



The University of
Nottingham

Noise Issues, Noise Levels and Noise Perception from Small and Micro Wind Turbines

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INTRODUCTION

RESEARCH OUTLINE

This research investigates different individuals' perception of noise attributed to small wind systems compared to the measured environmental noise levels for a number of different installations.

- ***Psychology***
 - Perception of turbine sounds
 - Links with traits, attitudes and symptoms
- ***Faculty of Engineering***
 - Measurement of environmental noise levels
 - To understand the precursors for aerodynamic noise

SURVEY METHODOLOGY FORMAT

Questions about turbine and sounds

- Occurrence and loudness of perceived sounds

Personality scales

- STAR
- Frustration Discomfort
- Neuroticism
- PANAS

Health questions

- Experienced symptoms in last month

General Questions

- Age, sex, occupation, dwelling etc.

NOISE MEASUREMENTS

Equipment:

- ✓ Bruel and Kjaer Investigator (include windscreen);
- ✓ Microphone;
- ✓ Software 2260;
- ✓ Tripod.

Plus equipment to measure:

- ✓ Temperature;
- ✓ Atmospheric pressure;
- ✓ Distance;
- ✓ Sound signal;
- ✓ Wind speed and direction.

Identify:

- ✓ Measurement positions;
- ✓ Distances;
- ✓ Time periods.

Take:

- ✓ Non-acoustical measurements;
 - ✓ Acoustical measurements.
- Record sound signal.**

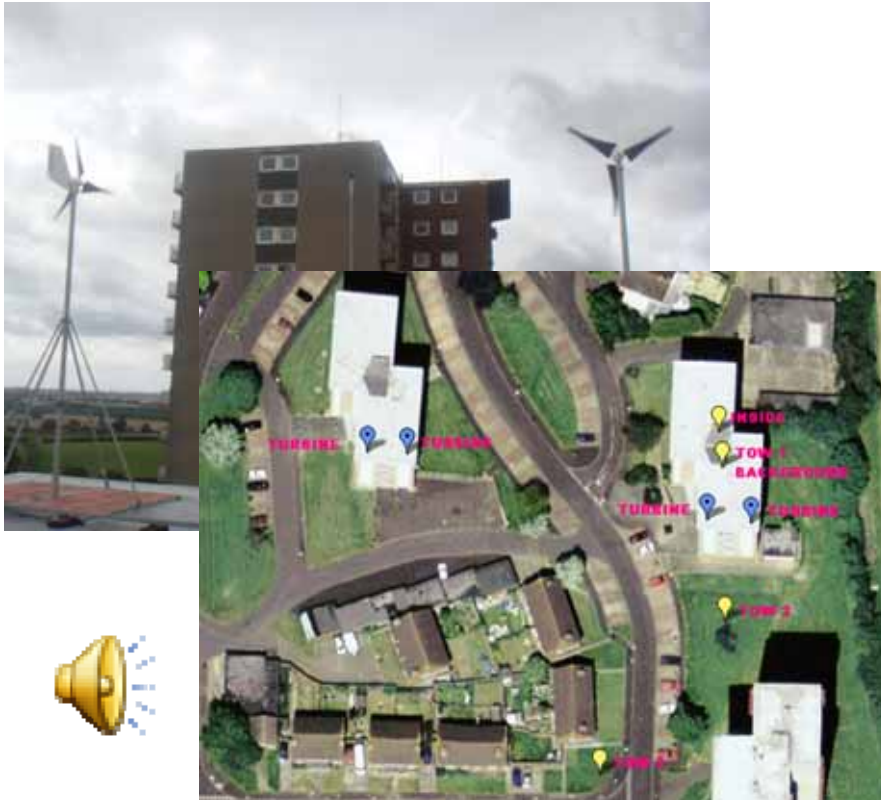
Analyze data:

- ✓ Third octave spectrums for L_{10} , L_{90} and L_{eq} ;
- ✓ A-weight;
- ✓ Correlate to wind speed/direction etc.

EXAMPLE INSTALLATIONS

Installation 1

- Two 0.6kW Micro Turbines
- Rotational Speed \approx 1000rpm
- Rotor Diameter 1.7m



Installation 2

- Two 5kW Small Turbines
- Rotational Speed \approx 200rpm
- Rotor Diameter 5.4m



SURVEY

INITIAL FINDINGS

Characteristics of Sample Population

- 138 Responses from 12 different installations
- Missing responses to some questions
- 11% Response rate

	<i>N = 138</i>
Age (Range 20-95 years)	53.80 ± 15.591
	<i>Sex</i>
Females (%)	45.6
Males (%)	54.4
	<i>Wind Turbine</i>
Attitude to Wind Power	2.33 ± 1.764
Can see a turbine (%)	64.8
Turbine attached to building (%)	14.8

- *Attitude range – 1 = ‘very positive’ to 7 = ‘very negative’*
- *Attitudes to wind turbines is not affected by visibility*
 - *Results of a independent samples t-test p=.001*

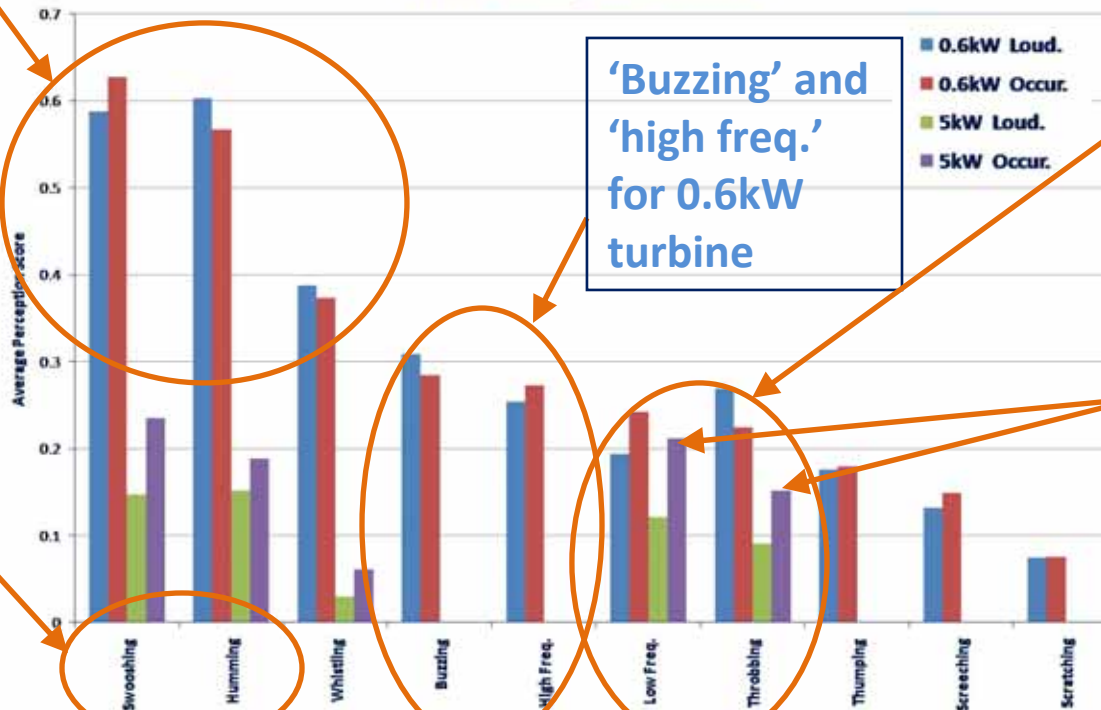
SURVEY

INITIAL FINDINGS

Wind Turbine Sounds

- Respondents who can see a turbine from their dwelling report significantly increased noise.
 - Results of a independent samples t-test $p=.001$

Noise Perception Scores



Scores higher for 0.6kW turbine

'Buzzing' and 'high freq.' for 0.6kW turbine

'Low freq. and throbbing' rank higher for 5kW

Top sounds are 'swooshing' and 'humming'

Ranking different for 0.6kW and 5kW turbines

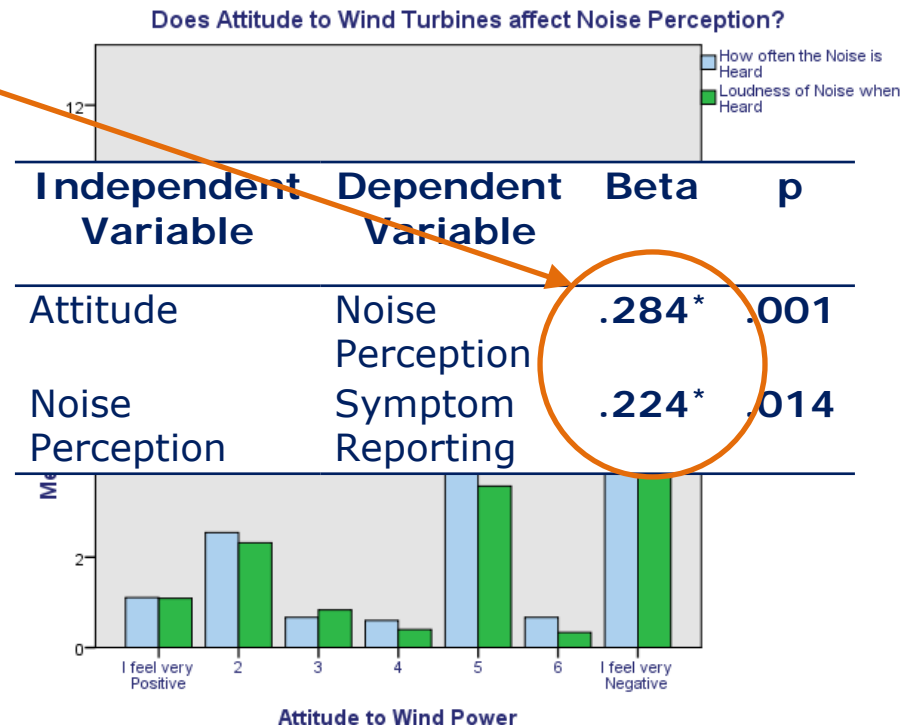
SURVEY

INITIAL FINDINGS

Attitudes, Noise Perception and Symptoms

- Linear regression test to determine whether:
 - Attitude predicts noise perception;
 - Noise perception predicts symptom reporting.

- Significant results ($* p < 0.05$)
 - More negative attitudes predicts increased noise perception;
 - Those reporting higher noise report more frequent symptoms.



SURVEY

INITIAL FINDINGS

Introducing Personality Variables

- Hierarchical linear regression introducing age and sex and personality variables.

Independent Variables	Dependent Variable					
	Attitude		Noise Perception		Symptoms	
	Beta	p	Beta	p	Beta	p
<i>Model 1</i>						
Age	.232*	.018	-.111	.250	.054	.577
Sex	.020	.833	-.005	.958	.060	.535
	R = .231		R = .111		R = .078	
<i>Model 2</i>						
Age	.191*	.039	-.097	.276	.088	.313
Sex	.022	.804	.024	.779	.081	.328
PA	-.427*	.000	-.342*	.001	.023	.810
NA	.382*	.000	.446*	.000	.204*	.037
Neuroticism	.104	.396	.122	.307	.410*	.001
FD Discomfort	.316*	.031	-.178	.210	.366*	.009
FD Emotional	-.142	.392	.348*	.034	-.158	.314
STAR Frustration	-.054	.591	-.080	.414	-.038	.691
	R Square = .290*		R Square = .282*		R Square = .325*	

- Significant results highlighted (* $p < 0.05$)

QUESTIONNAIRE

INITIAL FINDINGS

Positive

“I think the turbines are a great idea to save money and love to hear them humming/throbbing along with the strong wind.”

“.....although when windy it can be loud it is by no means irritating.”

Negative

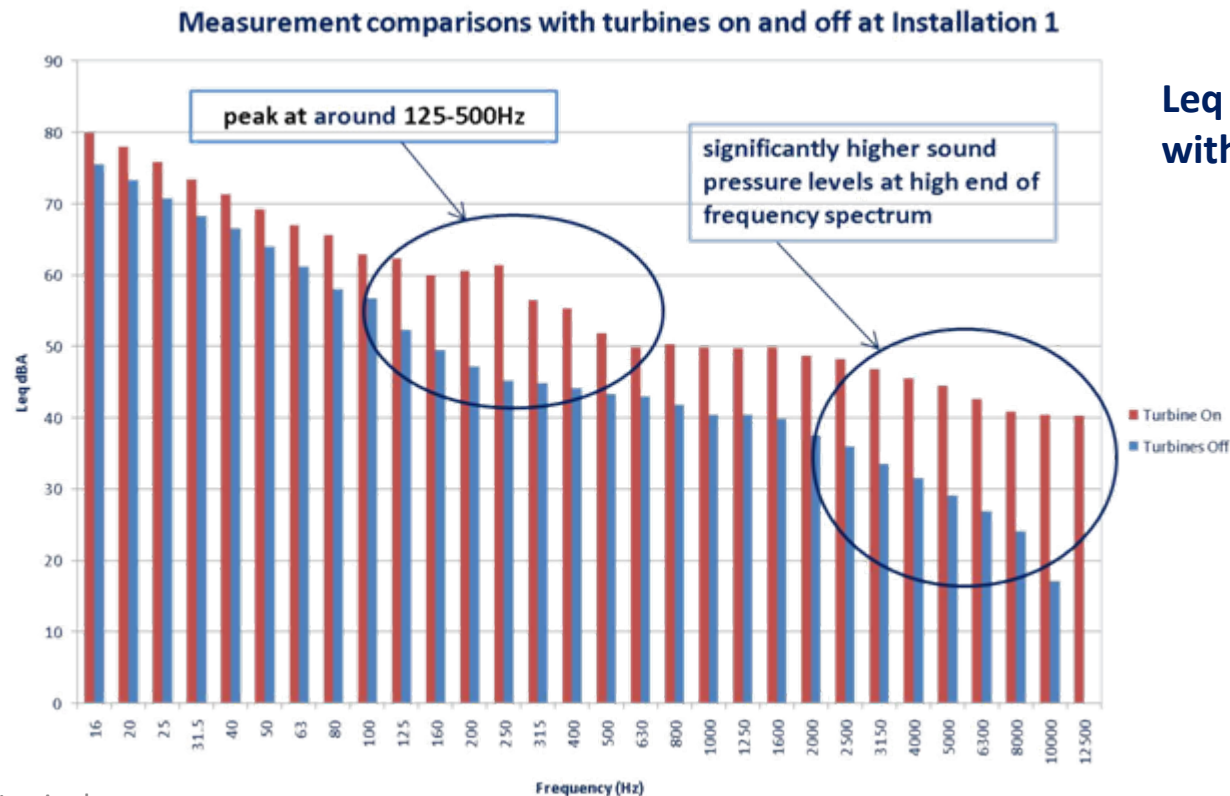
“The small wind turbine make a BIG NOISE. We can't sleep and take rest out from the terrible noise.”

“While the wind turbine is switched on, it is very noisy. At night time I am not able to sleep. I have to work and the lack of sleep causes me mood swings.”

NOISE ANALYSIS

INITIAL – Inst. 1, 0.6kW Micro Turbine

- **Spectra results from Installation 1**
 - 14m from turbines at 7m/s winds
 - Comparison with turbines on and off

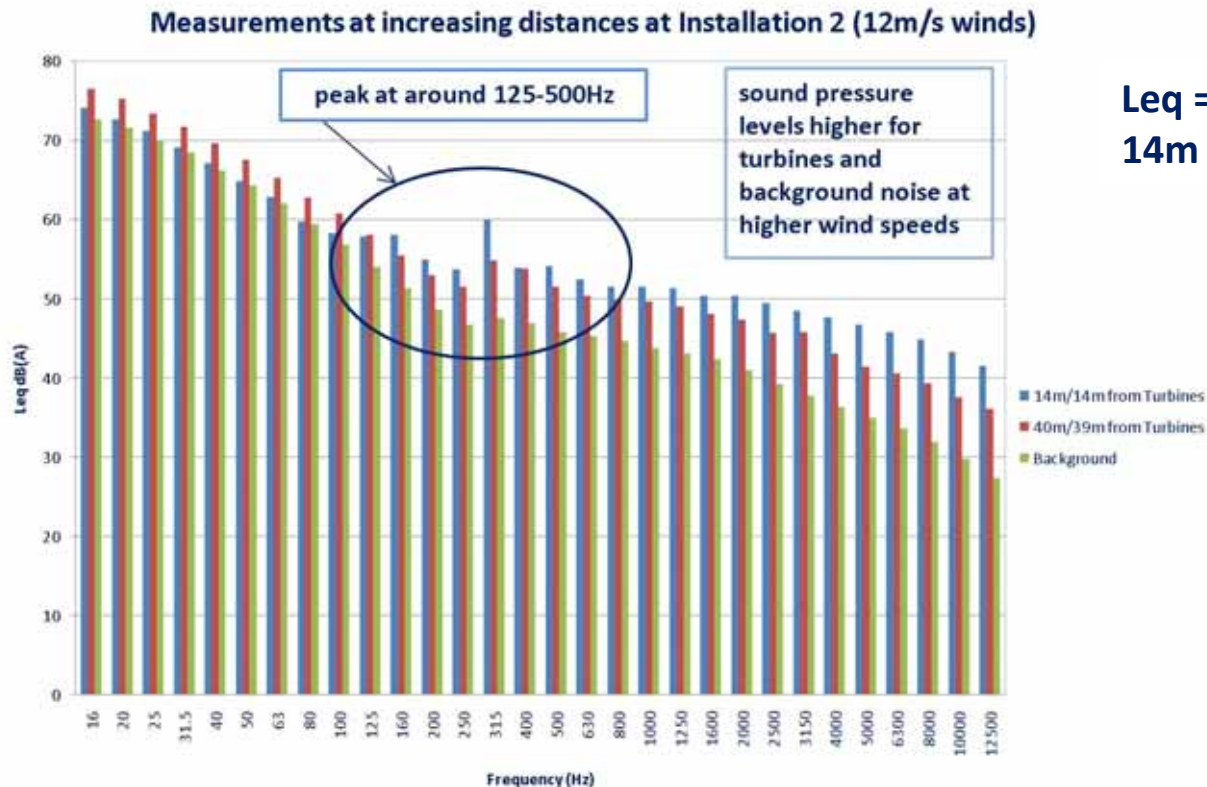


**Leq = 62.02dBA
with turbines on**

NOISE ANALYSIS

INITIAL – Inst. 2, 5kW Small Turbine

- **Spectra results from Installation 2**
 - Measurements at 3 locations
 - Comparison at increasing upwind distances



Leq = 63.19dBA
14m from turbines

SOUNDS AND SPECTRA

- ***Leq levels are NOT high***
 - Characteristics of noise may cause annoyance
- ***'Swooshing' is top perceived sound***
 - Broadband nature
 - Can be seen in spectra at higher frequencies
- ***Peak in spectra***
 - May be due to blade passing frequency
- ***'Whistling' reported from 0.6kW type***
 - Tonal in high frequency range
- ***'Low freq.' reported from 5kW type***
 - BUT turbine noise not apparent from spectra at low frequencies
- ***'Screeching', 'thumping', 'scratching'***
 - Not perceived from survey or spectra



Any Questions?

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