Ashenden House Wind Turbine Trial

CIBSE ASHRAE Seminar

May 2009

PROJECT TEAM

London Borough of Southwark: Tony Moseley, Sustainable Development and Infrastructure Manager; Client; data dissemination.

Brian Dunlop Associates and Gas Dynamics Ltd: Planning application; technical co-ordination; instrumentation selection; commissioning; data acquisition software; quality assurance and data processing.

London South Bank University: Prof. Tony Day, Dr. Steve Dance and students. Acoustic and vibration monitoring; analysis and reporting; wind and energy monitoring research programme.

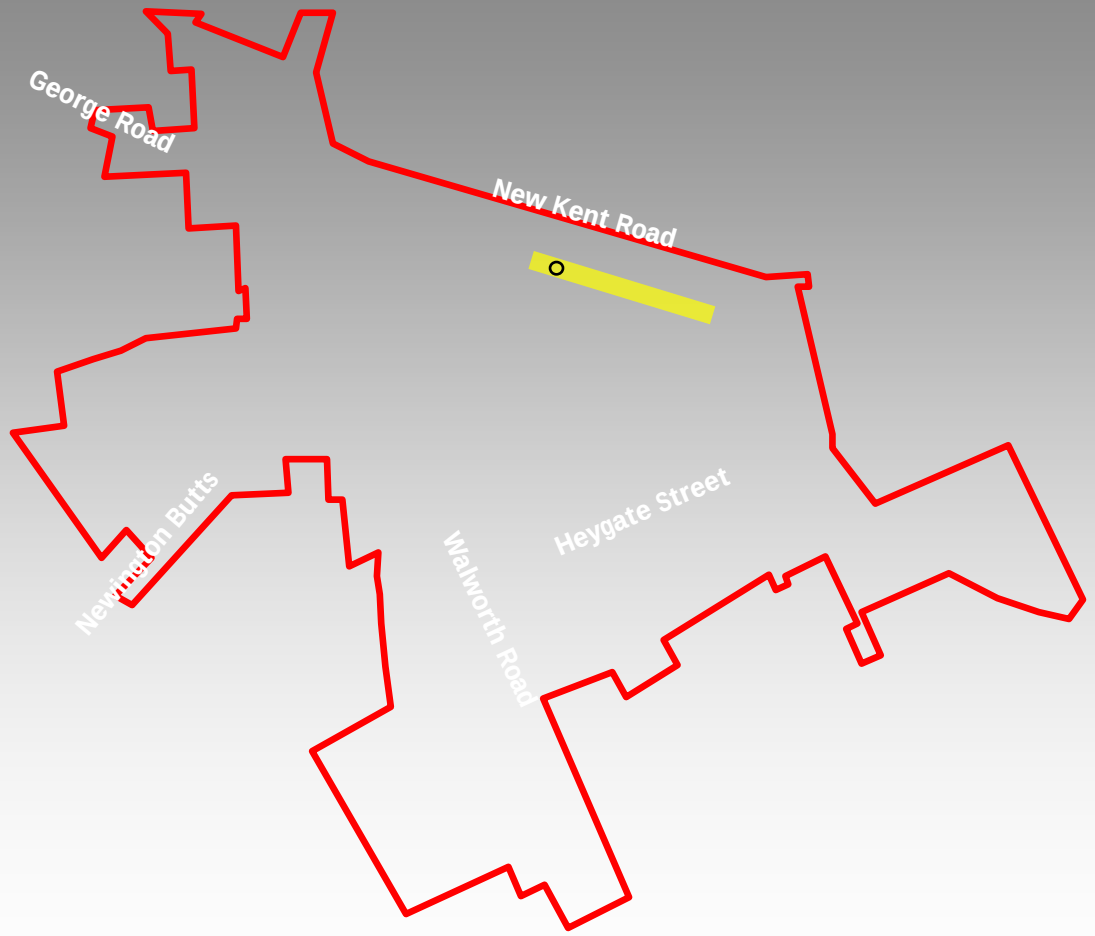
KCCC Ltd: Site survey; design and construction of footings and mounting frame; installation of anemometer mast.

Photon Ltd: Lead installer – construction programme; site manager; turbine assembly; erection and electrical installation

CORE DEVELOPMENT AREA SHOWING LOCATION OF ASHENDEN

During phase I a Proven 6kW horizontal axis turbine was installed on the roof of Ashenden House, an 11 storey residential block within the Heygate estate. The height of the block is representative of the buildings in the Elephant & Castle Development Framework.

In phase II, a Quiet Revolution QR5 vertical axis machine was also installed and the Proven moved to a second location on the roof. Results of these tests will be disseminated later.



TURBINE TRIAL OBJECTIVES

Monitor site specific energy yield

Compare with current prediction methods and manufacturer's data

Use measured data to refine prediction of energy yield from desk-top studies

Identify impacts of constraints e.g. size, weight, maintenance requirements etc

Obtain acoustic data: pre- and post-installation

Gauge community reaction to deployment of wind turbines on buildings e.g. visual impact

Compare performance of turbine technologies and responses from local community

Dissemination of site specific advice to planners and design teams

TIMELINE

Planning

Planning permission was granted in December 2006. The following files can be downloaded from the website:

- Planning application supporting documentation
- Conditions attached to planning consent

Roofworks

Carried out during March/ April 2007. Construction of concrete footings/ making good roof membrane. Design and fabrication of steel mounting frames.

Turbine Trial

The trial is being conducted in two phases.

Phase 1 (June 2007 – June 2008): COMPLETED

Install the Proven WT6000 turbine above a vacant flat. Monitor wind speed, turbine power, noise and vibration. Analyse data, discharge planning conditions and release preliminary results. A series of photographs documenting the full construction/ turbine erection sequence can be downloaded from the website.

Phase 2 (commenced June 2008)

Relocate the Proven turbine above an occupied flat to make way for the installation of the Quiet Revolution QR5 6kW turbine. Ongoing monitoring of wind speed, power output from both turbines, noise and vibration emanating from the QR5 turbine. Analyse data and release final results.

It is anticipated that at the end of this period the turbines will be demounted and relocated to London South Bank University for ongoing study.

TEST SITE DESCRIPTION

Turbine(s) mounted on a 9m mast on top of an 11 storey tower block.

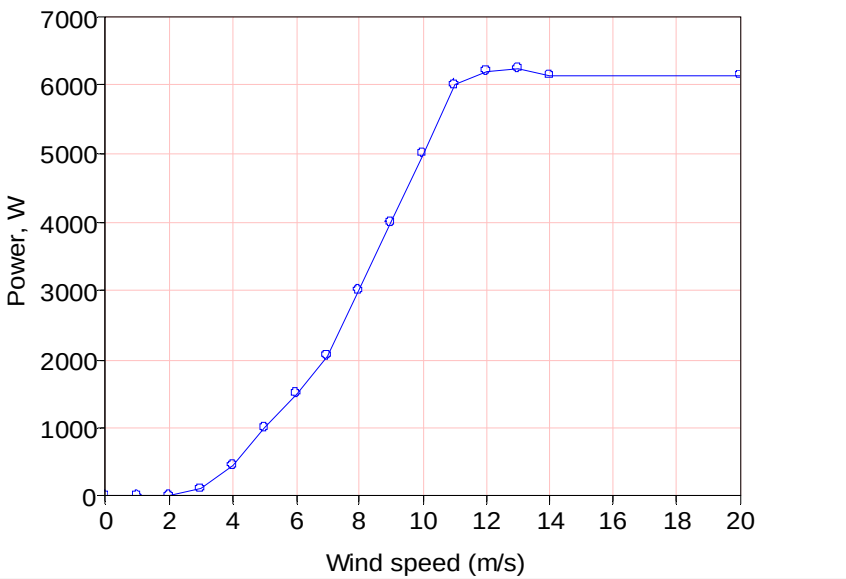
3-axis ultrasonic anemometer mounted at hub height ~10m from the turbine.

TURBINE DESCRIPTION – PHASE 1

Proven WT 6000 rated at 6kW with a wind speed of 12 m/s [1]

Cut-in wind speed of 2.5 m/s [1]

Rotor diameter = 5.5m



[1] Power curve and data extracted from Catalogue of European Urban Wind Turbine Manufacturers

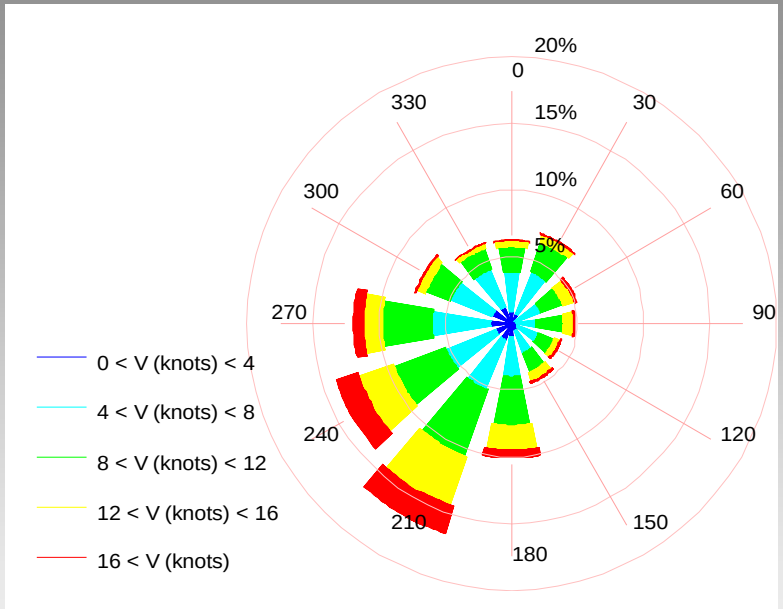
INSTALLATION COSTS

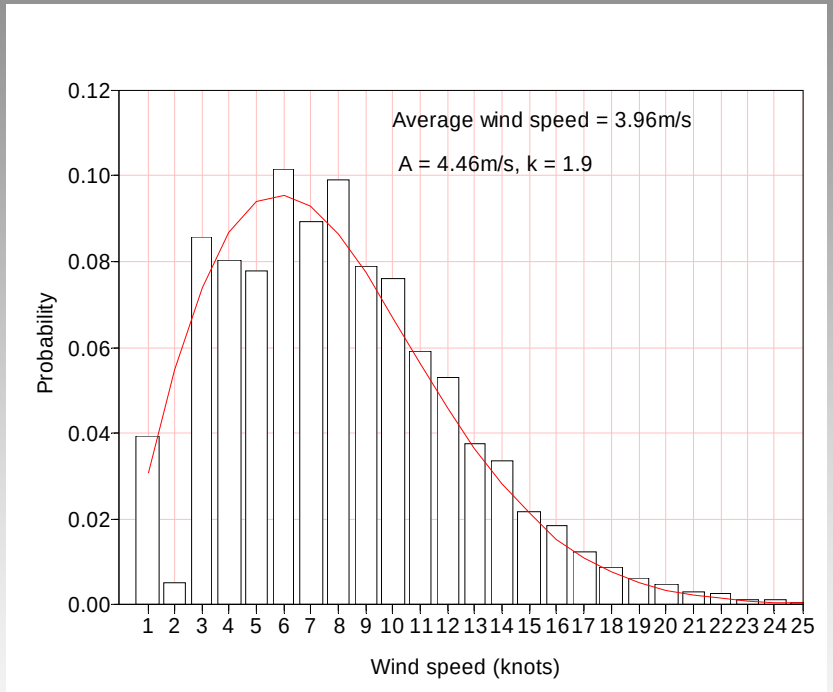
Roof works (exclusive of VAT)	**Common**
Crane Hire (one visits)	£2,150.00
Handrail	£8,593.46
Plinths	£6,766.48
Sarnafil roofing	£6,771.11
Lightning protection	£998.89
Walkway	£1057.50
Total	**£26,337.44**

Turbine Installation (exclusive of VAT)	**Common**	**Proven**	**QR5**
Turbine, mast, inverter, controller & delivery		£19,003.91	£31,925.00
Steel mounting frames (2 nr)	£10.826.36		
Crane Hire (two visits)	£6,336.00		
Installation & commissioning	£8,500.00		
Meeting, site organization, health and safety	£995.00		
Electrical items	£4,433.25		
Total	**£20,264.25**	**£19,003.91**	**£31,925.00**

YIELD PREDICTIONS – REFERENCE SITE DATA FOR HEATHROW

Wind speed distribution based on data supplied by the Met Office for Heathrow for the period Dec 97 to Nov 07





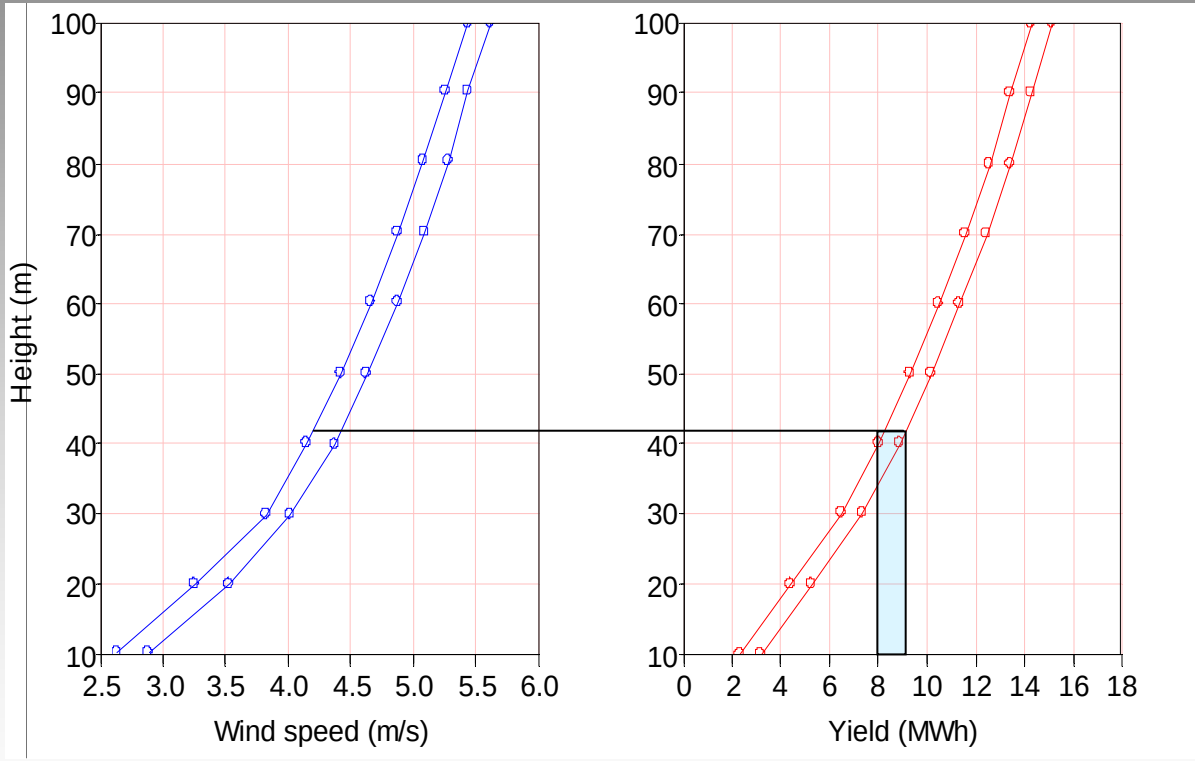
Wind speed distribution modelled using a 2 parameter Weibull function in the form:

$$f(u) = \frac{k}{A}\left(\frac{u}{A}\right)^{k-1} \exp - \left(\frac{u}{A}\right)^{k}$$

Where A is the scale factor and k is the shape parameter

ESTIMATED WIND SPEED AND ENERGY YIELD PROFILES FROM DESKTOP STUDY

Wind speed distribution based on data supplied by the Met Office for Heathrow for the period Dec 97 to Nov 07



Upper and lower estimates of wind speed (left plot) and yield (right plot) for the target site.

Estimated average wind speed 4.15 – 4.35 m/s, giving an annual yield figure of 8 - 8.9 MWh.

INSTRUMENTATION

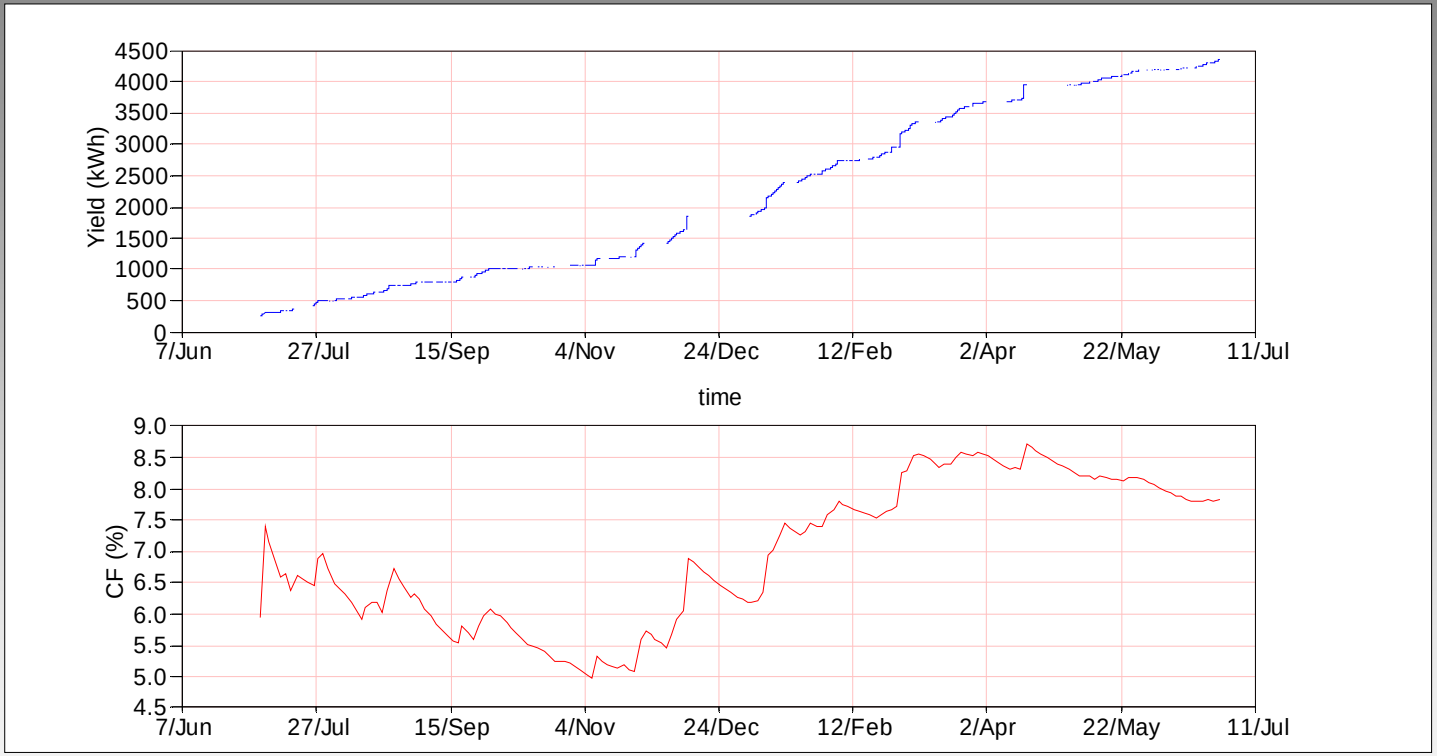
Anemometer: 3-axis Gill ultrasonic sensor logging continuously at 1 Hz on a PC.

Multicube multifunction current transformer (CT) meter: Instantaneous power readings logging continuously at 1 Hz on a PC.

Sunny-boy controller: Gross yield readings at ~15 min intervals, downloaded to a PC.

Data analysis performed using SCILAB

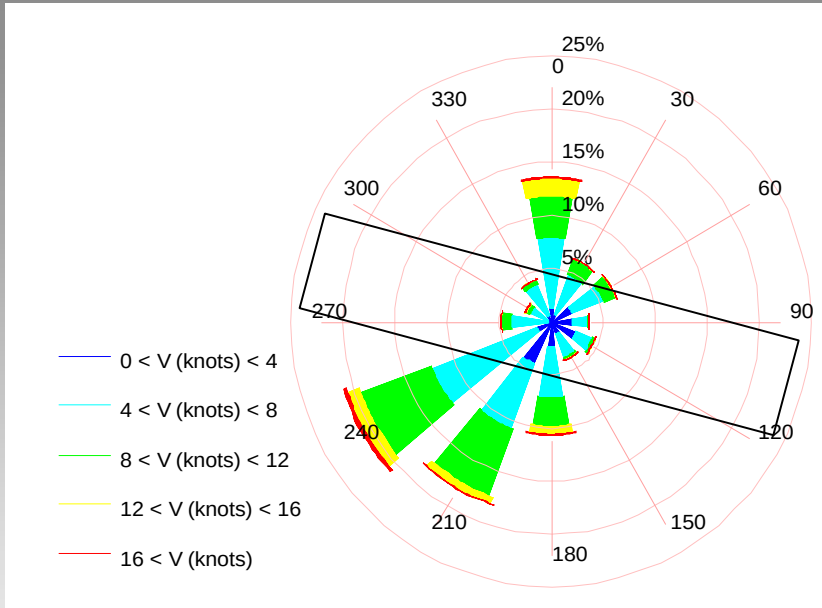
RESULTS – TURBINE YIELD

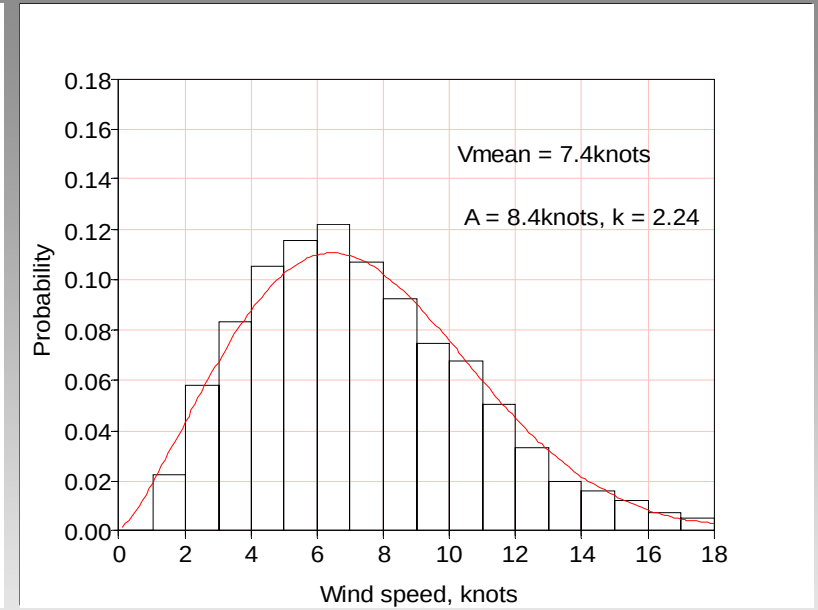


Turbine Yield kWh (blue curve) and cumulative capacity factor CF (red curve) for data between June 2007 and June 2008.

The annual yield from 07th June 2007 was 4200kWh.

RESULTS - ANEMOMETRY

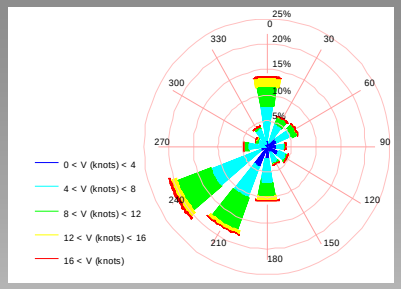
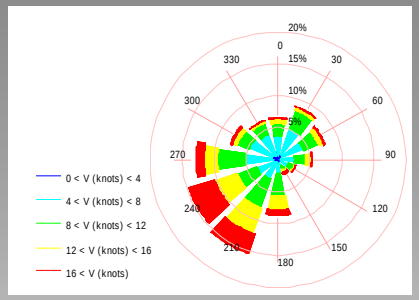
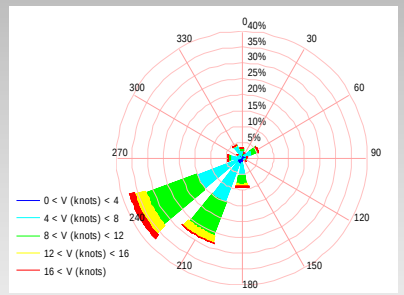
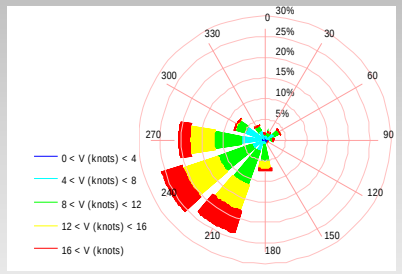
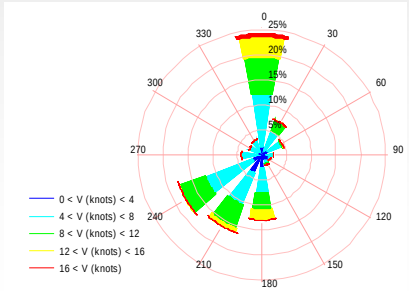
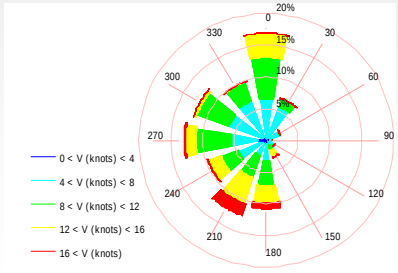




Wind rose and wind speed distribution evaluated from all data collected between June 2007 to May 2008 inclusive. Distribution based on hourly averages.

Average wind speed of 3.82 m/s, significantly less than the desktop estimate of 4.15 – 4.45m/s. Shape parameter k of 2.24 also much higher than the reference site (Heathrow).

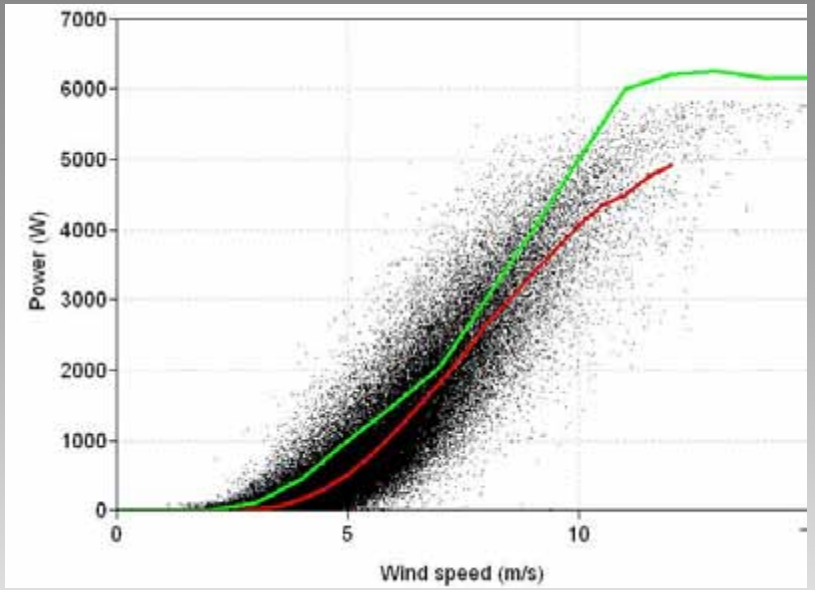
RESULTS - ANEMOMETRY

	Ashenden House	Heathrow Short Term
Annual Data		
Jul 07		
Aug 07		

Wind rose comparison between the target site at Ashenden (left) and Heathrow (right).

Note: monthly wind roses for the test site are available to download from the website

RESULTS – POWER CURVES



One minute average data

Black dots denote raw data;

Green curve denotes published power curve;

Red curve denotes mean power in 0.5m/s intervals

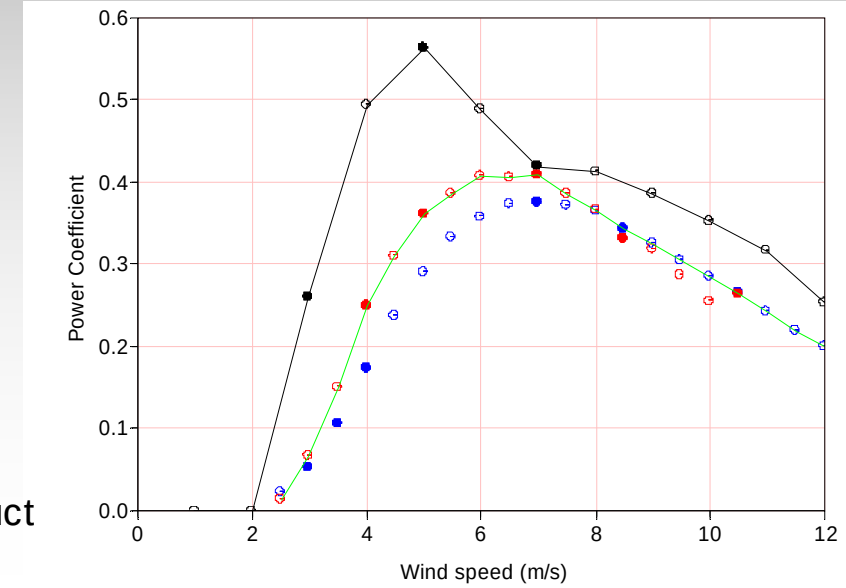
Average power coefficient curve

Black curve denotes published power curve;

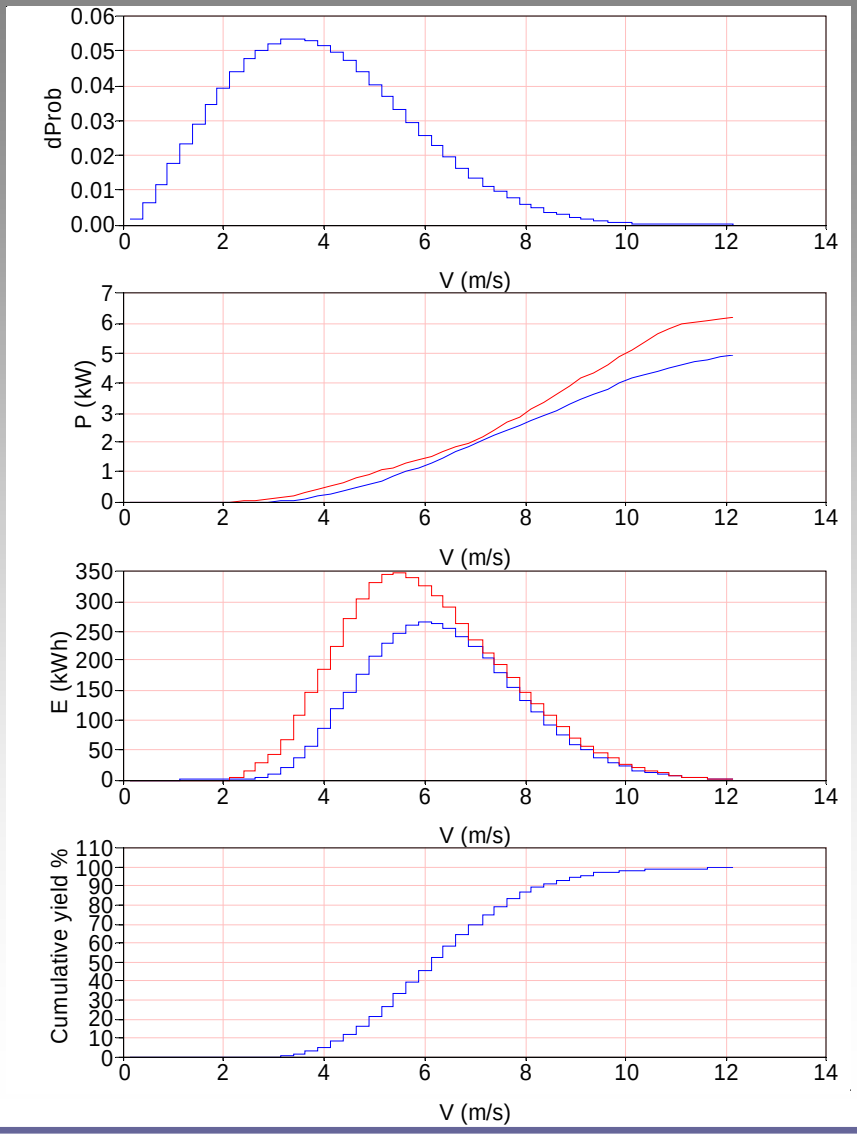
Red dots denote one hour average in 0.5m/s intervals (limited data points above 8 m/s);

Blue dots denotes one minute average in 0.5m/s intervals;

Green curve represents power curve used to reconstruct yield.



RESULTS - YIELD RECONCILIATION



Annual yield calculation using annual Weibull parameters (A = 8.4 knots, k= 2.24) and the measured average power curve.

Yield using Weibull distribution = 4,051kWh, compared with actual reading from inverters of 4,200kWh

- First plot shows the wind speed distribution in 0.25m/s intervals;
- Second plot shows the published power curve (red) and measured average power curve (blue);
- Third plot shows the yield in each wind speed interval using the published and measured power curve;
- Fourth plot shows the cumulative yield as a function of wind speed using the measured power curve – note that by 8m/s the turbine has generated 90% of the total yield.

Note also that the yield found using the published power curve is around 36% higher than the yield calculated using the measured average power curve.

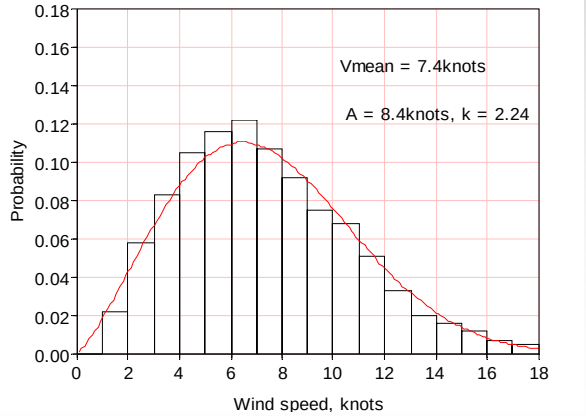
RESULTS – ANNUAL YIELD ESTIMATION BASED ON 12 MONTHS DATA

Can we predict the annual yield at the target site in a 'mean' year? i.e. is the wind speed distribution at the target site representative of an average year?

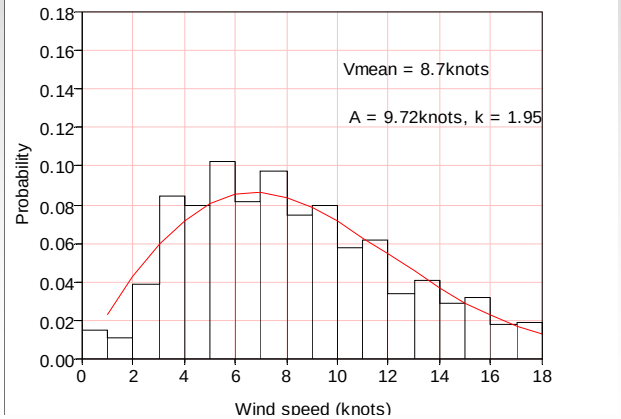
Begin by comparing short-term wind data (from June 2007 to May 2008) with the long-term distribution at the reference site (Heathrow). Plots below (from left to right) show; annual wind speed distribution at Ashenden House; annual wind speed distribution at Heathrow; long-term average distribution at Heathrow. Note that the scale factor for the Heathrow short term data is considerably higher than the long term average.

If the same trend was applied to the Ashenden dataset, the average wind speed would be 3.44m/s, resulting in a mean yield of around 2800 to 3050 kWh (cf 4,200kWh in the year to June 2008).

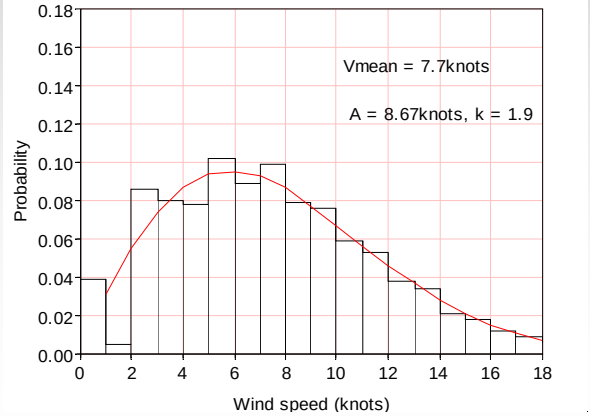
Ashenden House



Heathrow Short Term



Heathrow Long Term

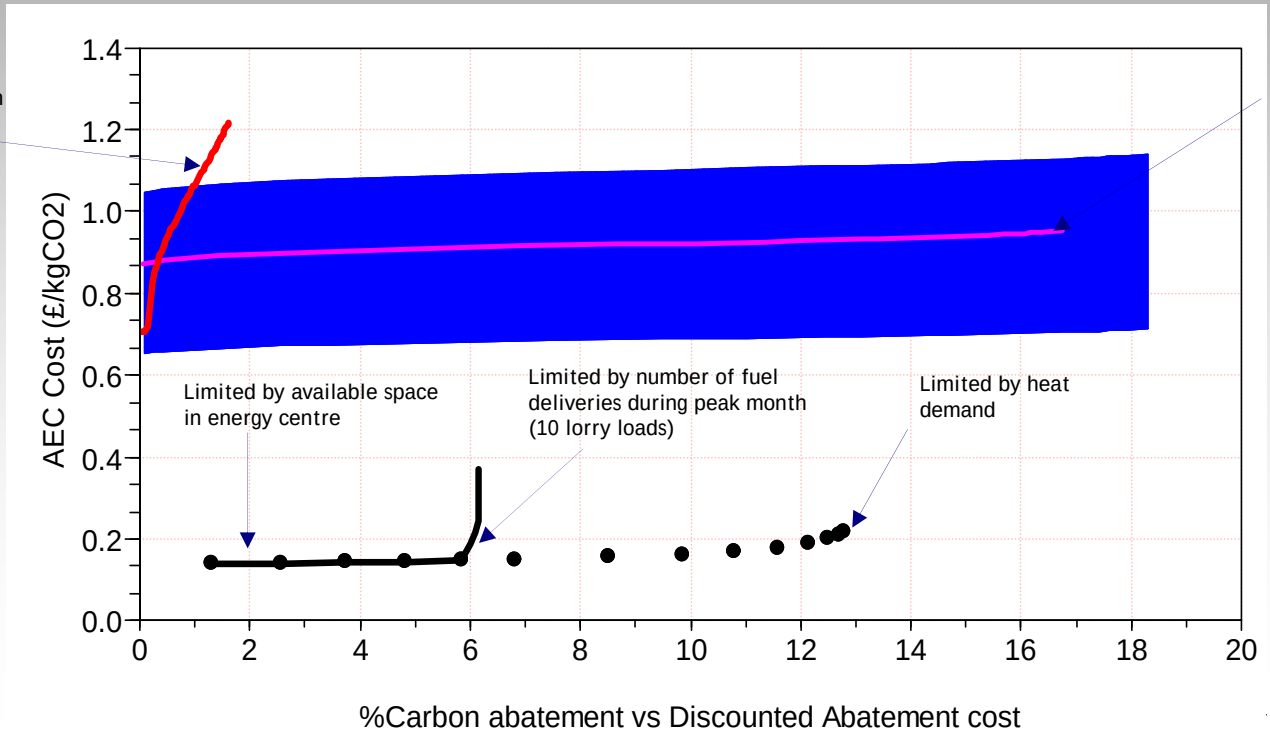


CARBON ABATEMENT COST

Comparison of cost per kg of carbon abated for three renewable energy technologies based on detailed consideration of the available resource and the physical constraints of the Elephant and Castle development:

- roof mounted pv (limited to roof areas receiving 800 – 1000 kWh/m^2) MAGENTA LINE;
- 6kW wind turbines (spaced at 5 times diameter apart) RED LINE
- centrally located biomass boilers (i.e. operating as peak load boilers and part of a shared infrastructure feeding an area-wide district heating network) BLACK LINE

6kW Proven roof mounted turbine (extrapolated from measured data)



KYOCERA KC120-1 120w panels on Solion "Sunmount" (data supplied by LSBU)

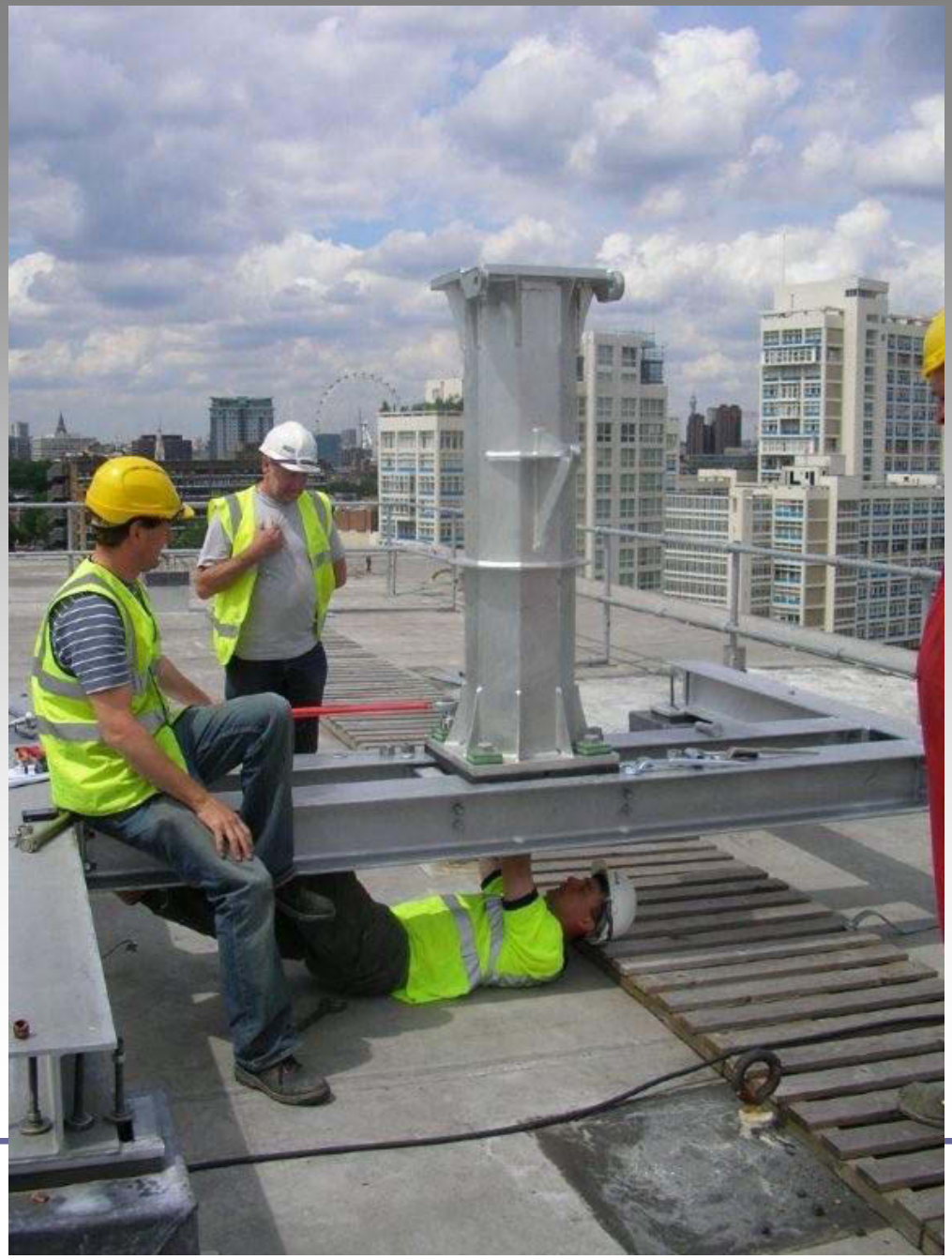
BLUE SHADED AREA INDICATES UPPER AND LOWER LIMITS FROM RENEWABLES TOOLKIT

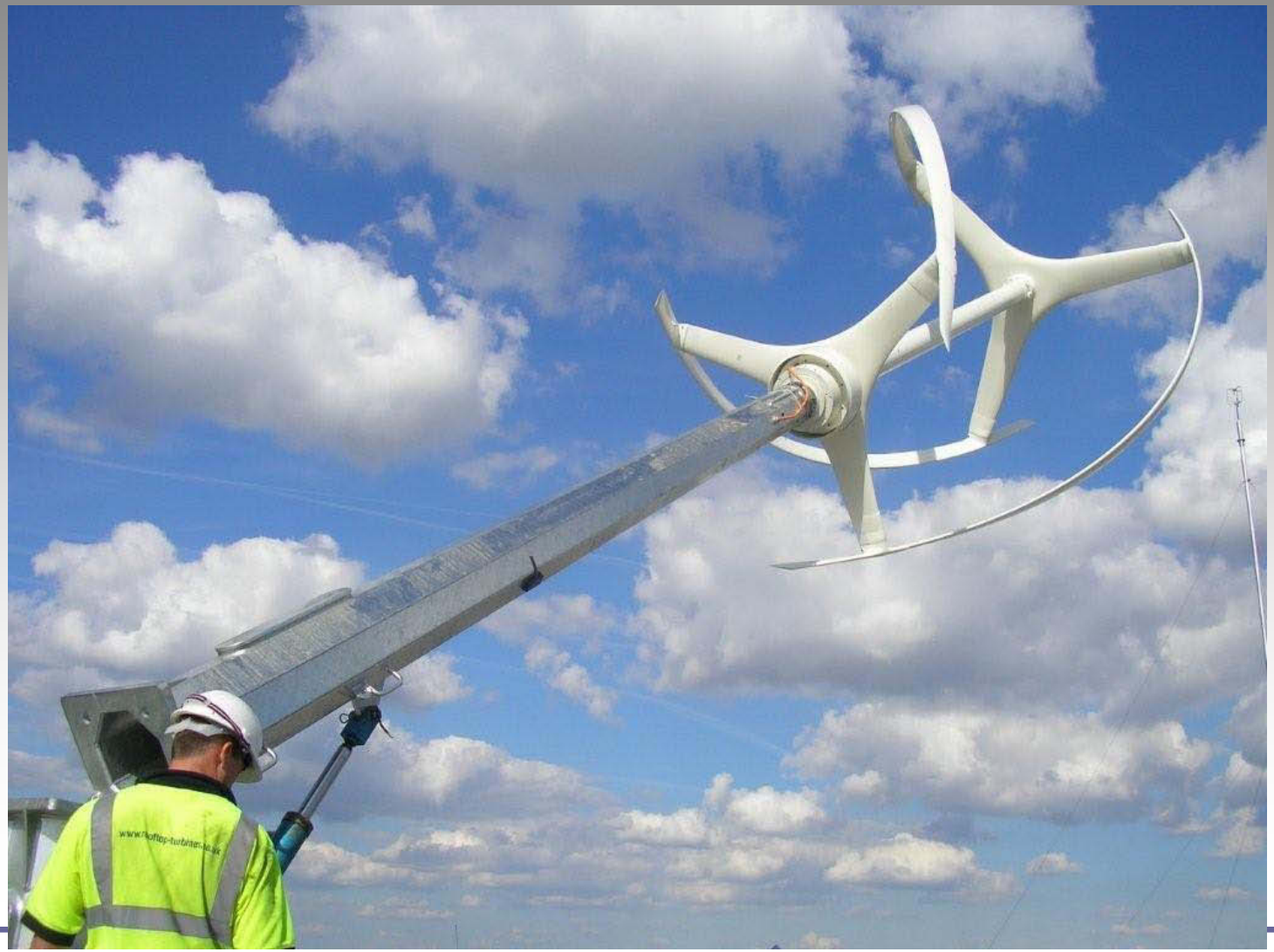
%Carbon abatement vs Discounted Abatement cost

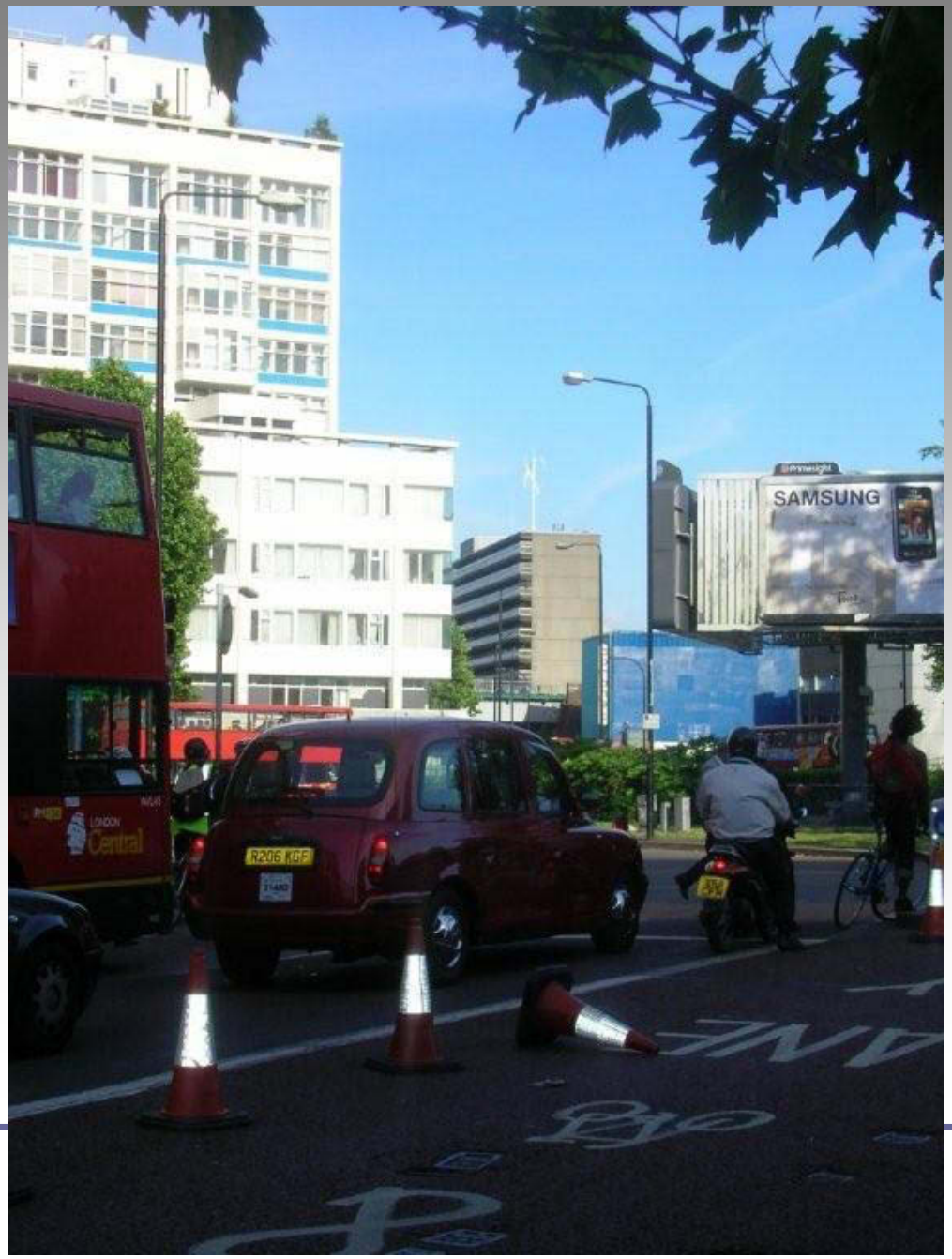
QR Installation

- Installed June 2008
- Some commissioning and control issues
- Yield should not be taken as fully indicative of typical outputs
- Recent changes to control algorithms
- QR generally look for a site with a higher mean wind speed

Photos by **Francesco Padovan**



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URLs:

http://www.elephantandcastle.org.uk/00,resource,1560,1559,00.htm

http://www.buildinggreen.com/auth/article.cfm/2009/4/29/The-Folly-of-Building-Integrated-Wind/

http://www.warwickwindtrials.org.uk/2.html