ADVANCES IN ROOF TOP WIND TURBINES AND THEIR INSTALLATION

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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. As an experimental site an 11 storey concrete residential building was selected for a pilot study. The first urbine (an urbine wind turbine), 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. Monitoring was undertaken on the roof top and in an unused flat directly beneath the primary turbine. In addition, wind, weather and electricity produced were recorded for the period June 2008-Feb 2010 [1,2,3].

2 ADVANCES IN URBINE INSTALLATIONS

The complexity of rooftop wind turbine installations has progressively increased, although the type of installation is the same: 1970s residential social housing, see Figure 1. In 2007 a single urbine was installed experimentally for a pilot study, Ashenden House. In 2008, an optimized installation for commercial generation of electricity of a single urbine was installed on Kestrel House, an 17 storey building. In 2009, three urbines were proposed for the Ethelred Estate a group of three 22 storey buildings. In 2010, six urbines were proposed for the Edward Woods Estate, a group of three 22 storey buildings with four penthouse flats on top of each tower.

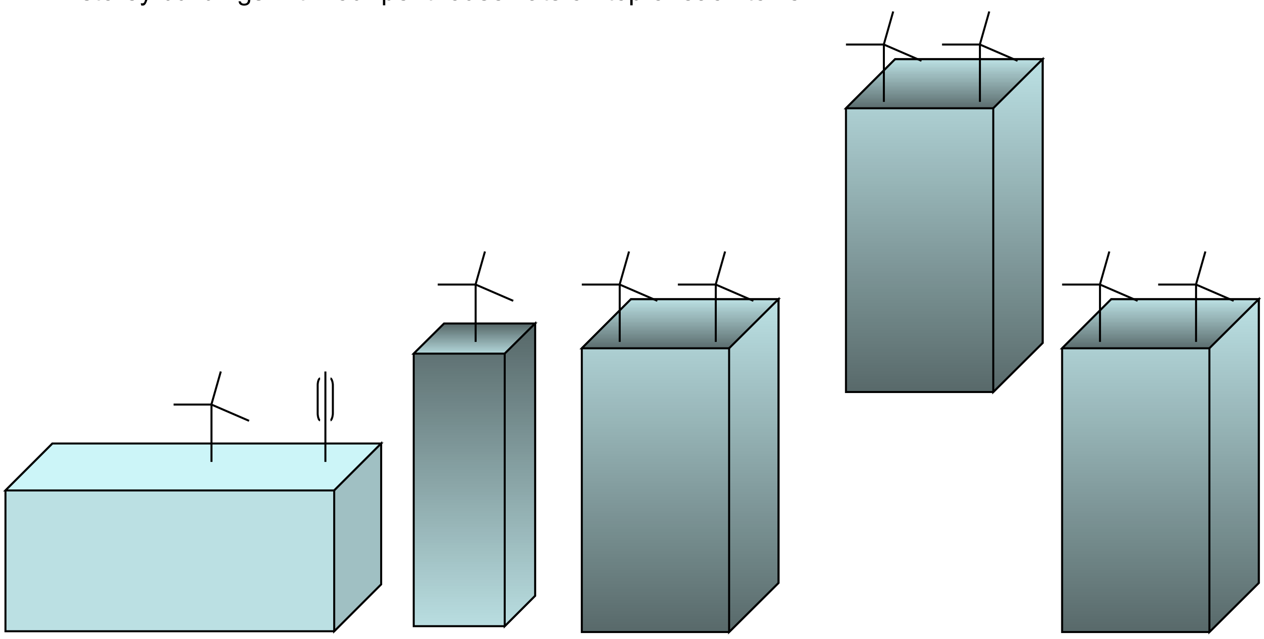

Figure 1. The increasing complexity of rooftop wind turbines in central London

3 ENVIRONMENTAL NOISE DIRECTIVE

The Environmental Noise Directive was implemented Europe wide in 2008 using strategic noise mapping techniques. The results are noise maps for major conurbations, populations greater than 250,000 people, based on road, rail, industry or mixed noise sources. There are 23 such conurbations in England. The noise maps will be extended to cities with populations greater than 100,000 people. The noise maps for each member state are freely available[4], and can be viewed as either L_{DEN} or L_{Night}.

Noise maps can be used as a tool in the sighting of rooftop wind turbines. By using the noise maps intelligently those sites unsuitable for rooftop wind turbines, based on the noise sensitive L_{Night}, can be dismissed early-on in the project cycle that now includes renewable energy considerations. The existing noise sources will mask the noise of the urbine, if positioned in relatively noisy sites. When the wind speed is high and hence when the turbine is noisier, the turbulent flow will increasingly mask the noise of the turbine.

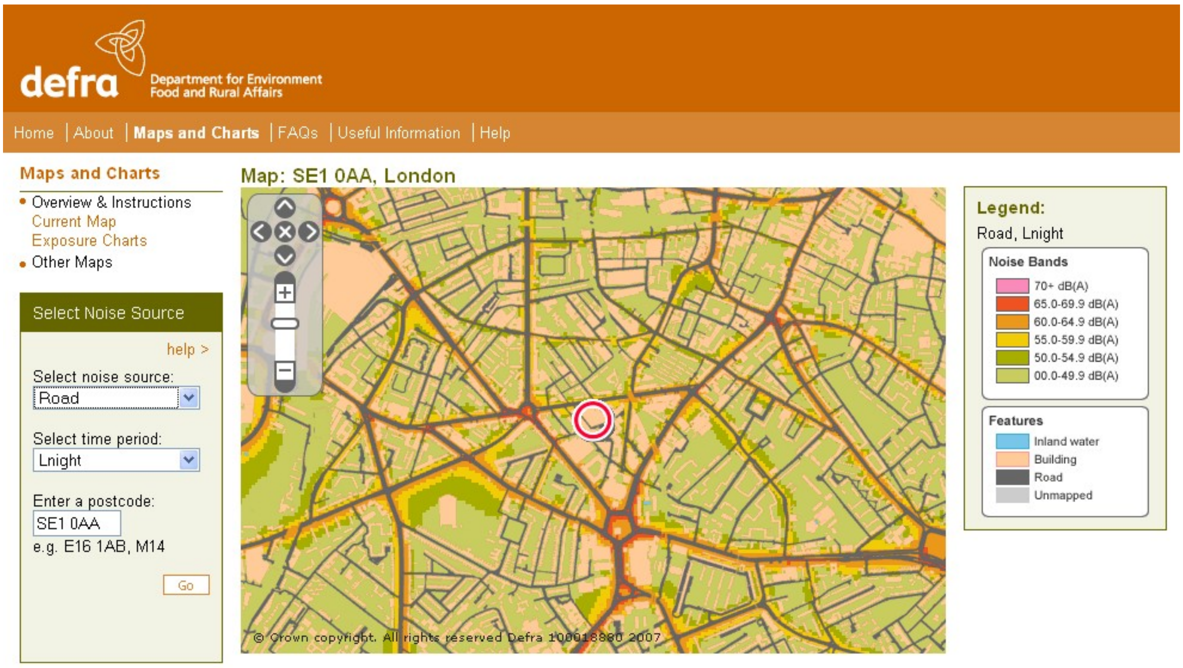

Figure 2. DEFRA website freely offers noise maps of England, shown L_{Night} of Elephant & Castle

4 NOISE FROM URBAN WIND TURBINES

The noise from the Quiet Revolution turbine is generally dominated by the traffic noise from the Old Kent Road. Hence, when noise monitoring was undertaken when the wind speed was below the cut-in of the QR turbine, the correlation between wind speed and noise level is very low, see Figure 3.

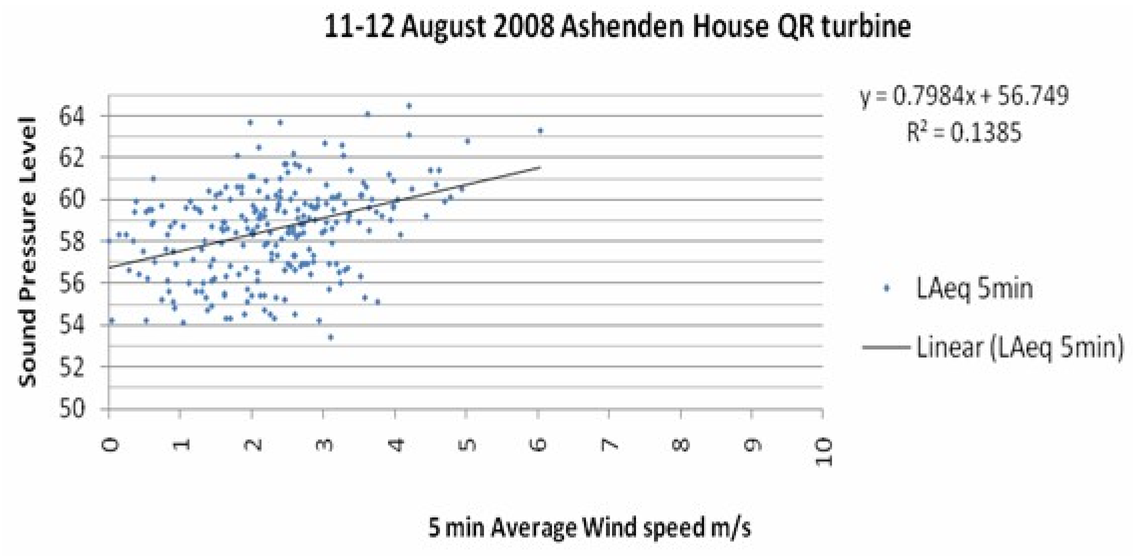

Figure 3. Effectively rooftop background noise levels

The noise levels were monitored and analyzed over the summer period of 2009. The correlation between wind speed and noise level is considerable higher at greater wind speeds, see Figure 4.

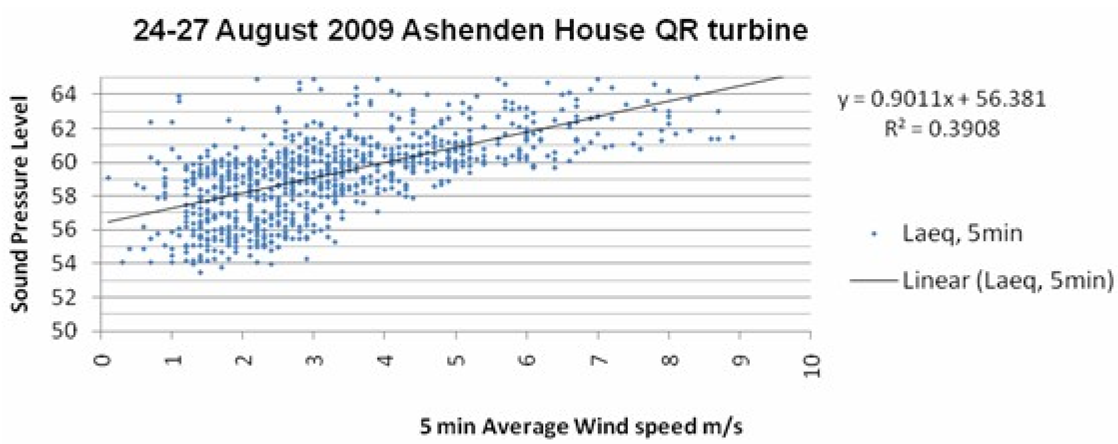

Figure 4. Weekday rooftop noise level measured 11m from QR turbine

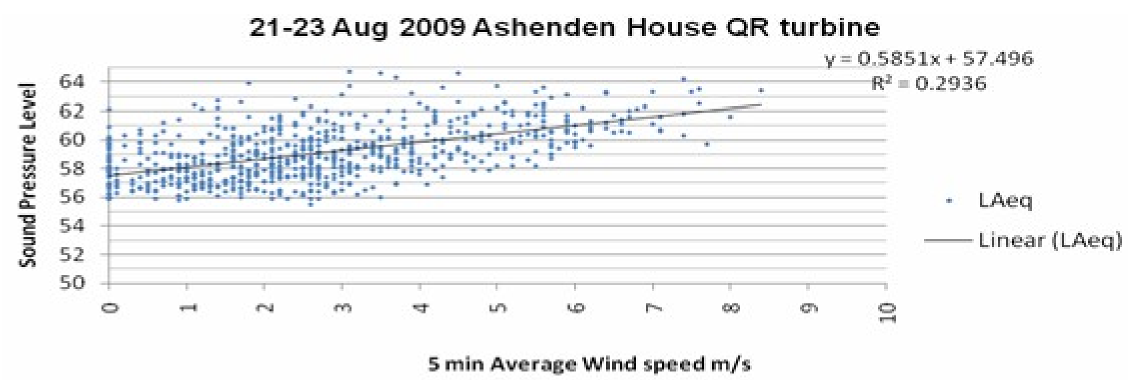

Figure 5. Weekend rooftop noise level measured 11m from QR turbine

As previously shown[1], the weekend noise measurements are generally not as noisy as the weekdays, see Figure 5, due to the reduction in traffic flow rates. The tonality of the QR turbine was determined using the BS4142:1997 procedure of analyzing the 1/3 octave bands for any rise of 5 dB or more compared to adjacent bands[5]. It was found that the QR turbine did not produce tonal noise, see Figure 6.

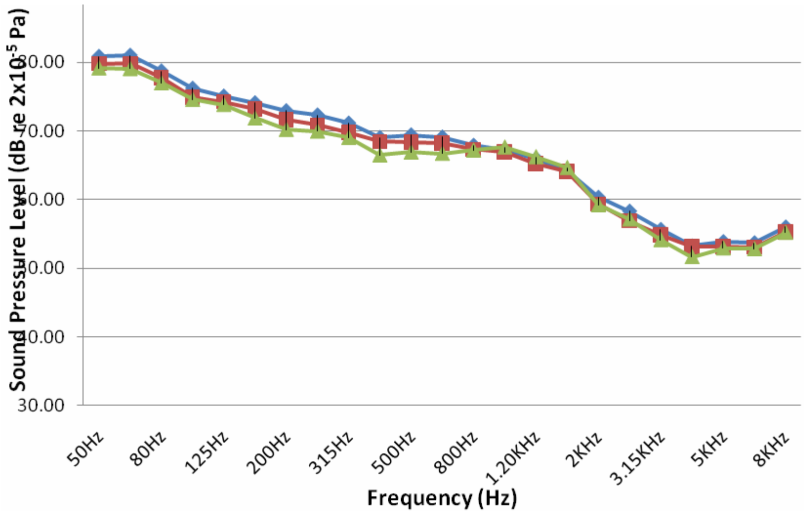

Figure 6. Rooftop noise spectra level whilst a QR turbine operating (three 5 minute periods)

Finally, we estimated the sound power level of the QR turbine under 5m/s wind speeds and 10 m/s wind speeds, based on our noise measurements taken at one location 11m from the base of the turbine. The results are as follows: at 5m/s L_w = 85 dBA, at 10m/s L_w=96 dBA.

5 URBAWIND: A COMPUTATIONAL FLUID DYNAMICS MODEL

By eliminating the sites unsuitable for wind turbines, based on noise, it is then possible to determine the wind resource potential of the remaining sites using computational fluid dynamic modelling techniques. CFD modelling is difficult to learn and slow to process. However, new tools are available, such as Urbawind[6] a pedestrian comfort model reworked for rooftop wind flow. When combined with Google Sketchup a model of a local built environment can be built which can predict the wind resource, relatively quickly and easily, see Figure 3. Using an energy model plug in to Urbawind the electrical power generation can be predicted for various types of rooftop wind turbines. This allows the positioning of the turbine(s) to be optimized and the design of the local environment (for large developments) to produce the optimum amount of wind resource which can be effectively harnessed.

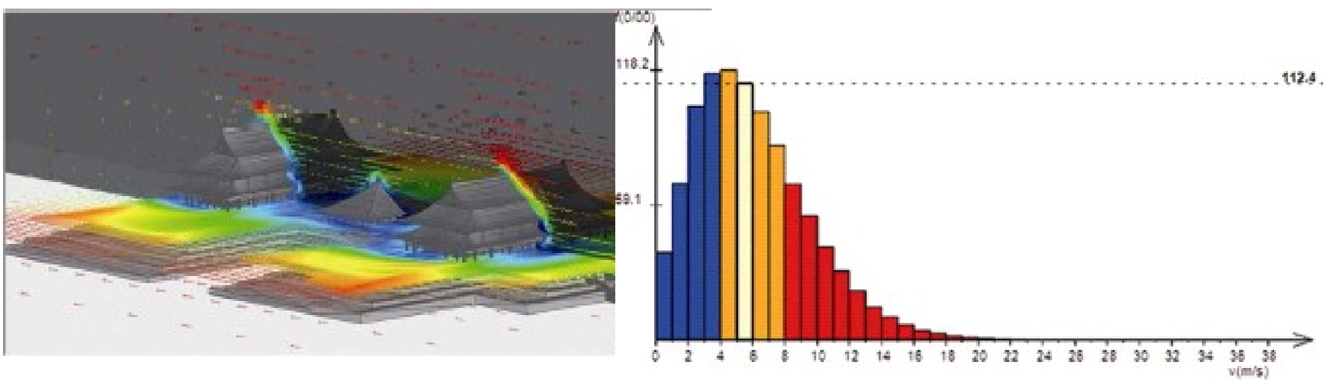

Figure 7. Example of CFD model and the predicted wind speed distribution in the environment

6 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 turbines, as such another site was also investigation for comparative purposes. An identical Proven urbine was installed in central London, but on a 18 storey building located on a hill ridge. Typical costs for such an installation are £20,000 plus £19,000 for the turbine. The Quiet Revolution by way of comparison costs £32,000 and hence, multi-installations are more cost effective.

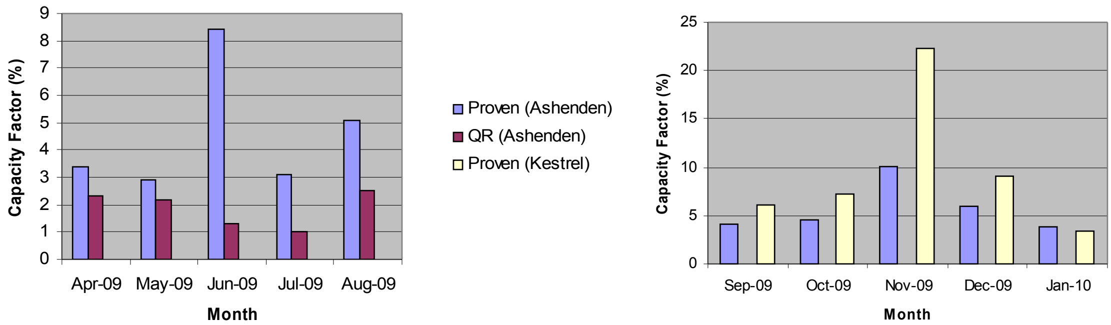

Figure 8: Capacity factor of central London rooftop turbines

It can be clearly seen, from figure 4, that on a selected site rather than the pilot site the Proven turbine is capable of generating between 50% and 100% more electricity. The Quiet Revolution turbine 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. The second thing which can be seen is that not all of the turbines were operating continuously – a Quiet Revolution turbine went wrong, due to a design flaw, and so all QR5 turbines were switched off remotely for safety reasons, see figure 5. The Proven on Kestrel House had a burnt out generator, and a replacement part took months to replace due to contractual reasons.

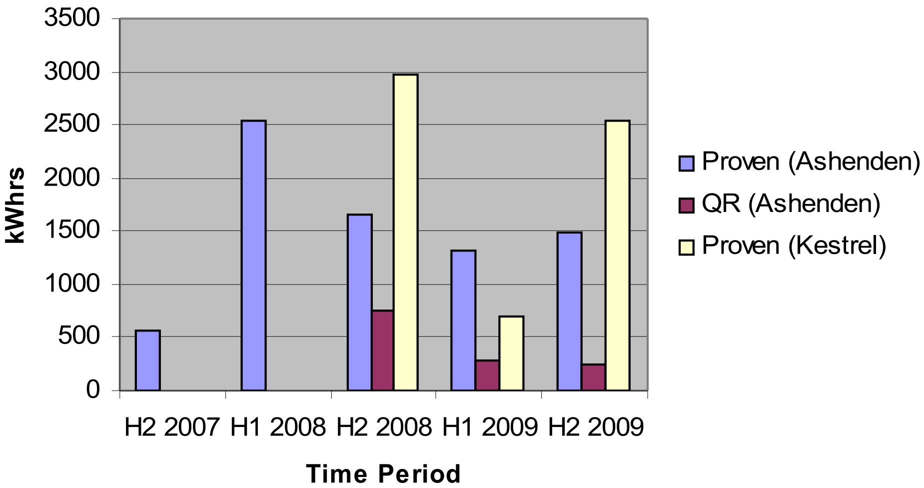

Figure 9. Total electricity generated by 3 rooftop turbines on 2 central London sites

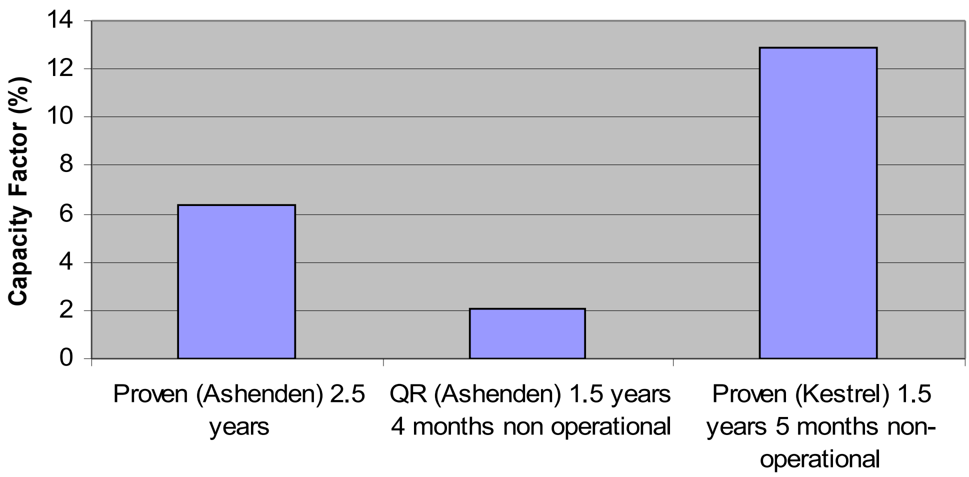

Figure 10. Adjusted capacity factor for 3 rooftop turbines on 2 central London sites

The optimized installation at Kestral House has demonstrated that a rooftop turbine can produce a capacity factor of 13% over a sustained period of time, see figure 6. The Quiet Revolution turbine on a non-optimized site used twice the energy it produced, due to the self starting motor and complex control systems.

7 CONCLUSIONS

A pilot study investigation was undertaken to establish the effectiveness of small urban wind turbines. Two types of turbine were installed and assessed. It was found that the Environmental Noise Directive noise maps were effective tools to select potential sites for rooftop wind turbines. The computational fluid dynamic models to predict local wind resources will be used to optimize site location, as this has been found critical in the effective installation of turbines, giving a capacity factor of 13% in a central London location.

The next generation of installations will be multiple buildings single turbine, followed by multiple building multiple turbines. These will all be erected on tall social housing blocks in central London undergoing refurbishment.

8 REFERENCES

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