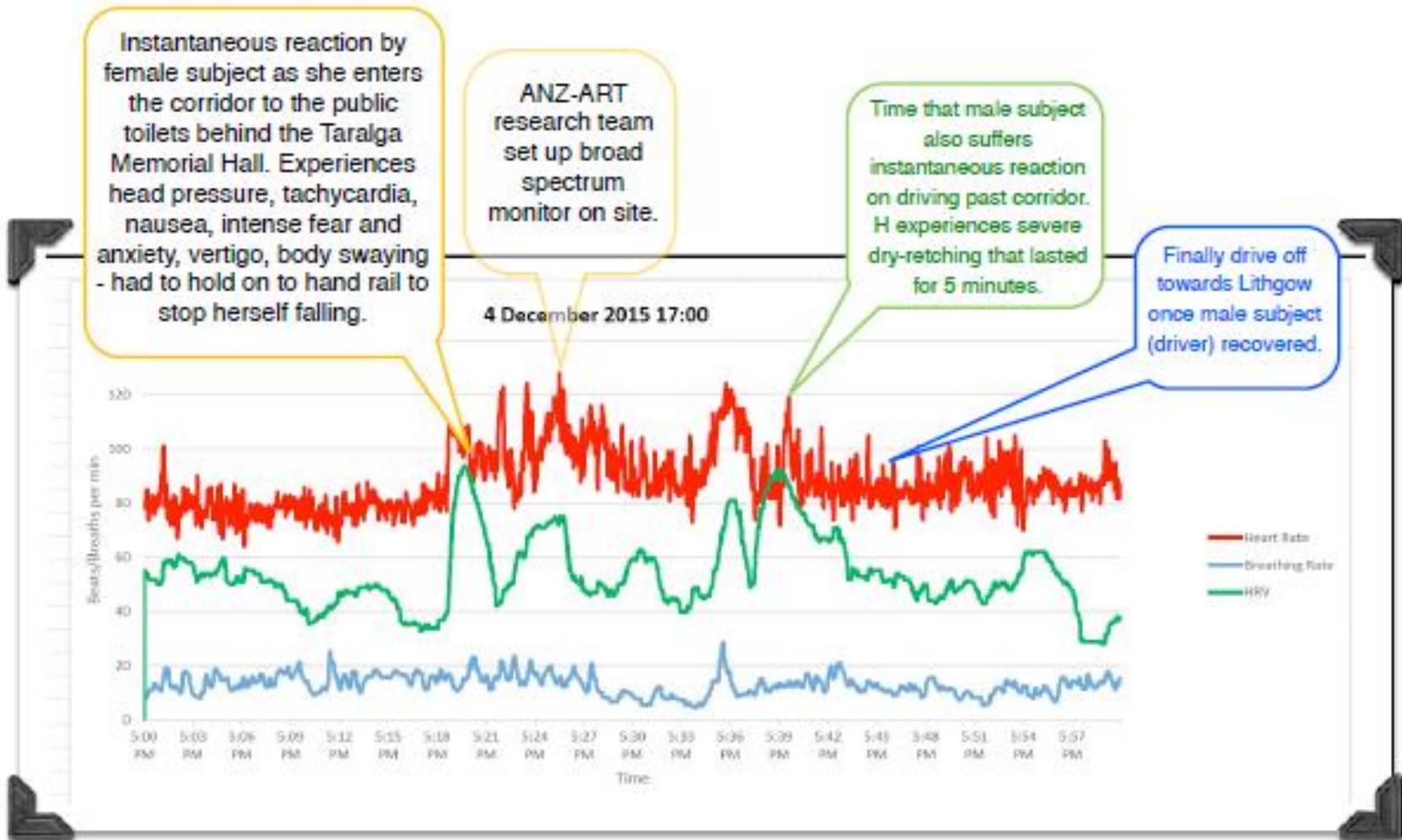


4/3/2016

Fossil Energy in Australia | Aneroid



- 2pm Subject 1 claims head starts pounding
- 2.10pm subject 3 is swaying (unsteady)



Physiological Monitoring of Female Subject between 5:00 pm and 6:00 pm at Taralga toilet stop, 4/12/15.

Courtesy of Atkinson & Rapley Consulting P/L (New Zealand)

Acoustic Waveguide



End of Waveguide – turbine 4.5km



Disturbances of sleep by noise

Griefahn B, Basner M, Acoustics 2011, Australia

The majority of sleep disturbances as a result of environmental influences are caused by noise. Noise-induced sleep disturbances are regarded as most deleterious as undisturbed sleep of sufficient length is undoubtedly essential for performance, for well-being and health (WHO 2009, 2011).

Most studies focussed on noise emitted by the three most important means of transportation (aircraft-, railway-, road traffic). This is reasonable not only because of the number of complaints but due to its ubiquitous presence and relative uniformity that allows the development of rather general abatement concepts. Priority was and is still given to aircraft noise, fewer studies were done with road traffic noise and the least with railway noise.

Other noises frequently mentioned to cause sleep disturbances but scarcely studied are emitted from industrial plants, entertainment facilities, construction sites and within the last years increasingly **often from wind turbines** for the provision of renewable energy. They are of rather regional (industry) or transient (construction) significance and they are, due to their variable structure not easy to evaluate. However, basic knowledge gained with studies on transportation noise can be at least partly transferred to these noise sources.

Tactile, acoustic and vestibular systems sum to elicit the startle reflex

Yeomans J, Li L, Scott B & Frankland P, Neuroscience and Biobehavioral Reviews 26 (2002) 1-11

- The data indicate that the startle is most sensitive to combinations of trigeminal, acoustic and vestibular stimulation (via pressure sensors around the body), especially when these stimuli arrive nearly simultaneously on the surface of the head. The auditory component is more effective if the onset is extraordinarily fast, and the frequency range is very broad. Location is not critical for auditory stimuli, but tactile stimuli are more effective if applied dorsally to the head or back.
- The startle effect is involuntary (not under conscious control), and bypasses the brain cortex where logical thought or suggestive (nocebo) processes occur.
- The startle reflex is used clinically to confirm diagnosis of PTSD, because the startle reflex is enhanced in people with PTSD.
- The pulses tested were relatively slow pulses which could be described as being similar duration to the infrasonic pulses seen with IWT.
- Can startle reflex account for audible/inaudible IFLN?
- Can startle reflex account for Sensation (Cape Bridgewater study)?
- Can repeated startle reflex account for sensitisation rather than habituation?
- Whole Body Vibration?

Autonomic Arousals Related to Traffic Noise during Sleep

Barbara Griefahn, Peter Bröde, Anke Marks, Mathias Basner, SLEEP, Vol 31, No. 4, 2008

Aim: To analyze the heart rate (HR) response to traffic noise during sleep and the influence of acoustic parameters, time of night, and momentary sleep stage on these responses.

Measurements and Results: The participants slept in the laboratory for 4 consecutive nights in each of 3 consecutive weeks and were exposed to aircraft, road, or rail traffic noise with weekly permutations. The 4 nights of each week consisted of a random sequence of a quiet night (32 dBA) and 3 nights during which aircraft, rail traffic, or road traffic noises occurred with external maximum levels of 45-77 dBA. The polysomnogram and the electrocardiogram were recorded during all nights.

In case of awakenings, the HR alterations consisted of monophasic elevations for >1 min, with mean maximum HR elevations of 30 bpm. Though obviously triggered by the noise events, the awakenings per se rather than the acoustical parameters determined the extent and pattern of the response. Without awakenings, HR responses were biphasic and consisted of initial accelerations with maximum HR elevations of about 9 bpm followed by decelerations below the baseline. These alterations were clearly influenced by the acoustic parameters (traffic mode, maximum level, rate of rise) as well as by the momentary sleep stage.

Conclusions: Cardiac responses did not habituate to traffic noise within the night and may therefore play a key role in promoting traffic noise induced cardiovascular disease. If so, these consequences are more likely for responses accompanied by awakenings than for situations without awakenings.

Repeated elicitation of the acoustic startle reflex leads to sensitisation in subsequent avoidance behaviour and induces fear conditioning

Götz and Janik, BMC Neuroscience 2011 12:30



Conclusions: Our results demonstrate that the acoustic startle reflex plays a crucial role in mediating flight responses and strongly influences the motivational state of an animal beyond a short-term muscular response by mediating long-term avoidance. The reflex is therefore not only a measure of emotional state but also influences emotional processing. The biological function of the startle reflex is most likely associated with mediating rapid flight responses. The data indicate that repeated startling by anthropogenic noise sources might have severe effects on long-term behaviour. Future studies are needed to investigate whether such effects can be associated with reduced individual fitness or even longevity of individuals.

Physiological effects of wind turbine noise on sleep

Smith M, Ogren M, Thorsson, Pedersen E and Waye KP, ICA 2016

Small scale experiment served as a laboratory pilot study

Conclusions

Physiological measurements indicate that nights with low frequency band amplitude modulation and $L_{Aeq,8h} = 45$ dB, slightly open window ($L_{Aeq,8h} = 33$ dB) impacted sleep the most. In particular, amplitude modulation and the presence of beating were important constituents of the wind turbine noise contributing to sleep disruption.

Wind farm infrasound – Are we measuring what is actually there or something else?

Steven Cooper

170th Meeting of the Acoustical Society of America

Jacksonville, Florida

02-06 November 2015

Signal Processing in Acoustics: Paper 4pSP7

4.0 CONCLUSION (Extract)

In a “traditional” narrowband analysis of 10-minute sample the results indicate the presence of discrete tones associated with the blade pass frequency and harmonics of that frequency.

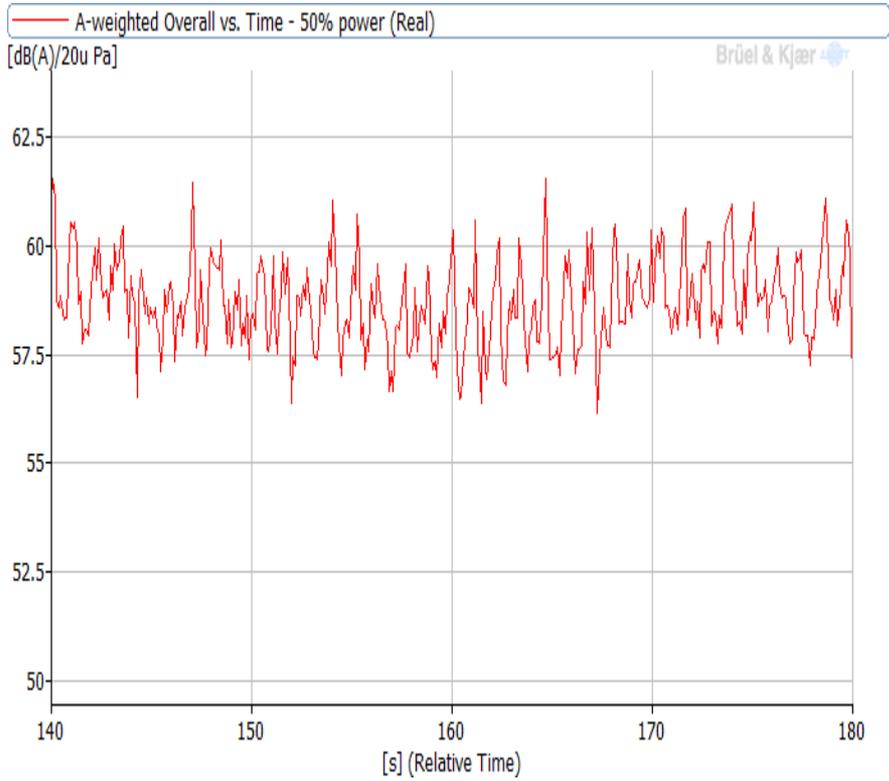
Adopting the UK approach [6] to examine individual 1/3 octave bands that stand out above the ambient Leq level (when A-weighted) show that there is a modulation of those frequencies occurring at the blade pass frequency with the time signal having a mixture of pulses related to the blade pass frequency and harmonics of that frequency.

The preliminary results of the investigation suggest that the amplitude modulation method adopted in the UK may very well have a corresponding relationship to the presence of discrete infrasound frequencies described by the author in the Cape Bridgewater study [12] as the Wind Turbine Signature (the “WTS”), and that an increase in the amplitude modulation by the UK method relates to an increase in the WTS.

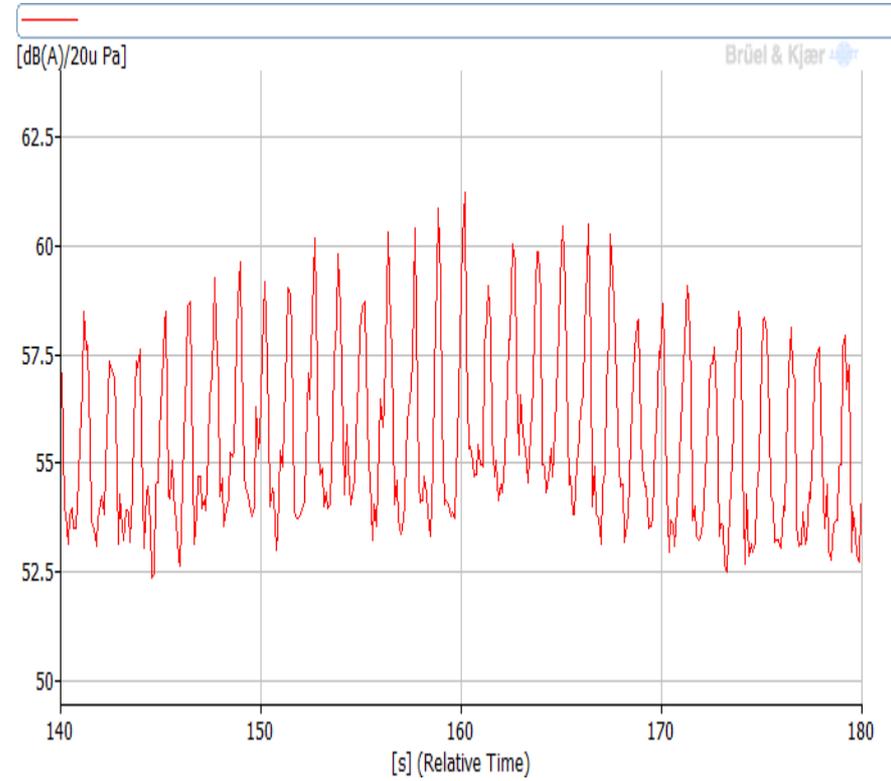
TURBINE 13 LOCATION 7

A-WEIGHTED OVERALL VS. TIME

50% power



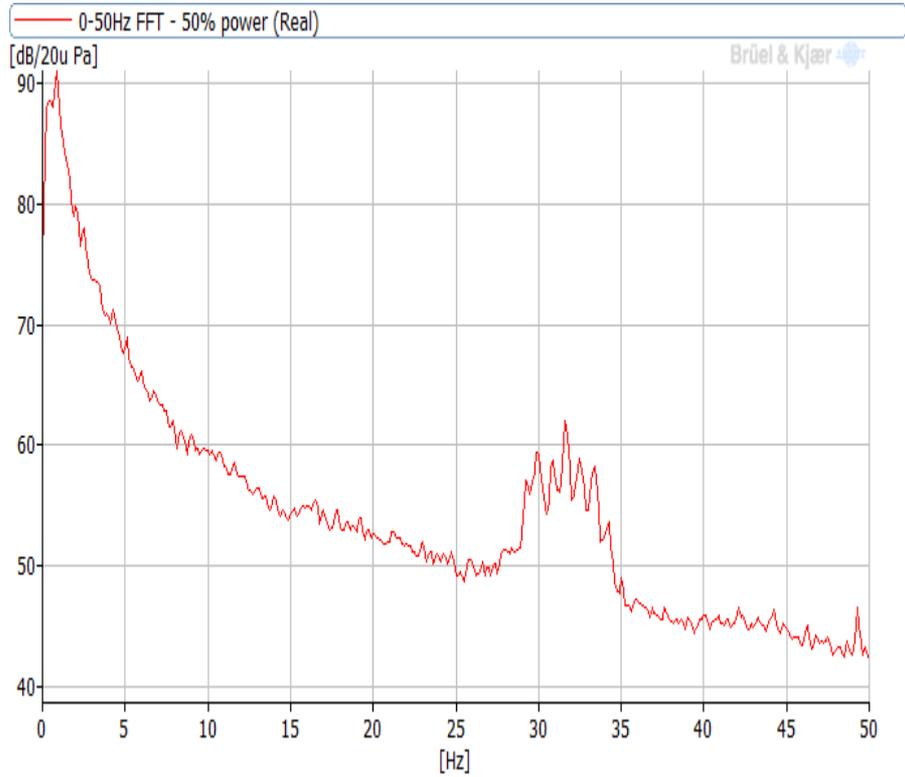
14% power



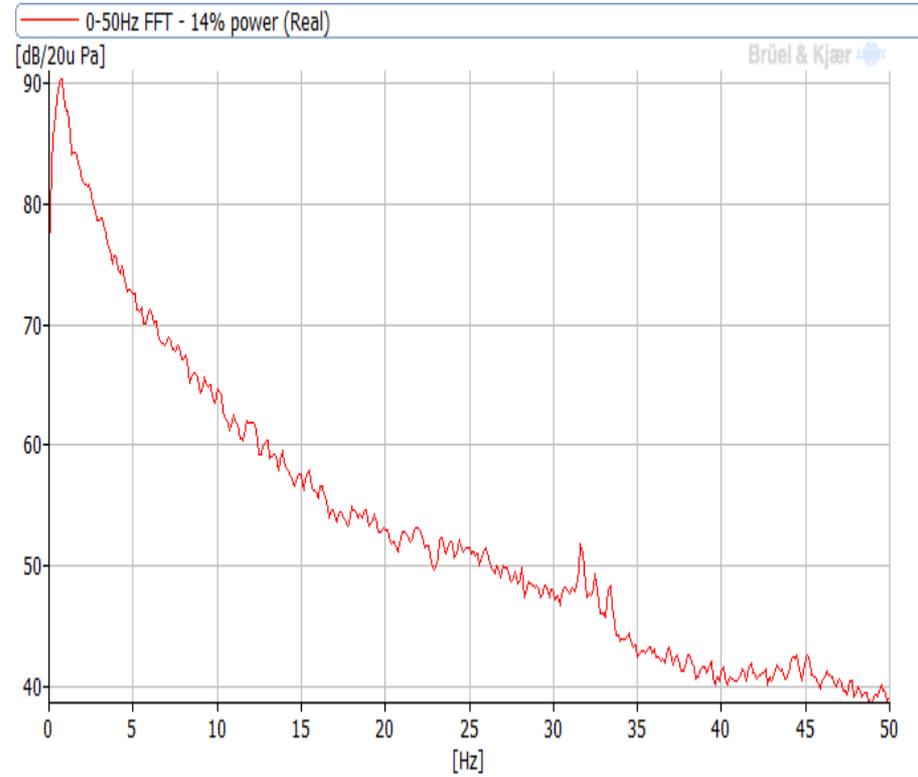
TURBINE 13 LOCATION 7

0-50Hz FFT

50% power



14% power



Pierpont 2009

“Wind Turbine Syndrome, I propose, is mediated by the vestibular system—by disturbed sensory input to eyes, inner ears, and stretch and pressure receptors in a variety of body locations. These feed back neurologically onto a person's sense of position and motion in space, which is in turn connected in multiple ways to brain functions as disparate as spatial memory and anxiety. Several lines of evidence suggest that the amplitude (power or intensity) of low frequency noise and vibration needed to create these effects may be even lower than the auditory threshold at the same low frequencies. Re-stating this, it appears that even low frequency noise or vibration too weak to hear can still stimulate the human vestibular system, opening the door for the symptoms I call Wind Turbine Syndrome.”

“Wind Turbine Syndrome: A Report on a Natural Experiment” , K-Selected Books 2009

Dick Bowdler

I do not think that the proponents of Wind Turbine Syndrome in its various forms have proved their case but this paper does not discuss that. It offers an alternative explanation to the undoubted symptoms people display which are similar to the symptoms that experienced acoustic consultants have observed with many types of noise – that the level and character of the noise are only part of the explanation. The strength of reaction to noise is brought about by non-acoustic factors moderating the perception of noise. One of the conclusions reached by Wolsink et al. [8] in their study of annoyance from wind turbines was that the amount of annoyance was hardly related to the objective sound level

There is no doubt in my mind, from some of the work above and from the author's own experience that there are people who live near wind farms who have the symptoms that have been described above. I also have no doubt (because I have met some of them) that there are some people blighted directly by noise from poorly sited wind farms. But the number of people it is suggested that Wind Turbine Syndrome effects, at distances of up to 10km, cannot be explained simply by the noise level. **My view is that there are three factors. First the measured noise level and second the character of the noise – in the case of wind farms mostly the presence of amplitude modulation but sometimes tones. Finally people's perception of the whole development and its implementation and of governments' stated attitude to wind turbine noise.** This paper considers primarily the UK approach to wind farm development but many of the comments apply to a greater or lesser extent to other countries.

“Wind Turbine Syndrome – An Alternative View” , Acoustics Australia Vol 40, No. 1, April 2012

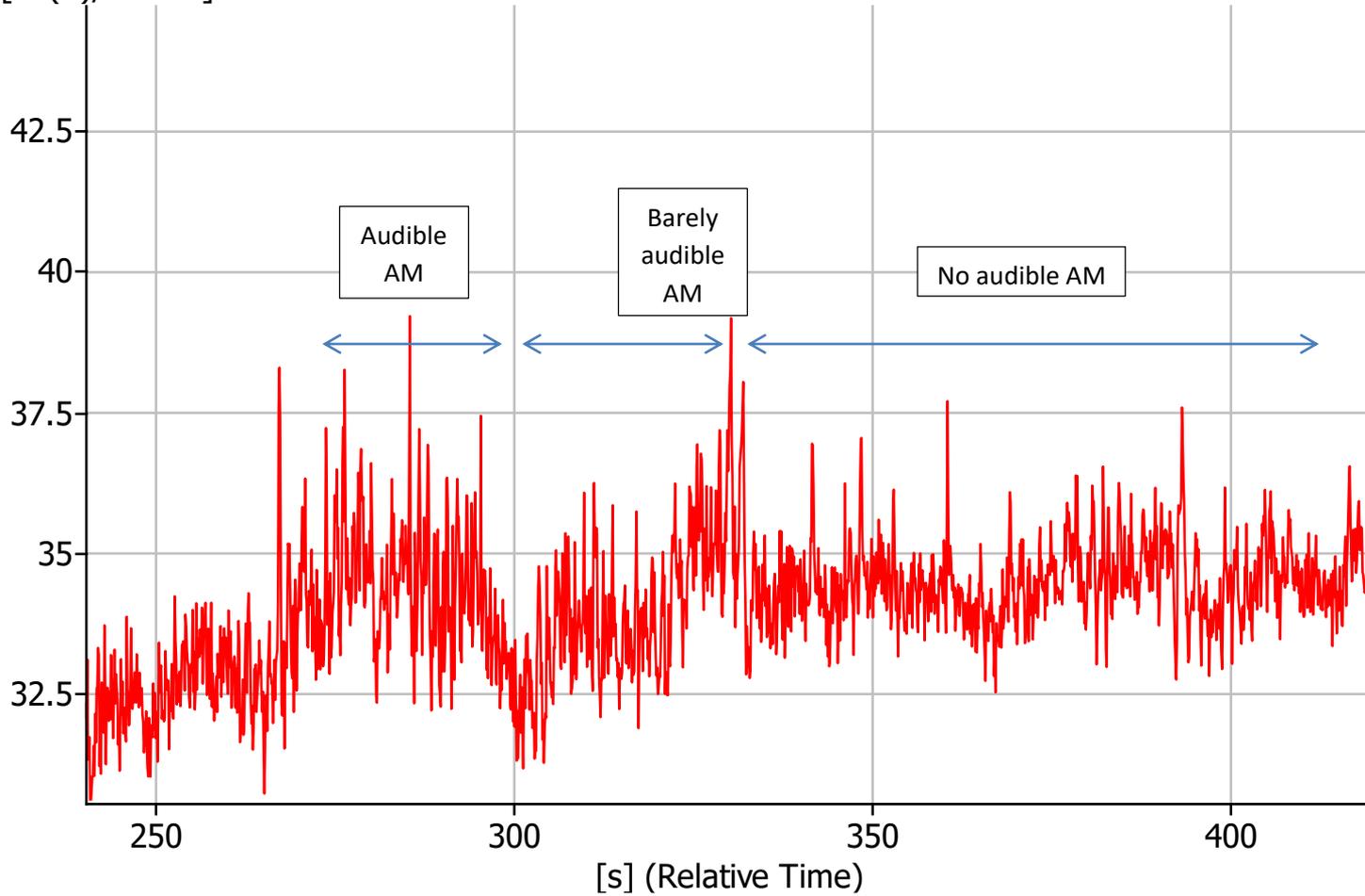
If we join the dots of different disciplines and concepts outlined above can we find a link with startle reflex and wind turbines or other sources of pulsating low frequency noise?

- We know from clinical research by psychiatrists that impulsive sound can induce startle reflex, which is particularly marked in those who have PTSD – the strength of an individual's objective response to a standardised acoustic stimulus is used to establish the severity of their PTSD.
- From an acoustic perspective startle reflex is based on high levels short duration. On a dose response can we have sensitisation over time for a low level long duration?
- Does dynamically pulsed amplitude modulation from turbines trigger the startle reflex in people who have become sensitised to wind turbine (or other sources of amplitude modulated) noise?
- Does dynamically pulsed amplitude modulation give rise to sleep disturbance?
- The next test.

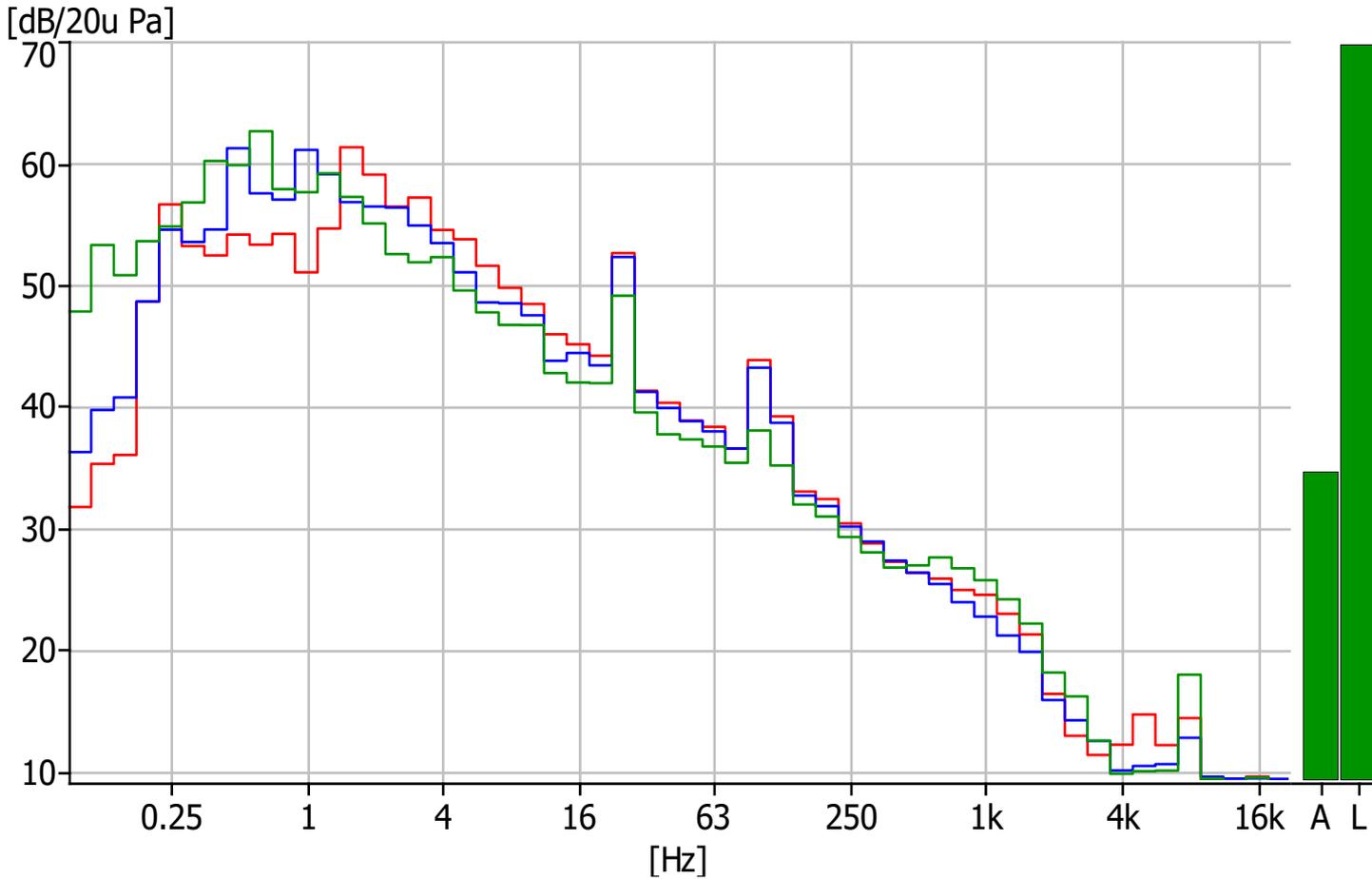
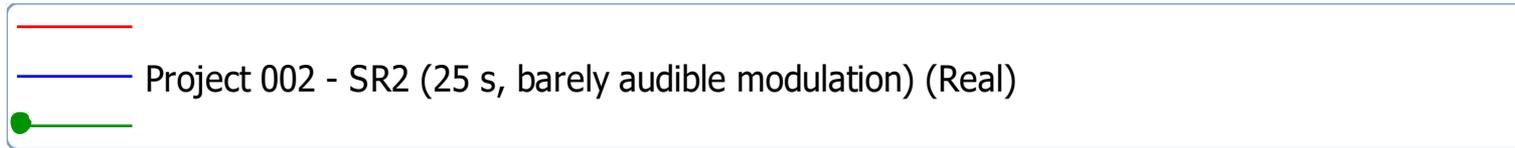
Capital Windfarm

— Project 002 - SR2 (3 min, no extraneous noise) (Real)

[dB(A)/20u Pa]



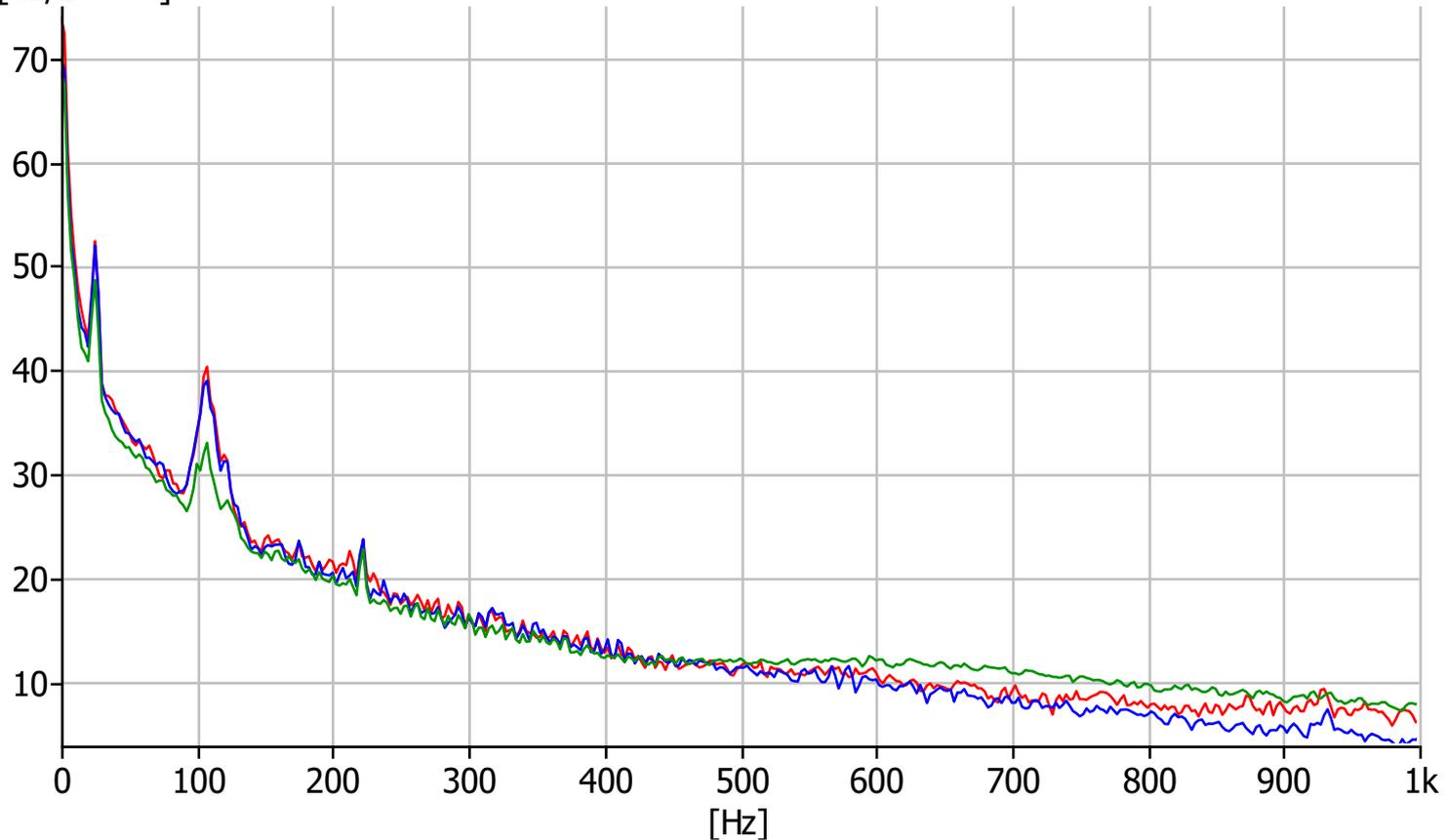
Capital Windfarm



Linear FFT (0 – 1 kHz, 400 Lines, RMS)

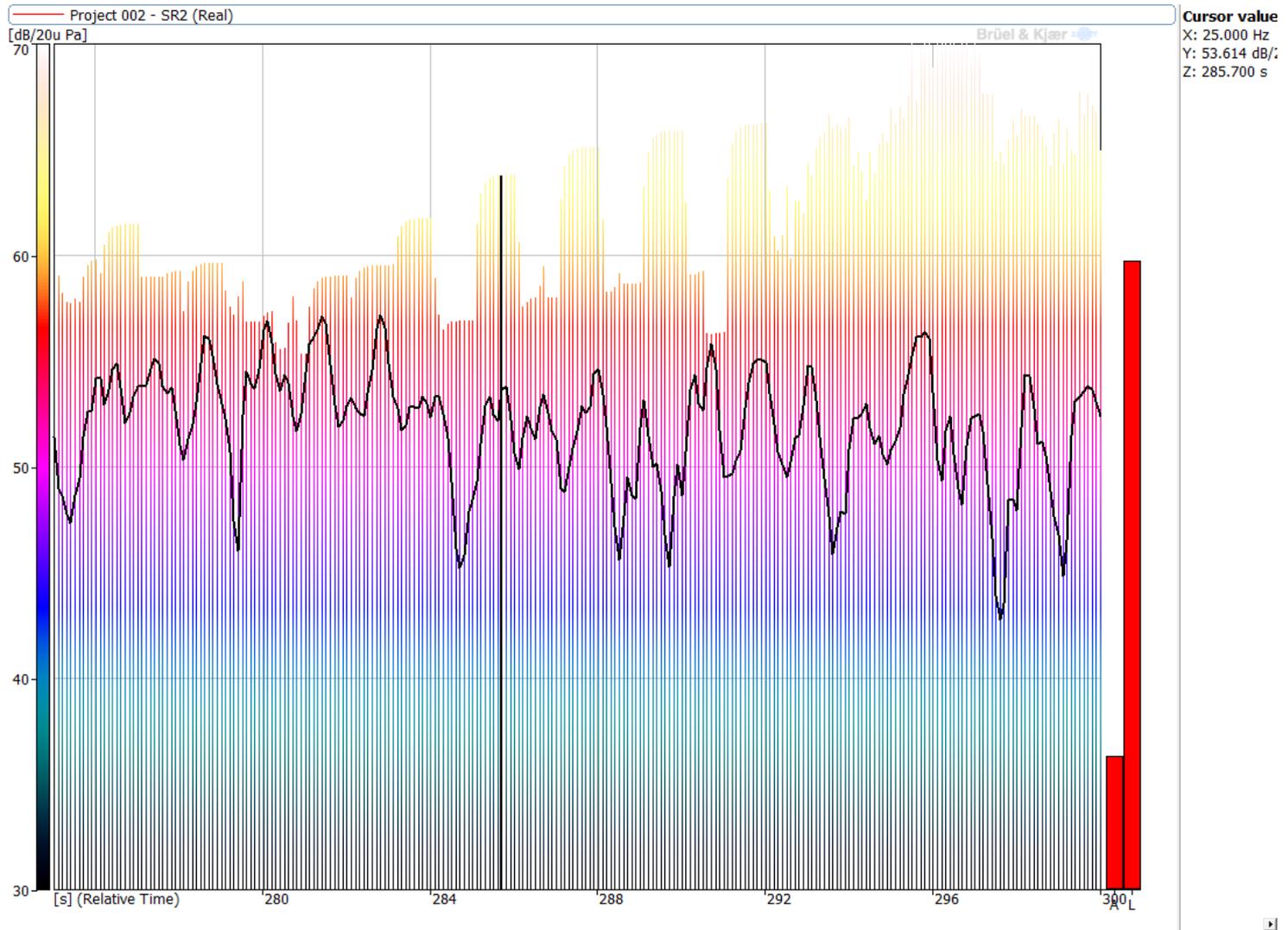
- Project 002 - SR2 (25 s, audible modulation) (Real)
- Project 002 - SR2 (25 s, barely audible modulation) (Real)
- Project 002 - SR2 (1.5 min, no audible modulation) (Real)

[dB/20u Pa]



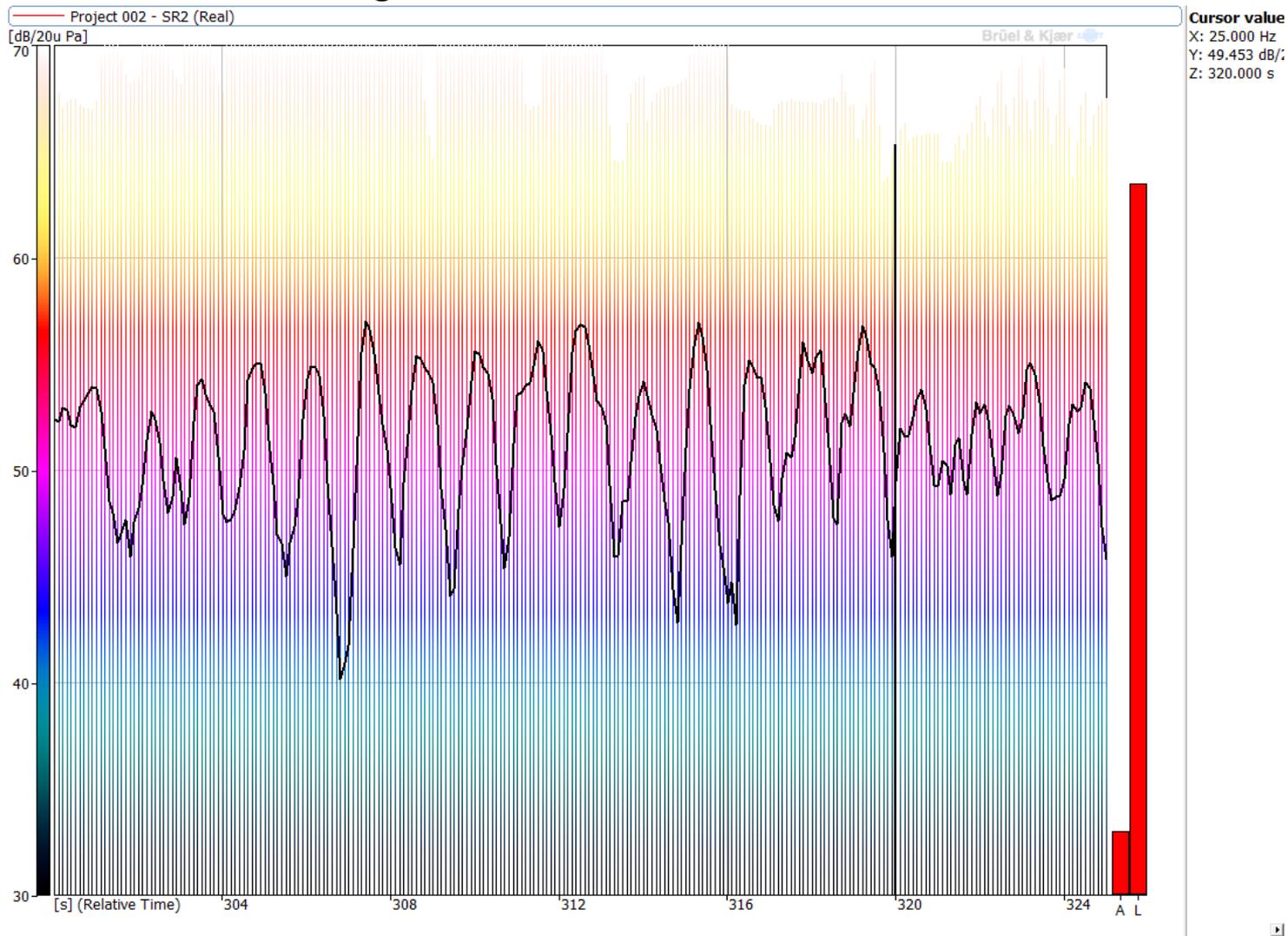
Capital Windfarm (audible amplitude modulation)

A-weighted 25 Hz 1/3 Octave Band vs. Time



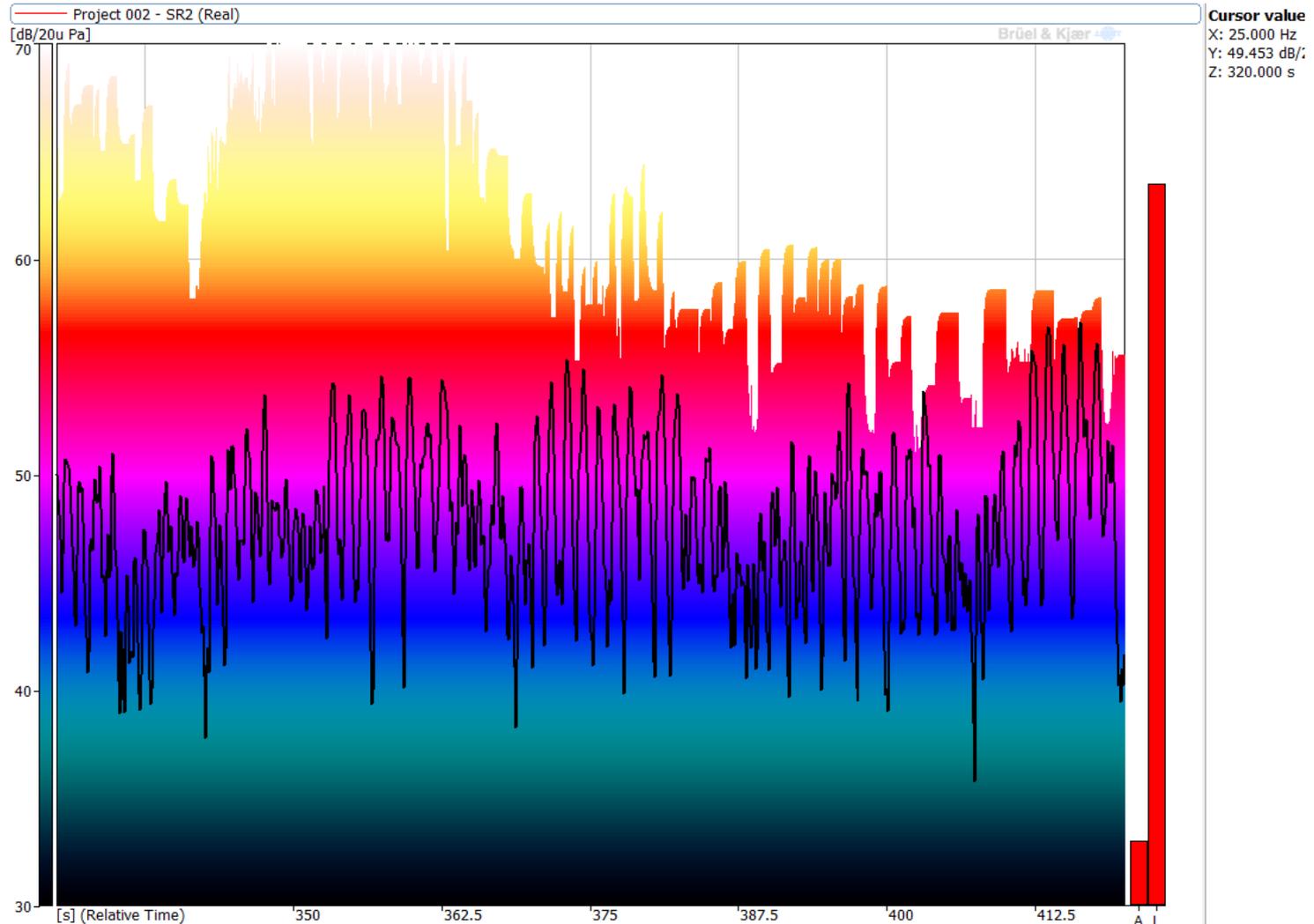
Capital Windfarm (barely audible amplitude modulation)

A-weighted 25 Hz 1/3 Octave Band vs. Time

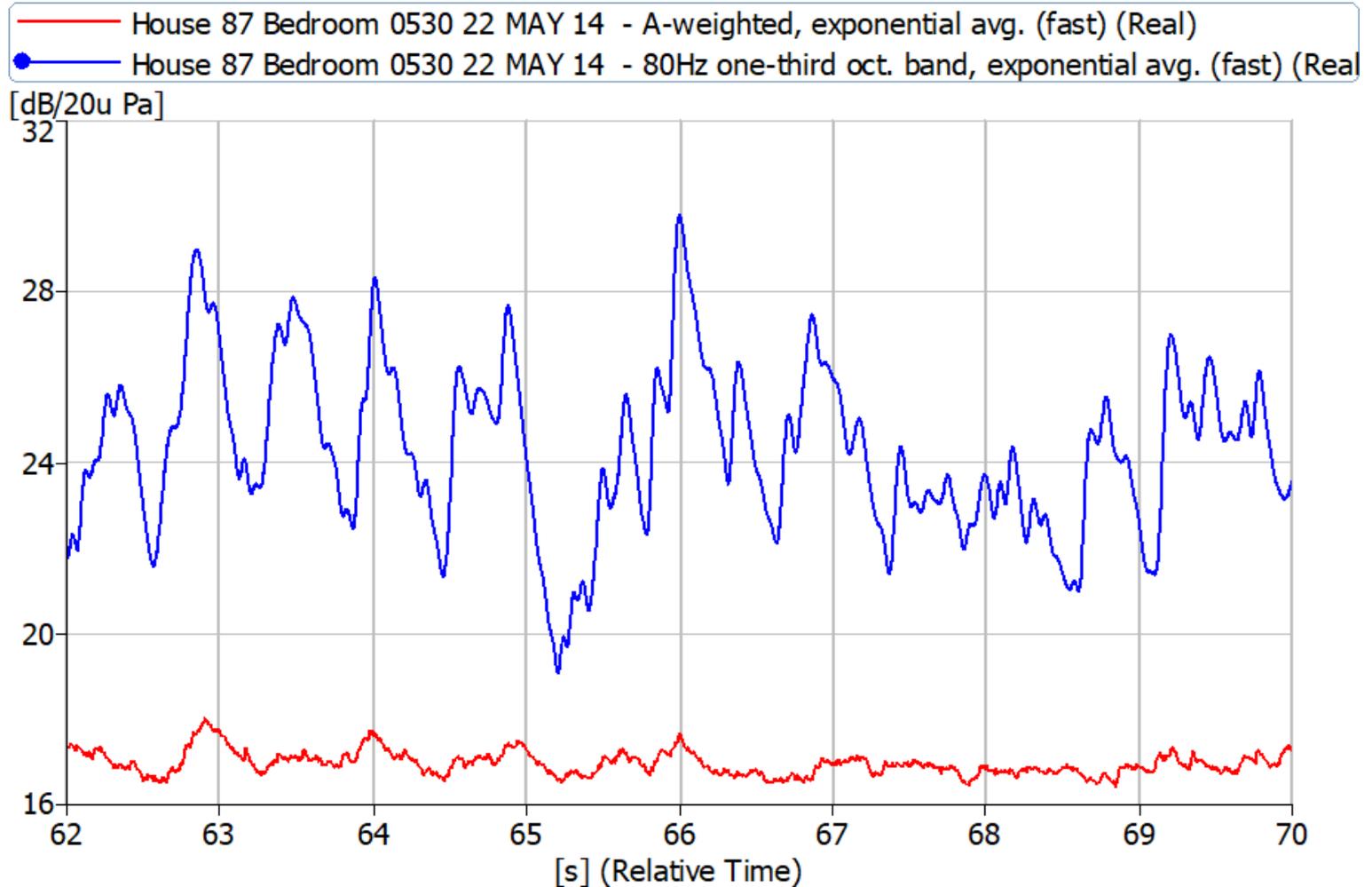


Capital Windfarm (no audible amplitude modulation)

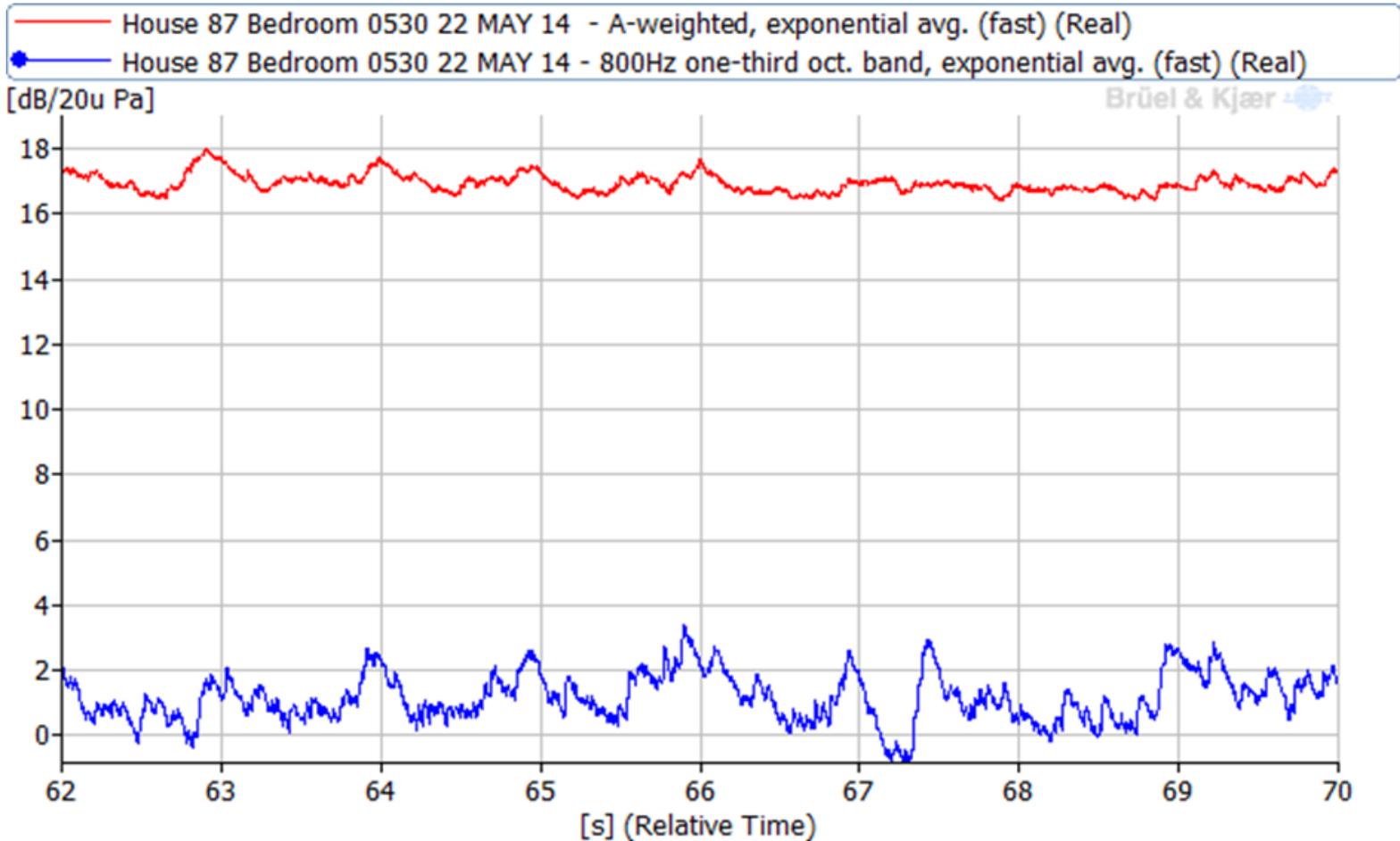
A-weighted 25 Hz 1/3 Octave Band vs. Time



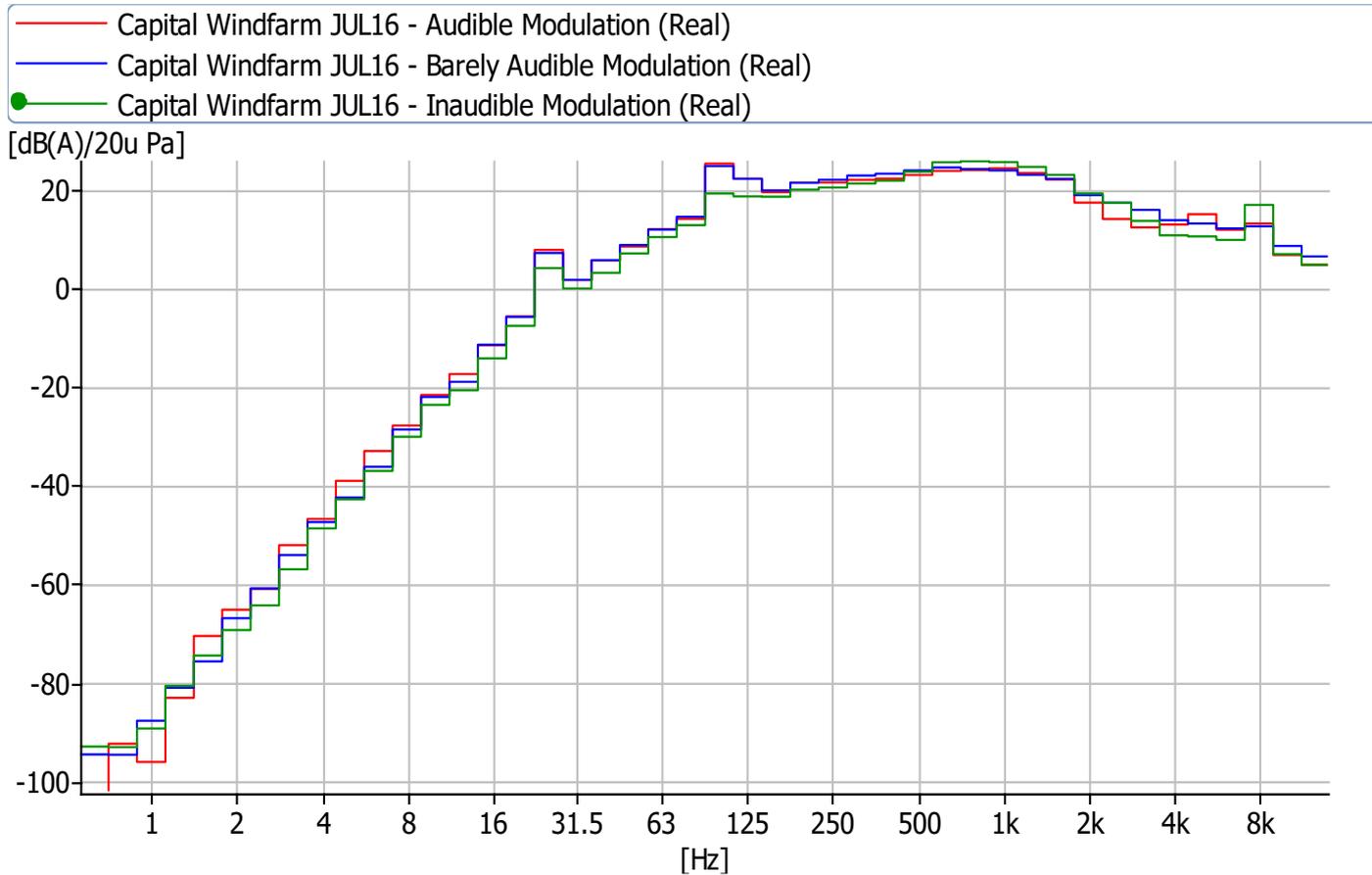
Cape Bridgewater inside bedroom



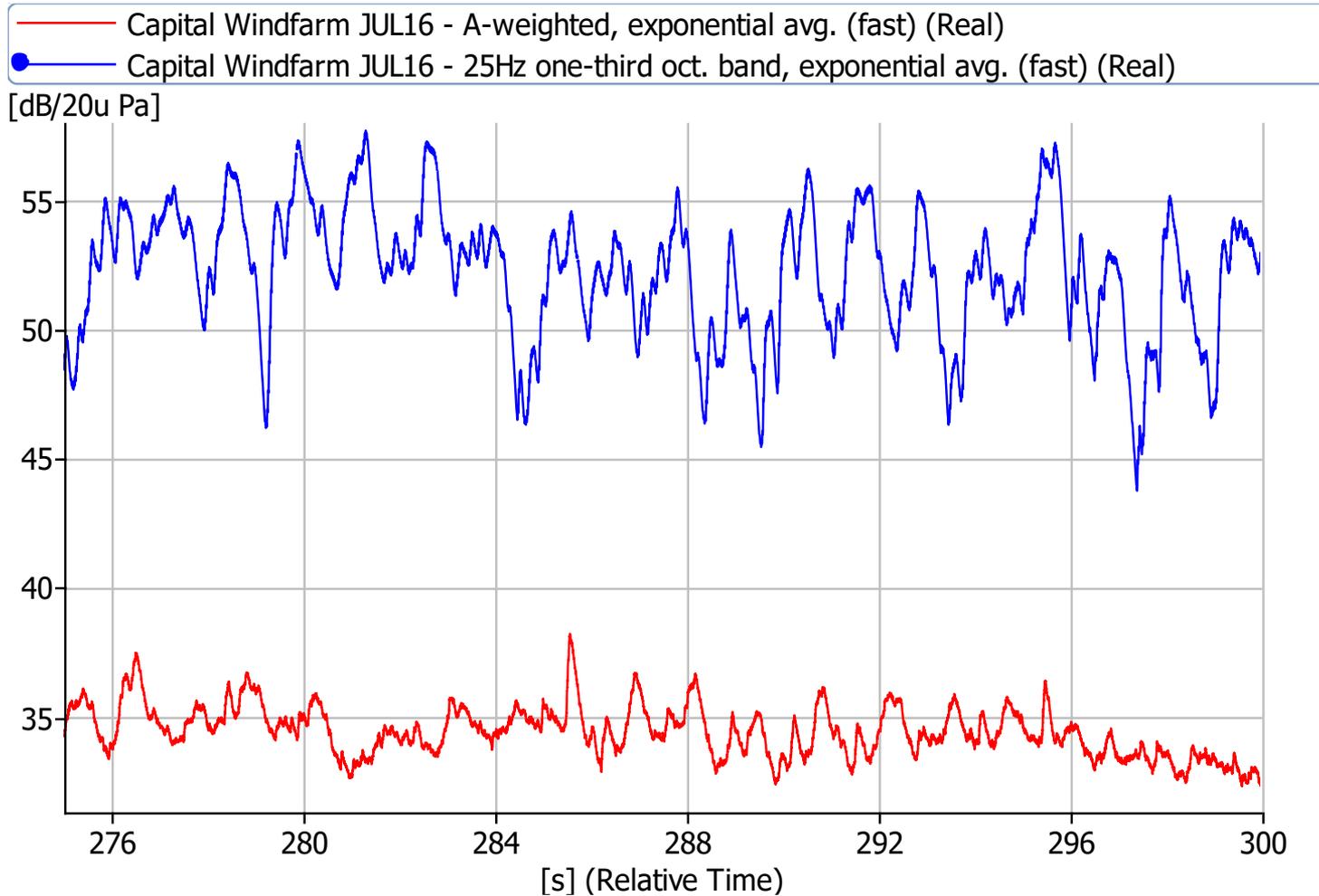
Cape Bridgewater inside bedroom



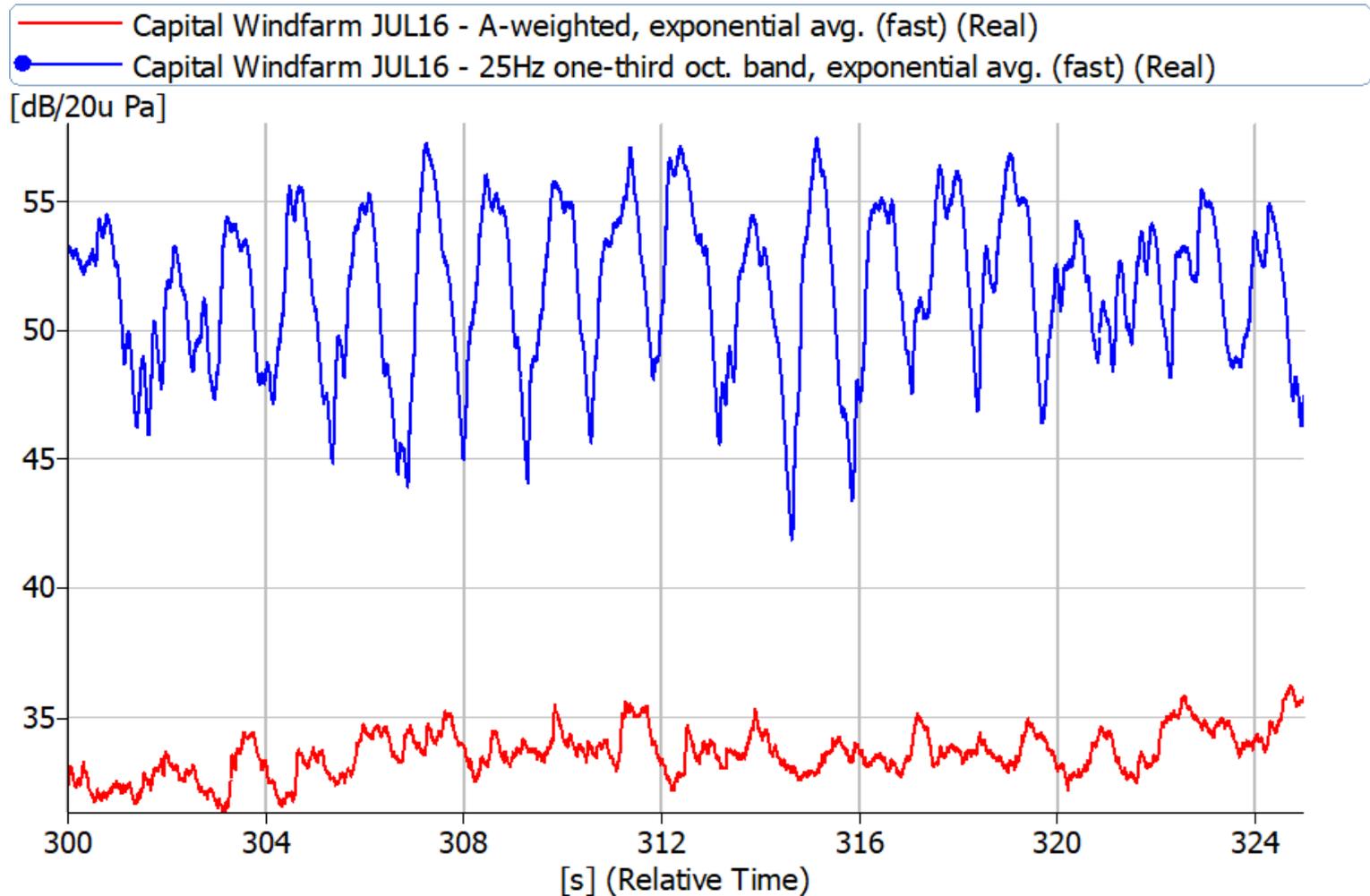
Capital wind farm – audible blade swish



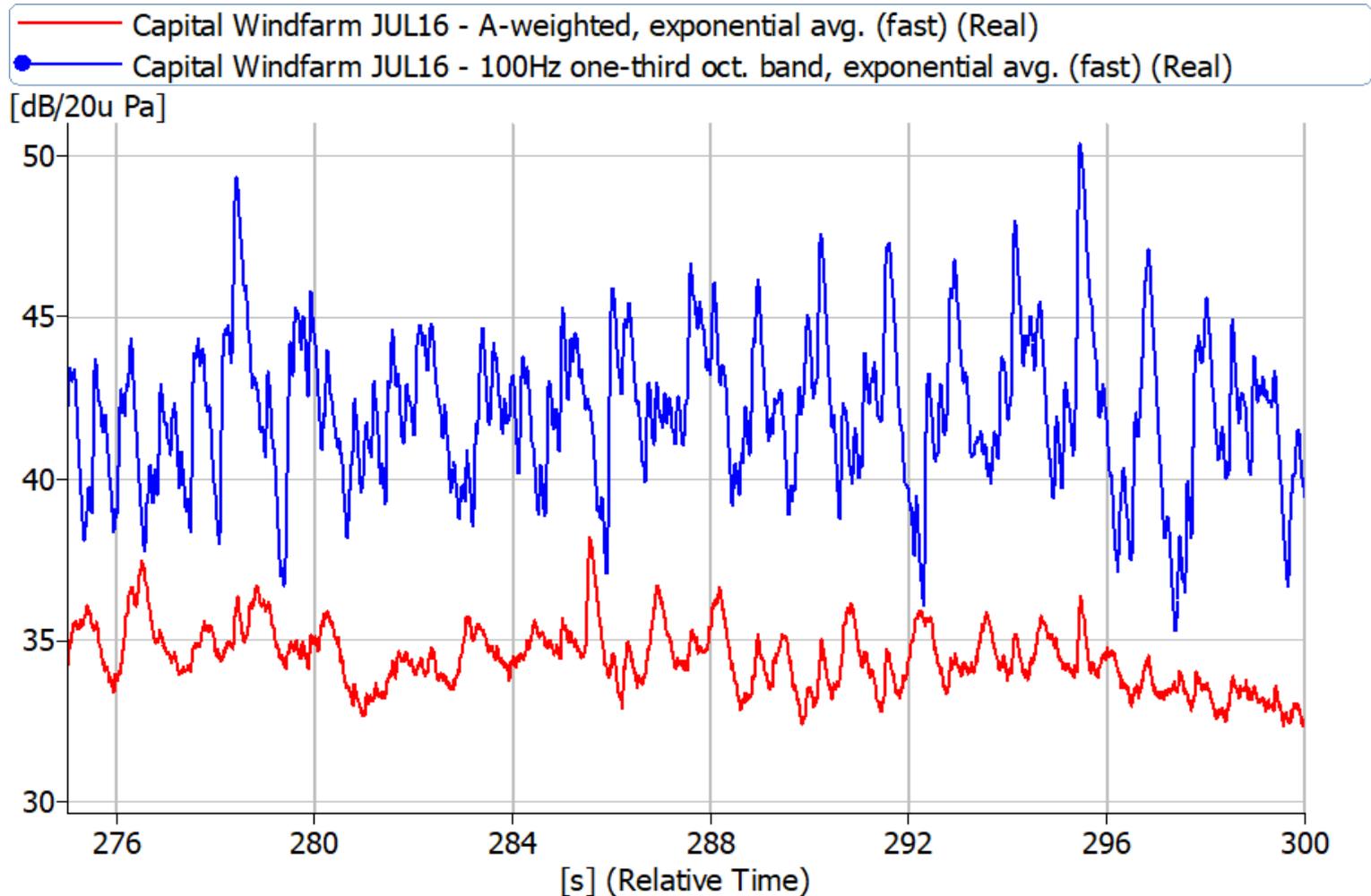
Capital wind farm – audible blade swish



Capital wind farm – audible blade swish



Capital wind farm – audible blade swish



Capital wind farm – audible blade swish

