# Why the Taralga Windfarm Environmental Impact Statement – Noise Impact Assessment is critically flawed

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* The meteorological content of this document has been viewed and verified by C. Arthur BSc (Hons), a qualified meteorologist currently employed by The Weather Co.

This document aims to illustrate why the Noise Impact Assessment (NIA) provided in the Environmental Impact Statement (EIS) for the Taralga Windfarm is flawed to the point that it has no real value. It will focus on the fact that the NIA has made an assumption which is only applicable a certain amount of the time. That assumption is that the wind speed at a reference height of 10 metres can be related to the wind speed at turbine height using a linear logarithmic equation, and can thus be used to calculate the likely noise output of turbines. It will show that the predicted noise output from turbines with respect to background noise on nearby premises has likely been underestimated in the NIA and will suggest that the proposal be rejected on these grounds, or at least that the NIA be repeated after more suitable input data has been acquired.

**Contents**

A soft copy of this document may be found online at
http://members.ozemail.com.au/~amiskelly/windfarm_taralga_submission_noise_am.pdf

## Introduction

The Environmental Impact Statement (EIS) for the Taralga Windfarm includes a Noise Impact Assessment (NIA) which is detailed in Appendix H. Appendix H states the following in its introduction (Taralga EIS, Appendix H, p1):

"*[The NIA] describes the assessment of the likely acoustic impact of the proposed Taralga wind farm. Noise can have an effect on the environment and on the quality of life enjoyed by individuals and communities.*"

The NIA also correctly states the following, under the heading '1.5 Background Noise Survey' (Taralga EIS, Appendix H, p7):

*"…background noise levels depend upon wind speed, as indeed do wind turbine noise emissions…"*

The NIA follows the guidelines set out in the 'Environmental Noise Guidelines - Wind Farms' (produced by the EPA-SA) and uses a method described in the 'Acoustic Report for a Wind Energy Converter Type NEG Micon NM 82/1650' to calculate the likely noise output of wind turbines.

The latter document describes how a method of calculating noise output of turbines was formed for which wind speed data at a height of 10 metres could be used as input. This involved calculating the 'standardised wind speed' at 10m using the actual wind speed at turbine height, which in this case was 96.5 metres (Acoustic Report - NM 82, p11), over a period of 4 hours during the day (Acoustic Report - NM 82, p7). Presumably the purpose of forming this method was to make noise assessments easier for prospective users of the turbine.

The NIA is summarised in Volume 1 of the EIS and states the following (Taralga EIS, Volume 1, p5.19):

"*A unique characteristic of windfarms is that the noise level from each wind turbine increases as the wind speed at the site increases. As an offset, the background noise also generally increases under these conditions and masks the noise from the turbine.*"

Unfortunately both the method described by the NEG report and the statement made above are too simplistic for practical use in Taralga's case. This statement is only applicable a certain amount of the time but despite this it is the principle on which the integrity of the entire NIA depends.

The reason the statement is simplistic is that it assumes that the wind speed at a height of 10 metres (which is related to background noise) is relatable to the wind speed at turbine height (which is related to turbine noise – both aerodynamic and mechanical). This assumption does not account for all situations and is generally only applicable during daylight hours.

In fact it is very common for a meteorological condition to arise where the wind speed at the surface and at a height of 10 metres is nil or very light, but the wind speed at turbine height (69 metres in Taralga's case) remains well above cut-in speed. This condition is generally brought about by a nocturnal temperature inversion.

The effect of this is that there is no ambient noise at the surface as the wind has been displaced upwards by the inversion layer, but the turbine noise remains as wind speeds at turbine height are unaffected by the surface inversion.

The fact that the NIA does not address the occurrence of this condition is a major oversight. A strong and well defined nocturnal temperature inversion is extremely common all over the Tablelands due in part to their elevation and inland location. The result of this oversight is that the turbine noise figures produced in the NIA are likely to be badly underestimated at times when this condition occurs (generally at night when people are trying to sleep).

## **The nocturnal (radiation) temperature inversion**

Nocturnal temperature inversions come about due to the land's ability to absorb solar heat during the day and radiate it rapidly after sunset.

During daylight hours the temperature profile of the planetary boundary layer (PBL) is maintained by deep convective mixing which occurs due to solar heating of the surface. This mixing breaks down any stratification (layers) that may form in the lower atmosphere and means that wind blows relatively uniformly throughout, though increasing with height as friction with the surface becomes less of a factor (this increase is known as 'wind gradient').

On reasonably sunny days where convective mixing is occurring, a logarithmic profile for wind speed is suitable.

After sunset the surface cools rapidly as heat is radiated back into the atmosphere. Through conduction, the surface layer (the lowest few metres) of the atmosphere also cools rapidly resulting in a shallow, stable and dense layer near the surface. Above this layer the temperature rises rapidly and the nocturnal inversion is formed. Because the inversion grows largely through conductive processes, it slowly increases in depth, with a maximum depth of some tens of metres usually reached just before dawn (at which time the effects of solar radiation will break down the inversion once more).

All frictional effects become confined to the shallow surface layer, and the atmosphere above this layer is decoupled from normal frictional effects. This results in near-surface winds becoming calm (or almost calm), while winds above the inversion remain at a similar speed to the pre-sunset surface winds. In fact it is not unusual for the winds above the inversion to accelerate because of the reduced friction on the bottom boundary (the inversion results in an almost 'free slip' bottom boundary condition for the flow – a condition associated with a well documented phenomenon known as the 'nocturnal jet').

The development of a nocturnal inversion is not dependent on near-calm conditions. While near-calm conditions will result in faster growth of the inversion, it is still common for the inversion to develop when wind speeds are significant. This is demonstrated below under the heading 'an example from the EIS' using data from Goulburn Airport automatic weather station.

The nocturnal inversion has been recognised as a hazard to aviation at HMAS Albatross, Nowra. In a document entitled 'Winter Westerlies' the Station's Meteorological Officer states the following (Lance, 2004):

*"Cooling of the ground over night causes the lowest few hundred of feet of the atmosphere to cool, creating a temperature inversion near the surface. This inversion causes the winds at the surface to decouple from the winds above, creating large amounts of wind shear. This also creates a false impression of the upper wind conditions due to light winds at the surface."*

In situations where a nocturnal inversion has developed, it is not possible to relate a 10 metre wind speed to the wind speed above the inversion layer. A logarithmic profile will at the very least underestimate the wind speed drastically, and if the 10 metre winds are calm then the data is certainly unrepresentative.

Image 1 and image 2 graphically depict typical day time and night time conditions respectively.

**Image 1**

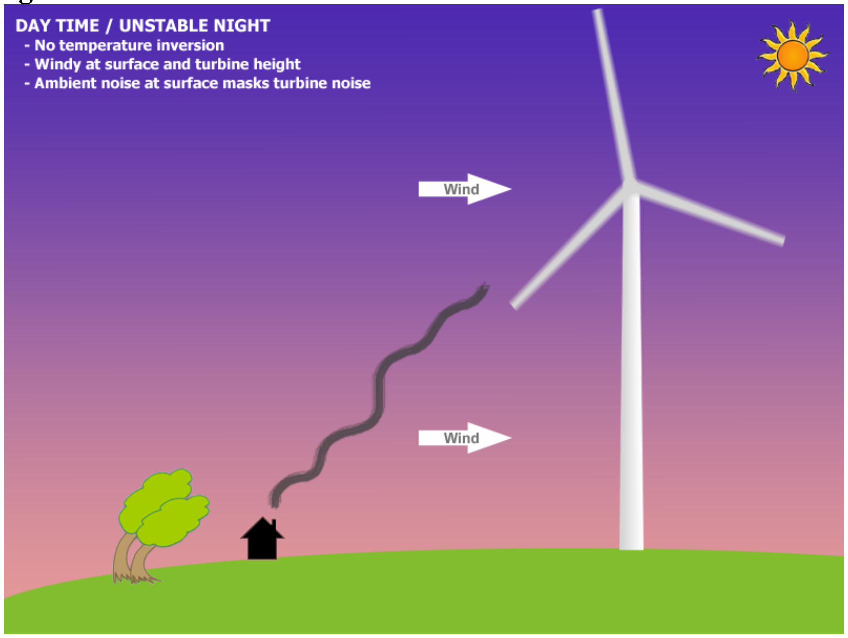


*Image 1 shows a typical lower atmosphere during the day time and on less stable nights where a surface temperature inversion is not allowed to form. The lower atmosphere is mixed by convection that occurs during the day, thanks to solar heating of the surface. The wind blows right throughout the lower atmosphere and increases with height as friction with the surface becomes less of a factor. This increase with height is known as wind gradient.*

**Image2**

*Image 2 shows the situation on a stable night. After sunset the earth's surface commences radiation of heat back into the atmosphere. This radiation results in the formation of a layer of cold, dense, still air which grows in depth, upwards from the surface as the night progresses. This dense layer displaces the mixed, windy layer upwards until it is broken down once more by convection when the sun rises the following morning.*

The scenario depicted in image 2 is most common under the following conditions:

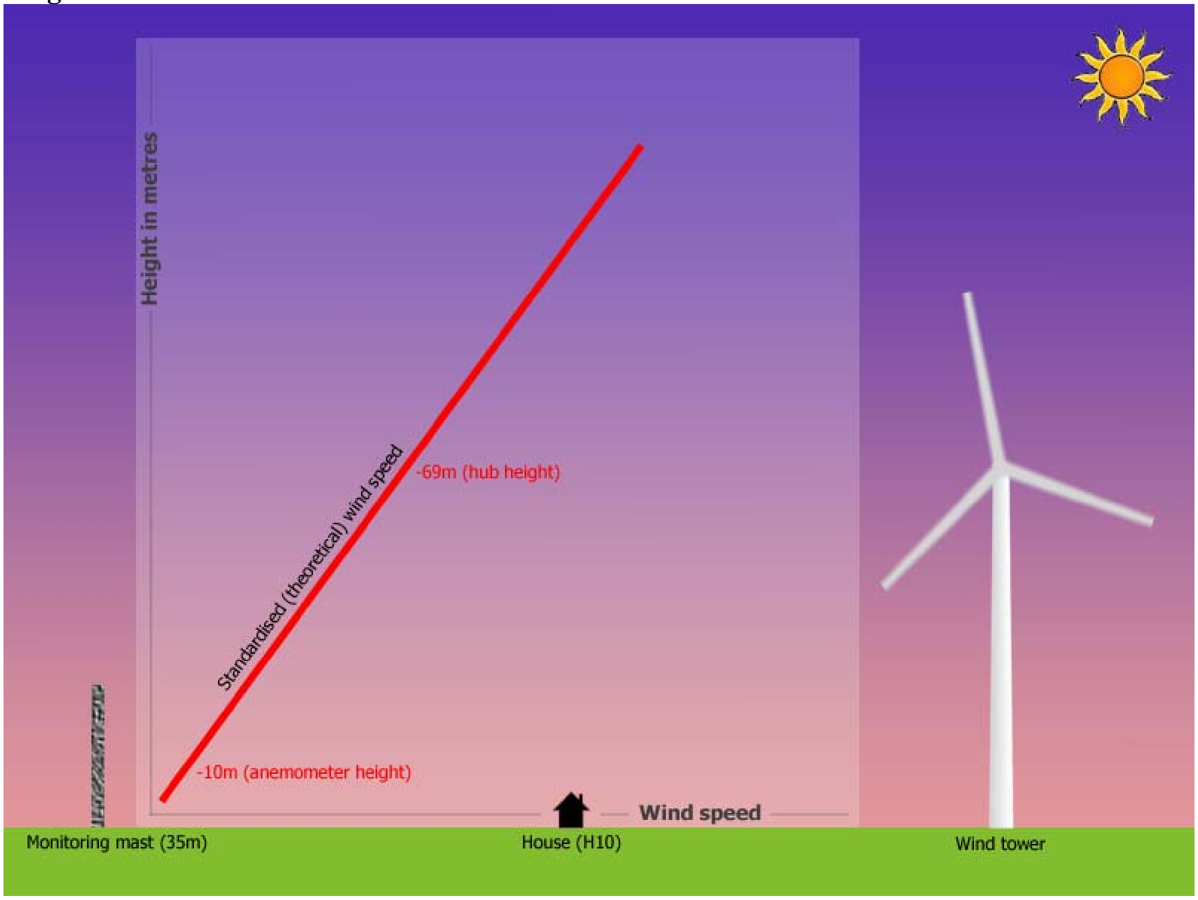
- at inland locations, away from maritime influence
- at elevated locations where radiation into the atmosphere is more pronounced
- in winter when the surface is cold

The Taralga area and indeed the greater Tablelands meet both of the first two criteria which is why they are famous for cold, frosty nights and mornings in autumn, winter and spring (Foley, 1945, p17). Radiative frosts occur in the cold, still conditions underneath a temperature inversion.

## The Noise Impact Assessment's assumption versus reality

The difference between the lower atmospheric conditions assumed by the NIA, and the conditions in reality with a surface temperature inversion in place are illustrated below.

**Image 3 – the assumed scenario**



## Description of image 3 – the assumed scenario

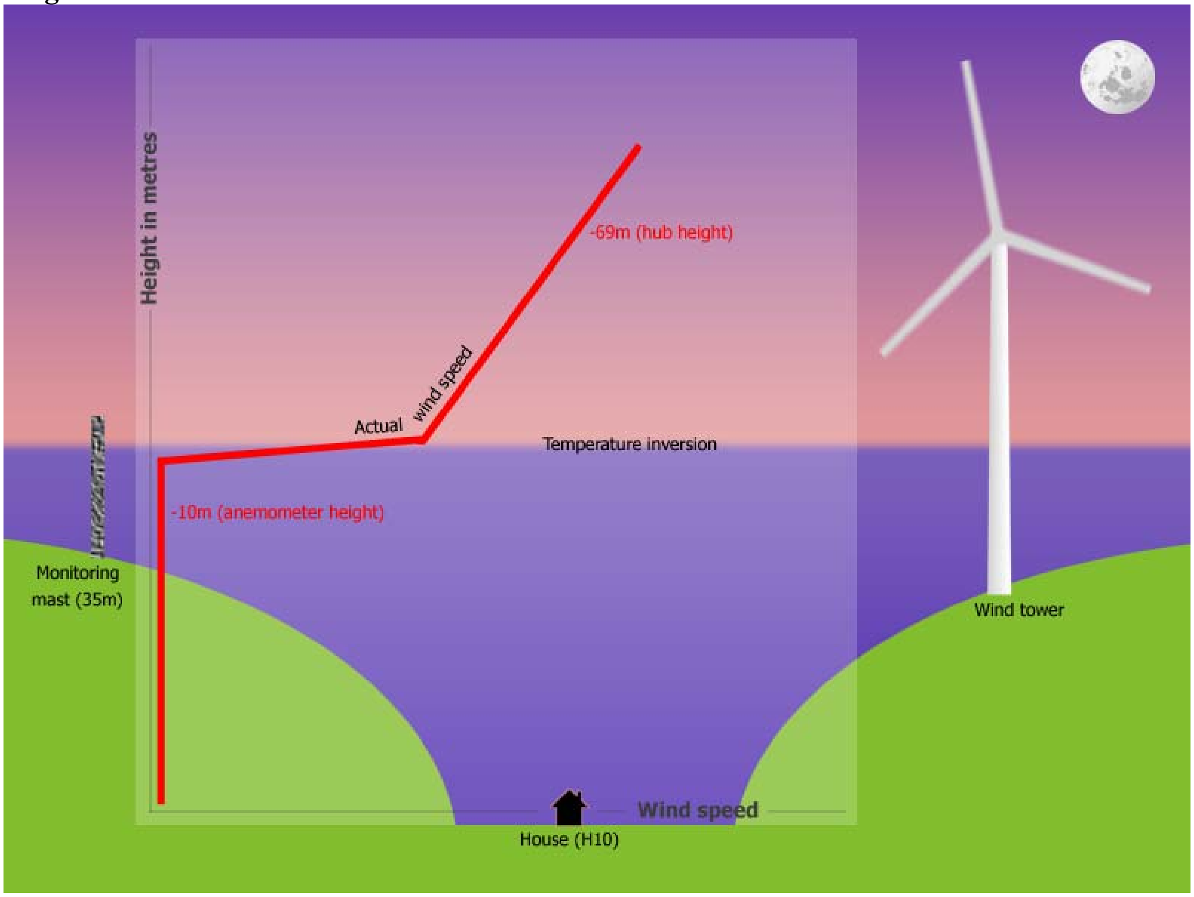
**Monitoring mast:** The existing monitoring masts associated with the site stand at a height of 35 metres, though wind data for the noise assessment has been used from 10 metres.

**House:** In this example we will look at H10 – "Killarney" (Taralga EIS, Appendix H, p3).

**Wind tower:** The wind tower stands at a height of approximately 110 metres with the hub at 69 metres (Taralga EIS, Volume 1, p2.10).

**Height in metres vs Wind speed:** The graph shows in simple form (the relationship depicted is not logarithmic) the assumption that the NIA makes. That is, that wind speed is related to height and that the wind speed at hub height can be calculated from the wind speed at a lower anemometer height (10m). Thus it assumes that turbine noise output can be calculated using the 10m wind speed. This assumption is meteorologically unsound.

**Image 4 – the actual scenario**



## Description of image 4 – the actual scenario

**Monitoring mast:** The bases of the monitoring masts associated with the site are all at an elevation of approximately 920 metres. One of these is located adjacent to T10 (Taralga EIS, Vol. 1, figure 2.4).

**House:** H10 – "Killarney" – is at an elevation of 886 metres. It is located 513 metres to the north of wind tower T10 (Taralga EIS, Appendix H, pp3-4).

**Wind tower:** The base of wind tower T10 is at an elevation of approximately 920 metres. It stands on a hill 513 metres to the south of H10. The blades of the wind tower are high enough above the surrounding terrain (up to 142m above H10) to be well clear of any surface temperature inversion, thus the turbine is operational.

**Temperature inversion:** A nocturnal, surface temperature inversion has formed, as described above.

By the early hours of the morning the cold, still layer underneath it has developed to a depth of around 50 metres. There is no ambient noise whatsoever around the house.

Above the temperature inversion a moderate wind is blowing. The wind turbines are operational.

**Height in metres vs Wind speed:** The graph shows how the wind profile might appear through the lower atmosphere. Underneath the temperature inversion conditions are calm as the cold, dense air hugs the surface. Around the level of the temperature inversion the wind speed increases rapidly to the free atmospheric wind speed. Above the level of the temperature inversion the wind speed increases as consistent with the wind gradient.

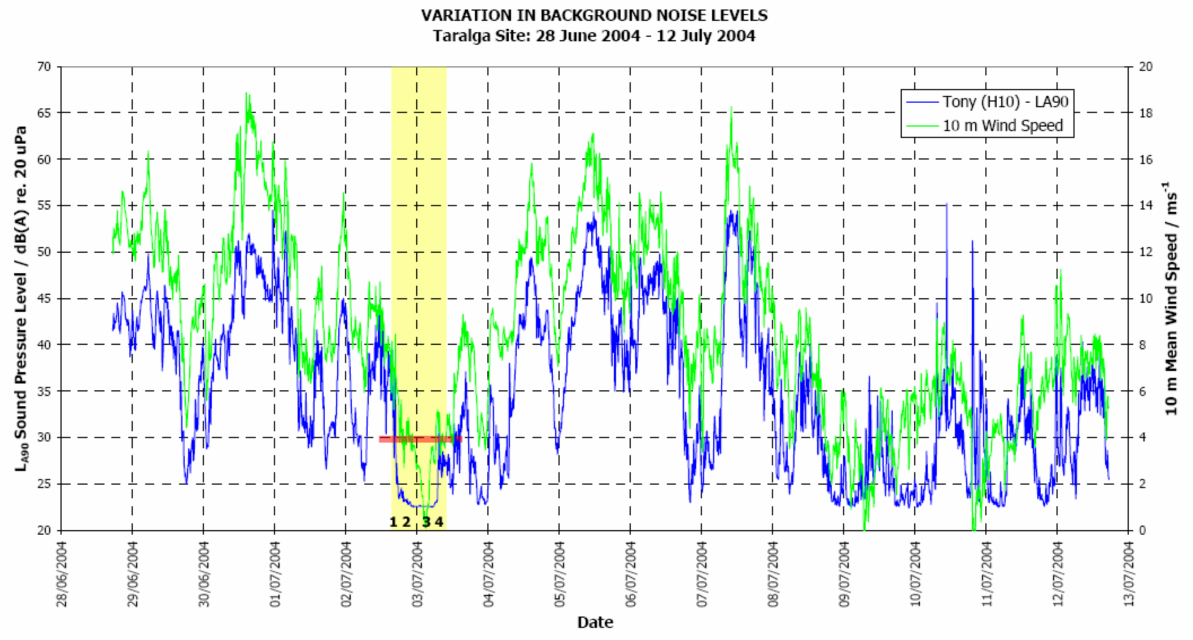
**What is demonstrated here is that under the conditions depicted by image 4 and described above, the method used by the NIA would have produced a 10 metre wind speed of zero, a background noise level of zero and a turbine noise output level of zero (due to its inclusion of 10 metre wind speed as a factor). In reality the 10 metre wind speed and hence background noise level were indeed both zero, but the turbine noise output level was above zero (due to the 69 metre wind speed being the required factor).**

## A real-life example from the EIS

Below is a graph which appears in the NIA (Taralga EIS, Appendix H, p17). It displays the measured background noise at H10 against the wind speeds at a height of 10 metres (around 44 metres above H10) measured nearby.

**Image 5**

**Figure 1.5 Measured Background Noise Levels at Taralga – Phase 1**



I have highlighted the period representing the night of July 2 (into July 3), 2004 for consideration. It is an example of what image 4 above depicts in action.

At time (1) – the evening of the 2nd - we see the background noise levels at H10 drop off rapidly. This is an indication that the sun has just set and the surface inversion has begun to form. At this time even the 10 metre winds are above turbine cut-in speed (approximately 4ms$^{-1}$ (Taralga EIS, Volume 1, p2.10), highlighted in red).

Between times (1) and (2) there is near-silence at H10 as the ground radiates heat and the inversion layer deepens but the wind speeds at 10 metres suggest that the wind speeds at 69 metres would certainly be strong enough for the turbines to remain operational.

At time (3) – the early hours of the morning of the 3rd - the inversion layer finally reaches 10m at the monitoring mast (44 metres higher than H10). The briefness of the period of calmness at the monitoring tower suggests that as in image 3 the inversion layer didn't get any deeper and the turbines were likely to be operational throughout the period. There is complete silence at H10.

At time (4) – mid-morning on the 3rd - the inversion layer finally breaks down and the fog clears as the ground is heated once more by the sun. The winds that have been present above the inversion layer all along are once again allowed to mix back down to the surface and ambient noise returns at H10.

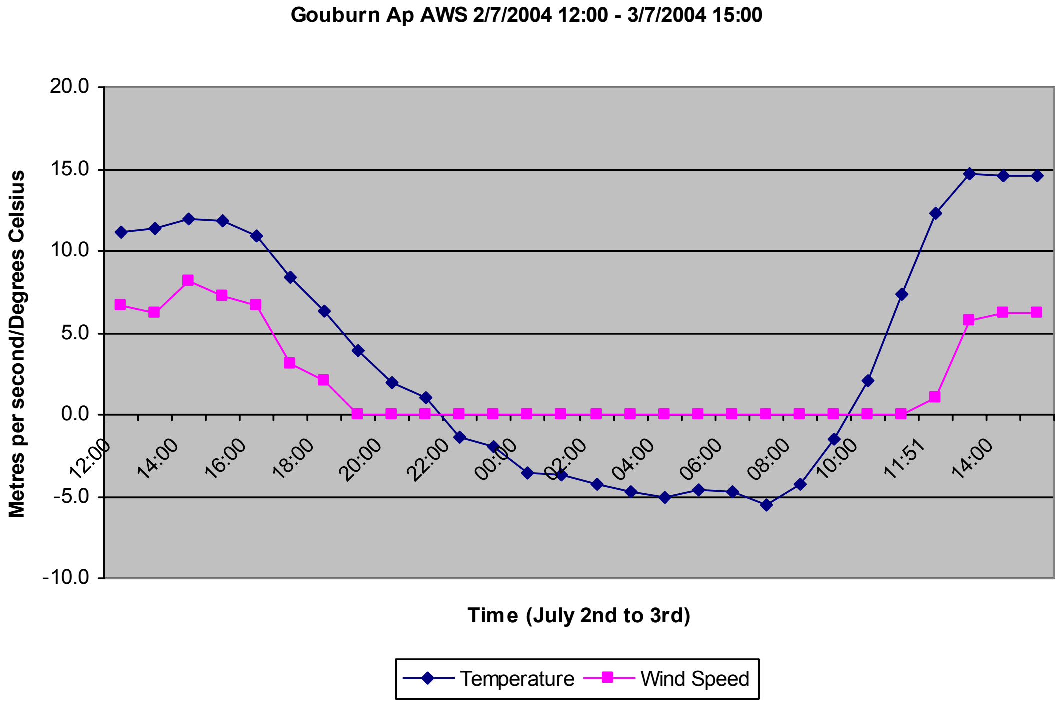
The data in the graph confirms that this pattern is quite common, particularly that data in the final week of the survey. Note that the survey only spans a little over a fortnight.

For extra background I have included and summarised some independent and more detailed meteorological observations from both the Taralga Post Office manual weather station and the Goulburn Airport automatic weather station for 2nd and 3rd (Bureau of Meteorology).

Firstly, the observations from Taralga Post Office are noted and summarised below.

| **Time** | **Weather** | **Summary** |
|---|---|---|
| 9am, July 2. | Weather: None.<br>Wind: Moderate westerly<br>Temperature: 7.4°C | This indicates that winds were present during the 2nd. These winds are displaced upwards some tens of metres overnight by the surface inversion. |
| Daytime, July 2. | Maximum temperature: 11°C | 1°C above average. |
| Nighttime, July 2. | Minimum temperature: -4°C | The severity of the frost indicates that a deep surface inversion formed. |
| 9am, July 3. | Weather: Fog clearing.<br>Wind: Calm.<br>Temperature: 0.5°C | The clearing fog and the temperature both indicate that the inversion is still breaking down. The timing is consistent with the indications of the graph in image 5. |

Secondly, the temperature and wind speed at a height of 10 metres at Goulburn Airport are graphed below for the period between midday on July 2 and 15:00 on July 3. This data shows the 10 metre winds becoming calm overnight as the nocturnal inversion and associated frost form, and returning late in the morning as the inversion breaks down.



## Conclusion

The validity of the information provided above, the detail supplied in the document entitled 'Effects of the wind profile at night on wind turbine sound' and the plight of many windfarm affected residents both in Australia and abroad all indisputably suggest that the results of Noise Impact Assessments being provided by developers are critically flawed.

In Taralga's case I would suggest given the proximity of neighbours to landowners signed up with the developer that the noise issue cannot possibly be addressed satisfactorily. This then is enough reason to reject the development.

At least I would recommend that the Department demand a more adequate Noise Impact Assessment from the developer, specifying that it include input wind measurements taken at the proposed turbine height. This way there is no speculation and it is less likely that we will repeat mistakes that have been made elsewhere.

# Appendix A – References

Anon. 2004, **Environmental Impact Statement – Taralga Windfarm**, Prepared for RES Southern Cross PTY LTD by Geolyse

Anon. 2003, **Environmental Noise Guidelines: Wind Farms**, Environment Protection Authority – South Australia

Anon. 2003, **Acoustic report for a wind energy converter type NEG Micon NM 82/1650, hub height 93.6m**, WINDTEST Grevenbroich GmbH (this document is provided as Appendix C under Taralga EIS, Appendix H)

van den Berg, G.P. 2003, **Effects of the wind profile at night on wind turbine sound**, Journal of Sound and Vibration (this document is available online at http://www.sciencedirect.com)

Lance, Leut. B. 2004, **Winter Westerlies**, Royal Australian Navy, Nowra
http://www.navy.gov.au/publications/touchdown/html/april2004/winter.htm

Foley, J.C. 1945, **Frost in the Australian Region,** Commonwealth Meteorological Bureau
J. J. Gourley, Government Printer, Melbourne. Pages 12, 17, 141

## Appendix B – Communication to the Environment Protection Authority – South Australia

The following is a comment I sent to the EPA-SA regarding their 'Environmental Noise Guidelines: Wind Farms'. The communication was not responded to.

> *Attn: Information Officer*
> *Environment Protection Authority*
>
> *I would like to make a comment on the document entitled 'Environmental Noise Guidelines: Wind Farms' (ISBN 1 876562 43 9) which you published in February 2003 and would appreciate a response including any remarks or explanations you may have.*
>
> *My comment relates to the practice of using wind speed data at a height of 10 metres for establishing both background noise levels and wind farm turbine noise levels, as prescribed by your document.*
>
> *The validity of this practice appears to rely on the idea that wind speed at turbine height (say 70 metres) can be calculated from the wind speed at 10 metres using a linear equation. Using this idea, one could go on to assume that when the wind speeds lower at 10 metres the noise generated by a turbine also lowers. This idea is meteorologically unsound.*
>
> *In fact, a scenario where the wind speed at 10 metres and below is zero and the wind speed at turbine height is above turbine cut-in (say 3.5 metres per second) is common - particularly at inland locations, at night and during winter.*
>
> *This scenario generally comes about due to nocturnal radiation of heat from the earth's surface causing the formation of a cold, still layer near the surface underneath a temperature inversion. The depth of this layer is often such that background noise at the surface in the area of wind turbines is nil but turbine noise remains significant. The depth of this still layer would seldom ever reach turbine height.*
>
> *Your noise guidelines do not appear to address this likelihood.*
>
> *I would appreciate your comments on this matter including whether or not you consider your guidelines suitable for locations outside of South Australia.*
>
> *Kind regards,*
> *Andrew Miskelly.*

# Appendix C – Information on nocturnal (radiation) temperature inversions

Gill, A.E. 1982, **Atmosphere-Ocean Dynamics**, Academic Press

Blackadar, A.K. 1957, **Boundary layer wind maxima and their significance for the growth of the nocturnal inversion**, Bulletin of the American Meteorological Society. Pages 38, 283-290

Foley, J.C. 1945, **Frost in the Australian Region,** Commonwealth Meteorological Bureau
J. J. Gourley, Government Printer, Melbourne. Pages 12, 17, 141

Lance, Leut. B. 2004, **Winter Westerlies**, Royal Australian Navy, Nowra
http://www.navy.gov.au/publications/touchdown/html/april2004/winter.htm