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Urbines: Roof top urban wind turbines- A comparison of horizontal and vertical axis designs

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ABSTRACT

The current planning guidance in London requires that all new or refurnished large buildings should include 10% renewables. As part of a study two urbines have been erected on a residential building in central London to determine the effectiveness of locally generating electricity using wind power. The two urbines are a Proven 6 kW traditional turbine and an experimental vertical axis Quiet Revolution 5 turbine. The investigation includes long term wind, weather, noise, electricity and vibration monitoring. The effect on the residents, the local community and the building structure has been determined. The electricity utilization has been calculated over 1.5 years for the Proven urbine and 0.5 years for the QR urbine.

1. INTRODUCTION

Elephant and Castle is undergoing urban regeneration, 40 hectares will be redeveloped between 2006 and 2018. This part of the project was designed to establish which type of urban wind turbine is most effective, whilst minimizing the effect on the residents and community. The first urbine, a Proven 6 kW turbine, was installed in June 2007; the second, a Quiet Revolution 5 was installed in June 2008. The urbines were installed on condition that a noise and vibration report covering the initial 3 months was acceptable to Southwark Council. Ashenden House, an 11 storey concrete residential building on the Heygate Estate, was used as the pilot site. Monitoring was undertaken on the roof top and in an unused flat directly beneath the primary urbine. In addition, wind, weather and electricity produced were recorded. This paper compares the performance over June 2008-2009. For more information [1,2].

2. ROOF TOP NOISE MEASURMENTS

Noise measurements were taken on the roof top using a CEL 593 at a distance equal to the height of the turbine in the prevailing wind direction, see [3] for more details. This was as compliant as reasonably practical to the BS 61400:2008 standard for the assessment of small wind turbines. The findings were that there was no correlation between environmental noise and the wind speed [4]. This can be seen from figure 1, where 3 days of measurements show the

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background noise levels are high, L_{A90}, even in the middle of the night. The near constant relatively high environmental noise levels were due to the road noise from the Old Kent Road – A2.

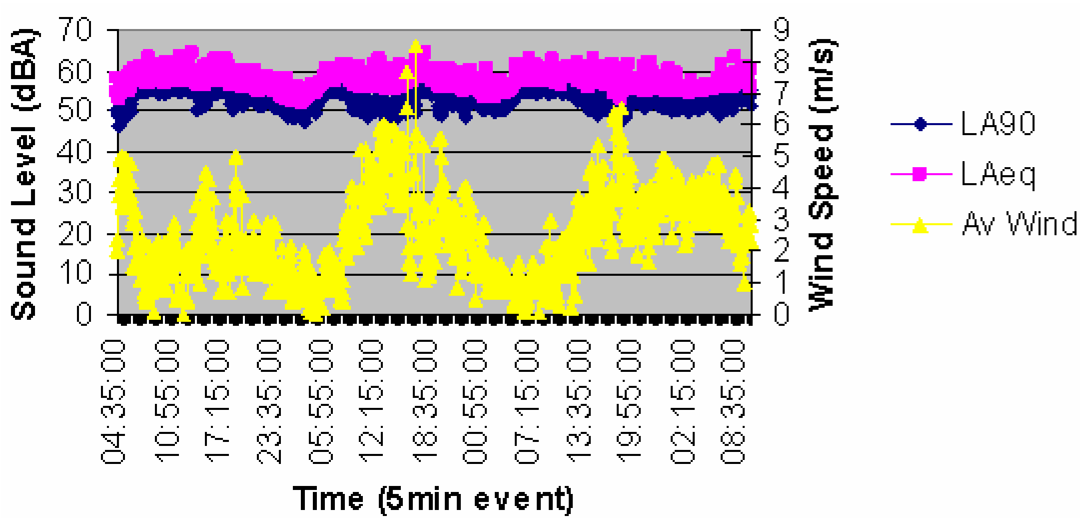

Figure 1: Background noise level , L_{A90}, on the roof top

When the QR5 urbine was installed a tonal analysis was undertaken, it was found that there was no tonality introduced, as defined by BS 4142: 1997 [5]. The wind conditions during the measurement was 4.5m/s to 6.5 m/s, which was 1.5 m/s less than the tonal analysis for the Proven urbine [3]. A broadband type spectrum was found with a peak of 67 dB at 50 Hz, see Figure 2. No tonal elements were found for the Quiet Revolution urbine.

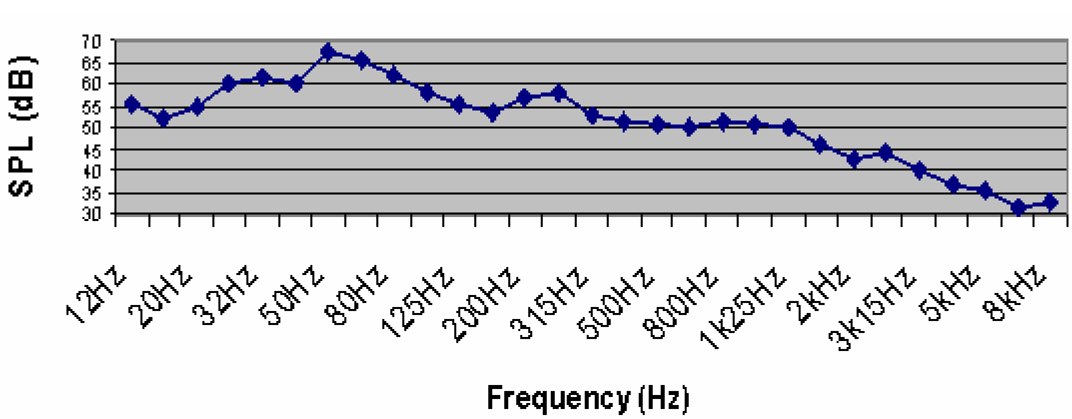

Figure 2 : Quiet Revolution roof top spectra taken over 4 days and a range of wind speeds

3. VIBRATION MEASURMENTS

Vibration measurements were taken on the roof top using a Rion VX54 vibration meter on the frame of the wind turbines and in a flat directly beneath the primary turbine. Vibration Dose Values were measurements were taken in accordance with BS 6472:2008 [6] using d and b curves. Background vibration measurements were also taken, see Figure 3.

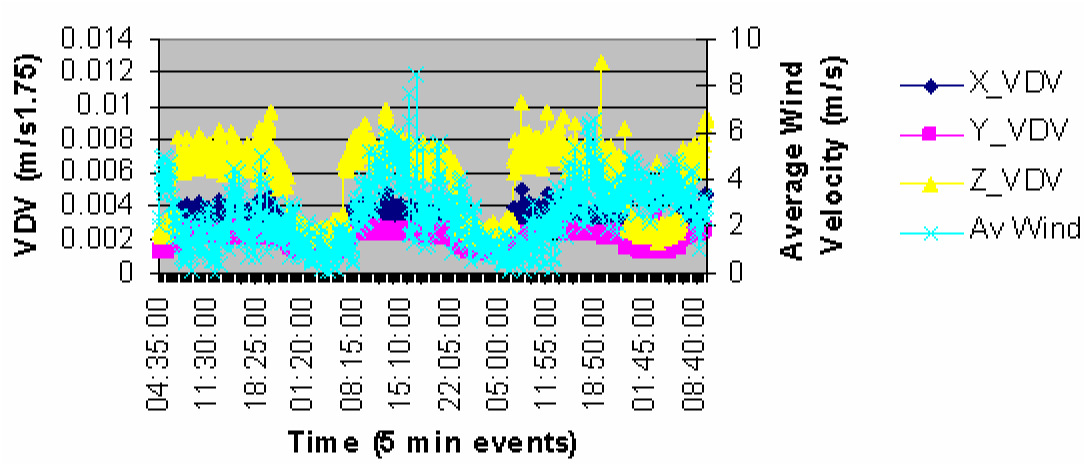

Figure 3: Background vibration, VDV, measured in the flat

The background vibration, in the vertical direction, was found to correlate with the mean wind speed, see Figure 3. However, the measured levels values were far below a low probably of adverse comment. The low vibration levels were due to the heavy weight construction of the building, as is common for 1960s residential blocks.

The vibration was then measured in the flat with the urbine in operation. Figure 4 shows the mean wind speed compared to the tri-axial vibration measurements over 24 hours in January 2009 with the QR in operation.

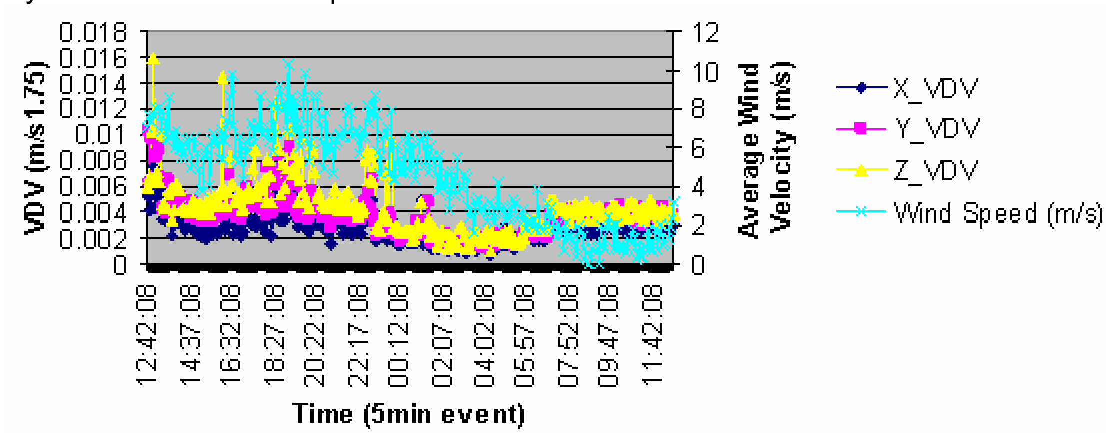

Figure 4: Vibration, VDV, measured in the flat beneath the QR urbine

There was only a minimal increase in vibration with the QR in operation, see figure 4. This was due to the balanced design and the excellent vibration isolation of the mast/frame mounting system. Marginally higher levels of vibration were found in the flat from the Proven urbine [2]. A more detailed analysis was undertaken on the central point of the frame of the urbines, to illustrate the worst case vibration levels over a range of wind conditions, see figure 5 and 6.

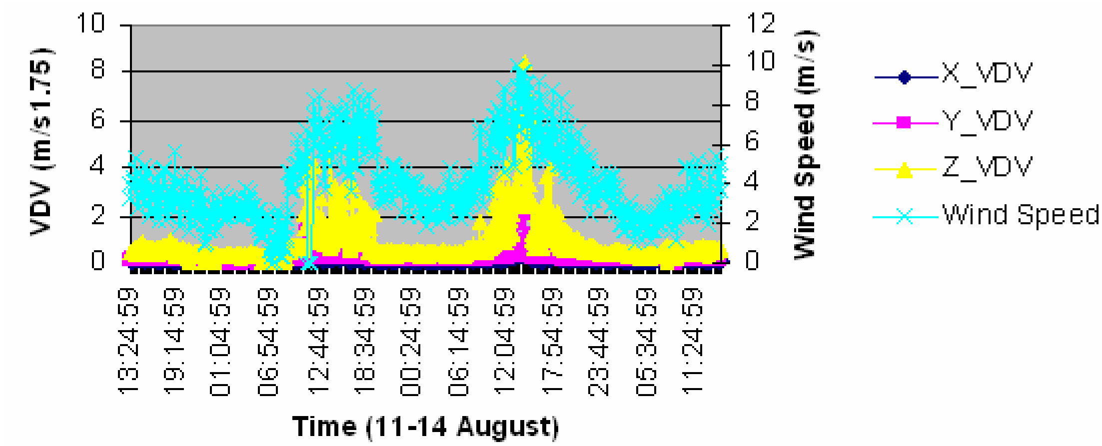

Figure 5: Vibration levels, VDV, against average 5 min wind speeds on the frame of the Proven urbine

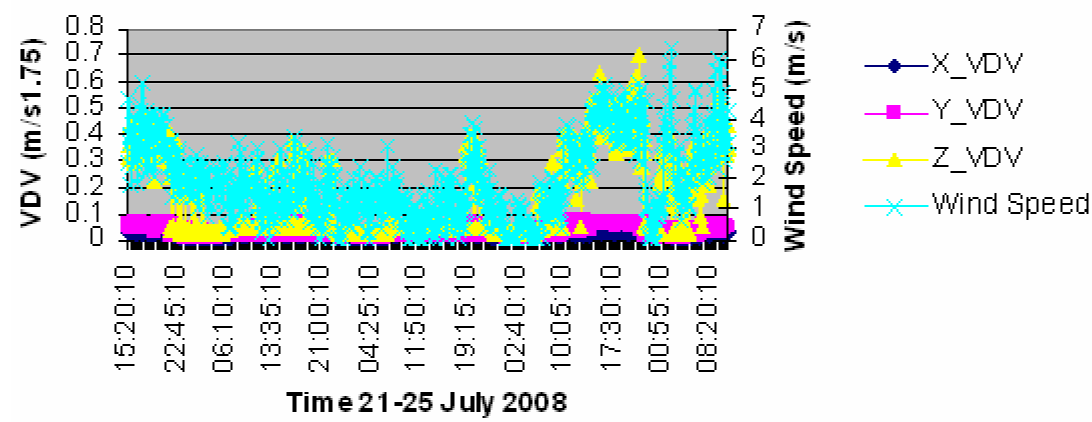

Figure 6: Vibration levels, VDV, against average 5 min wind speeds on the frame of the QR urbine

From figures 5 and 6 it can be seen that vertical vibration highly correlates with the wind speed for both urbines. The Proven produced vibration levels approximately an order of magnitude higher than the Quiet Revolution, although the higher wind speeds should be noted. This confirmed the early measurements of the minimal impact of operating the Quiet Revolution turbine.

4. ELECTRICITY GENERATION

The Ashenden site was chosen as a test site for the urbines on the basis that it was due for demolition in 2011. Hence, it was not selected on criteria which would lead to optimum operating conditions for urbines, as such another site was also investigation for comparative purposes. An identical Proven urbine was installed in central London, but on a 17 storey building located on a hill ridge. Typical costs for such an installation are £10,000 plus £19,000 for the turbine. The Quiet Revolution by way of comparison costs £32,000.

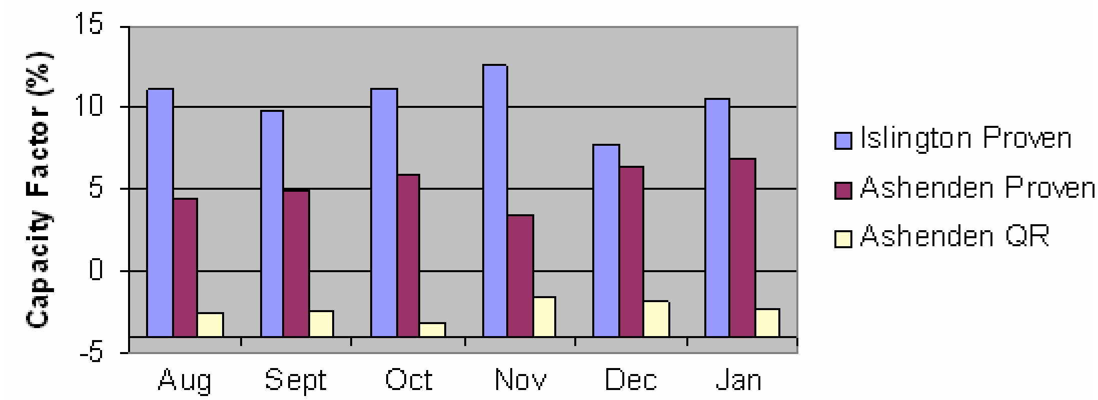

Figure 7: Effectiveness of urbines as a function of marketed potential electrical generation capacity

It can be clearly seen, from figure 7, that on a selected site rather than the pilot site the Proven urbine is capable of generating 50% more electricity. The Quiet Revolution urbine has a much higher cut in speed and it is not recommended for sites with an average wind speed of less than 5.5 m/s. This resulted in a negative electrical generation, due to an automated self starting system spinning up the turbine. The Proven was a purely mechanical design. The QR urbine also tended to cut out under windy weather conditions, over the initial 9 months 65% of the time it was not operating due to automated safety shut down systems. In February 2009 the cut out switch was replaced with an accelerometer, which has improved the urbines performance.

The Ashenden Proven urbine over the first year of operation produced 4.2 MWh approximately 50% of the predicted electrical output, based on sample wind speed measurements. This is in line with other urban small wind power installations [7]. Over the six months, August 2008-Jan 2009 there was significantly less wind compared to the same period in the previous year.

The computerized control panel of the Quiet Revolution would normally be located in a storage cupboard or outbuilding; however, for this pilot study it was located in the flat. There was a fan running continuously at 65 dBA cooling the electronics, but every 15 minutes for 5 minutes ‘turbo’ mode would be initiated with a consequent increase in noise level to 85 dBA. The Proven turbine requires no control panel.

5. CONCLUSIONS

A pilot study investigation was undertaken to establish the effectiveness of small urban wind turbines. Two types of urbine were installed and assessed. It was found that by selecting aspects of various regulations and standards a comprehensive evaluation of roof top installed small wind power could be undertaken.

The noise assessment of the urbines demonstrated that in central London the traffic noise dominated the environment and the turbine spectra do not contain any tonal component over a wide range of wind speeds. In other quieter metropolitan areas it is possible that the eenvironmental noise might not mask the urbine noise as effectively. Vibration in the flat directly beneath the urbine was found to be minimal and much below the adverse comment levels. On the urbine frame the worst case vibration levels were significantly lower for Quiet Revolution vertical axis turbine than the Proven horizontal turbine.

The electrical generation of the Proven was significantly better for the Quiet Revolution due to a design flaw in the automated control system of the QR. Criteria driven site selection was used for the installation of an identical Proven turbine. This was found to provide an additional 50% electrical generation. Over the course of the full year the predicted Capacity Factor would be 12%, this compares to 20% for large turbines installed in rural environments in England.

ACKNOWLEDGMENTS

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