VISUAL AND NOISE EFFECTS REPORTED BY RESIDENTS LIVING CLOSE TO MANAWATU WIND FARMS: PRELIMINARY SURVEY RESULTS

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ABSTRACT

Since 1996, when Tararua Wind Power Limited commenced the construction of 48 wind turbines, the number of existing wind turbines on the Ruahine and Tararua ranges has risen dramatically, to 158 in 2006, with more to come from unimplemented, approved resource consents. The companies behind the applications have won plaudits for the development of sustainable energy generation. However, the effects of wind energy can be controversial. In particular, it is reported in other countries that those who live near the wind turbines may suffer from undesirable visual and noise effects, and the national benefits and local costs may not be in balance. Assessing the precise impact of future wind farm development is important, since the number of proposed wind farms is likely to grow in the coming years. The objective of this study was to investigate the noise and visual effects on local residents from the existing wind turbines in the Manawatu and Tararua region. A total of 1100 urban and rural residents, the majority living within a 3km radius of the wind farms in the Tararua and Manawatu districts were administered a self-reporting survey. The survey asked residents to assess the visual and noise effects of the closest wind farm. This paper presents preliminary results from this study. It demonstrates that 45 percent of respondents living within 2km heard noise from the turbines, and 80 percent thought that the turbines were visually intrusive.

1 INTRODUCTION

New Zealand has a national goal of increasing the supply of renewable energy, such as wind farms, which is expressed in part by amendments to the Resource Management Act 1991 (RMA). The amendments elevate the importance of renewable energy as a consideration for decision makers to approve or decline a resource consent application. The recent Parliamentary Commissioner for the Environment's report on wind farms presents several scenarios for future wind farm development by 2016 with extremes ranging from 1,300 1.5MW turbines in 65 wind farms, to 67 3MW turbines in 7 windfarms [1]. Wind farms tend to be located in prominent locations, such as open or coastal areas and ridgelines. Most are

located close to existing infrastructure, such as a transmission line, and roads to reduce development costs. A wind farm consists of the turbines as well as substantial roads, buildings for substations etc., yards and high voltage transmission lines. The expansion of windfarms is likely to cause conflicts, particularly when this expansion occurs near existing housing. The benefits of wind farms are typically accrued nationally and include providing a renewable energy supply. The negative impacts are felt locally and include visual amenity and noise. Given the potential growth of windfarms, examining how these conflicts are addressed should be an important area of research.

Under section 104 of the RMA, planners are required to assess whether the effects of a wind farm can be avoided, remedied or mitigated. An applicant for a resource consent must include an assessment of environmental effects respecting the proposed project. This requirement has already generated a number of landscape assessment reports to show the perceived visual effects, noise modeling and related predictive modeling. However since industrial-scale wind farms are relatively new in New Zealand, little research on existing wind farms exists on post-installation visual and noise effects.

The objective of this study was therefore to undertake a survey of the visual and noise effects experienced by residents' who live near wind farms on the Ruahine-Tararua ranges near Palmerston North. This area is ideally placed to inform understanding of wind generation in New Zealand, due to its concentration of existing wind farms. In this region, there are currently 158 turbines operational with a generation capacity of up to 300MW of wind energy. A further 128 turbines have been consented or are under construction; a development consisting of 129 turbines is in the resource consent and proposals are being developed for at least one other wind farm with more than 60 turbines. In other regions of New Zealand further large scale wind farms are also in the planning or consent stage.

It is generally agreed that a buffer zone between wind farms and housing is important to minimize visual and noise effects but the size of this zone has been subject to considerable debated. To date few turbines have been built within 1km of existing residences in New Zealand. However, with wind farms that are currently seeking consent, the distances between proposed turbines and existing homes is now under 600m.

We aim to investigate and inform planners about the potential effects of wind farms from a visual amenity and noise perspective. Specifically, this paper presents the preliminary analysis of this survey, in which we aimed to answer the following two questions:

- What are the most important visual amenity effects from the wind farms?
- What percentage of residents can hear the noise produced by the wind farms and does wind farm noise vary with distance?

A survey was delivered to 1100 households mostly within 3km of the existing wind farms in the Manawatu/Tararua region. This area is located near a mountainous range known for strong and shifting winds.

To date few turbines have been built within 1km of existing residences in New Zealand. However, with wind farms that are currently seeking consent, the distances between proposed turbines and existing homes is commonly creeping under 600m. A household that was only 400m from the Te Apiti wind farm was deemed uninhabitable and the occupants were relocated by the wind farm owner after irresolvable noise issues [2].

In other regions around New Zealand, many large scale wind farms are in the planning or consenting stages. The recent Parliamentary Commissioners for the Environment report on wind farms presents several scenarios for future wind farms with a high level of development in New Zealand by 2016 with extremes ranging from 1,300 1.5MW turbines in 65 wind farms, to 67 3MW turbines in 7 windfarms [1].

This paper presents the preliminary analysis of this survey as well as a review of the latest research on noise and wind farms. We then describe the method that we employed to survey residents and describe our results. We conclude by highlighting the effects of wind farms and propose future avenues for research.

2 RECENT LITERATURE ON THE EFFECT OF WIND FARMS

2.1 PUBLIC ATTITUDES TO WIND FARMS

Most New Zealanders support sustainable energy, and consider wind farms as a clean, green source of energy [1]. A survey conducted on behalf of EECA on public opinions in New Zealand found that of the 750 people surveyed, 58.9 percent thought they were environmentally friendly, 0.1 percent thought they were attractive, 24.9 percent thought they were ugly, and 14.7 percent thought noise was a disadvantage [3].

However, the development of industrial-scale wind farms near existing housing is contentious, and achieving a balance between national interests and local effects is precarious. Both in New Zealand and overseas, opinions among residents who live near wind farms vary greatly. Some are in favour of turbines and consider them as unobtrusive and visually attractive. Others are strongly opposed to wind farms, citing concerns that they ruin the visual quality of the environment, produce noise pollution and adversely affect wildlife [4]. In Europe, community protests have had a significant impact on the introduction of wind power generation schemes [1] and it has been estimated that public opposition has prevented planning permission being granted for about 50 percent of European proposals. In the Netherlands 75 percent of proposals have been refused [5]. A report prepared by the European Renewable Energy Council [1] stated that:

> *"For many years, wind energy was considered environmentally sound. But recently, major social objections and land use concerns related to operation and siting of turbines have been raised. Social acceptance is one of the greatest limiting factors of wind's potential growth."*

In New Zealand few submissions were received in opposition to earlier wind farm proposals, however more recent proposals have seen an increase in both number and sophistication of submitters in opposition. A review of resource consents heard between 1996 – 2005 revealed:

- *An increasing number of objectors*
- *Increasing sophistication of the objections*
- *Increasing uncertainty on the part of the applicant as to the likely success at hearing, in particular how many turbines may be allowed*
- *Increasing requirement for consultation by the applicants* [6]

2.2 VISUAL EFFECTS

Although visual assessment techniques can inform the public how a landscape will look after it has been developed as a windfarm, mitigating this visual effect remains elusive. This was evident at the Meridian West Wind, Makara, wind farm resource consent hearing and the joint Unison Networks Limited and Hawkes Bay Wind Farm Limited hearing, where there was little agreement between the experts [7, 8]. In the latter hearing the Environment Court made the following comments;

> *"It is self-evident that landscape issues are matters about which reasonable and informed people may hold conflicting views. It is not possible to say that one is right and another is wrong....turbines need to be on or near ridgelines, and will often*

be on skylines, and there is no real prospect of remedying or mitigating their adverse visual effects. Either the activity proceeds, or the effects are avoided by refusing consent."

Guidelines developed in Europe specific to the visual effects of wind turbines [9] have not been applied so far as a condition for resource consent in New Zealand. These guidelines provide a matrix showing an increasing visual effect with decreasing distance between the wind farm and the receiver and/or increasing height of turbines. They include assessment criteria that may be useful in New Zealand.

Turbines are visually unique elements in the landscape due to their:

- height (often taller than a 30 storey high rise building)
- the number of blades, 2 or 3
- spacing between turbines and placement, such as clustering, or arranged in rows
- colour
- movement, which contributes to their visibility, visual stimulation and attracts the eye [1]
- flickering shadows [10].

Due to their height and need for wind, turbines are not easy to screen or hide and the *"highly modern, technological and large scale nature of windfarms can dominate..."* [1]. The scale and prominent location of wind farms means the visual impact can extend well beyond the site. In the hearing for Tararua wind farm (stage 3) James Baine, [11] an expert presenting a social impact assessment for TrustPower stated:

"For the immediate community of interest and neighbours, separation distance between dwellings and turbines is a critical factor in assessing the significance of effects. This highlights the importance of buffer areas between dwellings and turbines. A separation distance of 2.0-2.5km appears to be the threshold below which acceptance is more likely to be replaced by negative sentiments from neighbours who experience no direct benefits."

All existing New Zealand wind farms have been developed in rural settings. They therefore impact on rural amenity in several ways. For example, *"they introduce large potentially discordant structures that are not associated with normal types of rural activity. The associated works such as roading and earthworks can be at a scale that is unfamiliar in rural areas"* [1]. This may influence public acceptance of subsequent proposals.

2.3 CUMULATIVE VISUAL EFFECTS

Several wind farms located in close proximity can create cumulative effects. This is particularly pertinent to their visual impact. The cumulative visual effects have not so far been comprehensively addressed in New Zealand, possibly because it is a relatively new phenomena in this country, but have been researched elsewhere, notably in a report by the Scottish Natural Heritage [12]. This report lists the effects on the visual amenity and landscape from wind farms as a function of:

- the number of and distance between individual wind farms
- how wind farms relate to each other visually
- the overall characteristics of the landscape and its sensitivity to wind farms
- and the siting and design of the wind farm.

While the cumulative effect on the whole of New Zealand may not be significant, the cumulative effects at a regional or localized level can be significant [1]. The Tararua ranges, near Palmerston North is a New Zealand example where several wind farms of

different height turbines, tower types and number of blades have been located together. The Parliamentary Commissioner's report on wind farms states that this raises concerns for cumulative effect in this region. Wind farms are not unique in this regard. Other reports prepared by the Parliamentary Commission for the Environment state that the RMA has not adequately addressed the cumulative effects of other land uses such as subdivisions and urban development [13] This suggests that cumulative visual effects of wind farms should receive closer attention in the consent process and should be a specific section of a visual assessment.

2.4 NOISE

Noise is one of the most frequently raised concerns, both in New Zealand and overseas about wind farms [1]. Wind turbines generate noise from a number of sound production mechanisms related to the interactions between the turbine blades and air, and as the blade passes the tower. Gear box and generator noise in modern turbines is not significant when turbines are new but increases significantly as turbines wear [14].

New Zealand planners have recourse to a non-mandatory standard that is specific to the noise from wind turbine generators (*NZS 6808: 1998 Acoustics - The Assessment and Measurement of Sound from Wind Turbine Generators*). This standard is designed to provide a level of investigation and reporting that may be specified by land use planning procedures under any relevant legislation' [15]). This Standard also allows for Councils to apply their own noise criteria to be used, such as noise criteria given in their District Plan.

NZS6808 uses a simple propagation model that does not account for wind, ground or topographical effects, such as contours, and uses a simplified approach to account for atmospheric effects [15, 16]. This can underestimate both the noise produced and transmission of this noise. A four day caucus of acoustic consultants for the West Wind wind farm hearing heard before the Environment Court, found that NZS6808 is workable but has some significant technical deficiencies that need addressing, such as atmospheric effects [17]. A member of the West Wind acoustic caucus concluded that there is a temptation to only fulfill the requirements of the standard without considering the complex nature of wind farm noise, such as third octave data, topographical effects and atmospheric stability [18]. In practice, the application of NZS6808 may too simplistic an approach to something that is as complex as noise from a wind farm [16].

The approach of Standard NZS6808 is unusual in that it allows wind turbines to produce noise up to the greater of 40dbA or ambient noise levels plus 5dbA. The premise of this approach is the wind that makes turbines turn will also produce masking noise. However, van den Berg (2006) has found that with modern turbines, which can be 80 – 110m tall, there are frequent periods with sufficient wind at hub height to turn the turbines and generate noise, with corresponding stillness and lack of masking noise at ground level. He found that this effect is most pronounced at night time. Van den Berg, has concluded that the number and severity of noise complaints near wind farms are partially explained by three findings;

- that actual sound levels are considerably higher than predicted noise
- wind turbines can produce noise with an impulsive character which has been described as a "wump, wump sound" each time the turbine blade passes the tower [19, 20]
- noise measurements, which are expressed as averages of sound energy, substantially under represent the loud/quiet nature of the pulsing sound produced by turbines.

This study found residents up to 1900m away from wind farms expressed annoyance with noise, which is contrary to conventional wind industry calculations, which assumes minimal noise beyond 500m. Significant variations occurred between day and night time noise due to higher wind speeds at hub height turning the turbines during the night hence producing night time noise compared to lower wind speeds and a consequent lack of masking noise at ground level close to residences [20].

This research highlights some of the technical shortcomings that could be addressed in NZS 6808:1998. The standard was due for review in 2006, however the revised version has yet to be released. It is of interest that a household that was only 400m from the Te Apiti wind farm was deemed uninhabitable and the occupants were relocated by the wind farm owner after irresolvable noise issues [2].

2.5 CUMULATIVE NOISE

Some acoustical consultants consider the approach of NZ6808 in focusing on ambient sound plus 5dbA as erroneous, especially in areas with staged wind farm developments, or where there are a number of wind farms close together. In these situations, each subsequent development or stage of a development is permitted to build on the noise produced by existing turbines, with a net effect of ramping up ambient noise [14].

2.6 LOW FREQUENCY NOISE

Noise, especially low frequency noise, is a particularly contentious component of a planning consent assessment. Some acoustic consultants argue that low frequency noise is below the threshold of hearing, and is therefore undetectable (Leventhall 2005). It is not well addressed in NZS6808:1998 which uses only the dBA scale, which excludes low frequency noise [15].

However, low frequency noise disturbance has been well documented as an effect from wind turbines [18, 21-23]. The Report of the Noise Review Working Party 1990 published by the Department of the Environment [24] commented on low frequency noise as follows: ...."*Low frequency noise can have serious effect on the quality of life of those affected by it".* The Batho report and others [25] cited low frequency noise as a significant issue for regulators and planners, due to the difficulties with measuring it and mitigating it. The Casella report has cited low frequency noise as having several pertinent features different to other frequencies of community noise:

- low frequency noise is not attenuated with distance from the source, making low frequency noise more prominent at greater distances
- low frequency noise is not attenuated by typical building envelope designs to the same extent as other frequencies making low frequency more prominent inside a building
- inside buildings resonance can be set up inside a room with nodes (quiet points) and antinodes (loud points), which can elevate low frequency noise inside a room
- older peoples' hearing is proportionally more acute at low frequencies than other mid or high frequencies and
- low frequency noise can cause light weight elements of a building structure to vibrate.

2.7 HEALTH EFFECTS OF NOISE AND LOW FREQUENCY NOISE

Adverse health effects have been reported from wind farm neighbours. The World Health Organisation (WHO) has defined health as *"a state of complete physical, mental and social wellbeing, and not merely the absence of infirmity."* The WHO guidelines for community noise list specific effects to be considered when setting community noise guidelines. These include interference with communication; noise induced hearing loss; sleep disturbance effects; cardiovascular and psycho-physiological effects; performance reduction effects; annoyance responses; effects on social behaviour [26].

Symptoms akin to vibroacoustic disease [27] and increased frequency of hypertension and cardiovascular illness have been reported by people living close to wind farms. Although complex and controversial, it is thought that these symptoms arise from a combination of persistent audible noise, flicker and low frequency noise destabilising the human body (Stewart 2006). Hearing has evolved from our survival instincts to respond to danger as well as to alert, warn and communicate; our hearing is operational even when people are asleep. As a result, both wanted and unwanted sound directly evokes reflexes, emotions and actions which are both stimulants and stressors. The auditory system has the fastest response rate in the human brain and processes information hundreds of times faster than other senses [28]. The extent to which noise is a stimulant or stressor is a factor of noise source, onset of the noise, duration and characteristics of the noise and whether the exposure is voluntary or involuntary [29].

Worldwide there have been calls to have a mandatory buffer zone of 1.6km around wind farms, and in many situations an even greater distance between wind farms and residences, so as to avoid noise and visual impacts [30], Stewart 2006). However, until recently there has been little research conducted in New Zealand on the effects from current wind farms to inform the political or planning process. Consequently, we conducted a survey of visual and noise effects to inform the consent process.

3 METHOD

A four-page, self-reporting survey was developed to investigate the visual and acoustical effects experienced by residents who live within 3km of existing wind farms in the Manawatu and Tararua region. Some surveys were delivered to residence outside the 3km notional ring, in order to survey a complete street. Questions were asked about the distance from respondent's house to the nearest turbine, whether they could see turbines from their home, visual impacts, noise impacts, financial gain from the wind farms, effects on television, radio and phone reception, whether they had complained or considered complaining about the wind farm effects. Other questions canvassed their views on future developments and descriptor data, including the number of persons living in the household and length of time living at the address.

Prior to administration, the survey was peer reviewed by two senior academics with considerable expertise in questionnaire design and trialed on a small sample of people not living in the subject region. One of the peer reviewers was a Chair of a Massey University Ethics committee and advised that ethics approval was not required due to the low sensitivity of the questions and appropriate provisions for anonymity of respondents.

The survey was divided into 5 sections; visual, noise, general, complaining about wind farm effects, future developments, and household details. However, as only the visual and noise effects is the subject of this paper, other data will be reported in a subsequent paper. Most