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SMALL TURBINE COLUMN:

Warwick Urban Wind Trial Project Sheds Much Needed Light on Rooftop Wind Resources

by Mick Sagrillo

The interest in roof-mounted ‘urban turbines’ has been running unexplainably high for the past few years. Micro turbine manufacturers began the fracas by offering their products for this niche market. Homeowners looking for some way of lessening their carbon footprint are often fascinated by wind turbines. And the media, always looking for something interesting or controversial to feature, published pro and con pieces.

The technology referenced here, micro turbines and very small wind turbines, range in capacity from a few hundred watts to as much as 1.5 or 2 kW. This size is about the upper limit that one can safely mount on the roof of most residences of other buildings without doing substantial structural damage. In addition, manufacturers have argued that, due to the low cost of the wind turbine itself, a tower—and its associated cost—is simply not justified for these installations. For reference, we’re discussing turbines ranging from $1,500 to upwards of $6,000, while a full-blown installation for such a system on an 80 to 100-foot tower could easily exceed $30,000.

Understanding cost and payoff

What the purveyors of the rooftop urban turbine concept and equipment often focus on is cost, a message that appeals to potential buyers of their goods. But in reality, what the homeowner should be keying in on is how much electricity the system will generate. For example, a wind turbine that costs $6,000 but generates little to nothing is far more expensive than one that costs $30,000 but generates enough power to meet a substantial portion of the homeowner’s electric needs.

Lacking understanding about the physics of air flow and how energy available to the wind turbine is a function of the cube of the wind speed—in addition to possibly having an aversion to the heights associated with tall towers—many homeowners have unfortunately taken the bait. News coverage, meanwhile, is all too frequently done by people far less sophisticated in such esoteric concepts as air flow and turbulence over buildings than might be a motivated homeowner with the right intentions, some money to spend, and the diligence to adequately research the issues involved. Media interest all too often comes in the form of “eye candy” photos and a controversial story, or anything dealing with solutions to global climate change, still a controversy in the minds of many.

What have been completely lacking are any studies or data on the performance of roof mounted urban turbines. Do they actually do what the manufacturers claim they will? Has anyone actually monitored wind speed and turbine performance of these installations? Answers to these questions have unfortunately come only from the manufacturers of these products, who invariably claim that such information is proprietary data and cannot be shared with the public. Until recently, that is.

The testing protocol

Jim Green at the National Renewable Energy Laboratory recently informed me that such a study—that is, gathering information on rooftop wind speeds and urban turbine performance—is currently underway. In January a consulting firm known as Encraft, Ltd., whose consultants tout themselves as “independent technical advisors and designers of low carbon and renewable energy solutions,” issued an interim report titled “The Warwick Urban Wind Trial Project.” In the project, Encraft monitored 23 households in the United Kingdom (U.K.) that installed micro- or small turbines on their roofs. All participants volunteered to be a part of the study, and all purchased the wind turbine of their choice and at their own expense.

The project evolved out of a questionnaire posed to homeowners about energy efficiency, specifically, “Will the deployment of this technology deliver and encourage greater awareness of energy efficiency in the community?” Feedback on the questionnaire and the high level of interest in “urban turbines” ultimately lead to the monitoring of such installations.

What Encraft consultants working on the project discovered is that many urban turbines are marketed with claims such as a given “systems can deliver 30% of average annual electrical demand.” The report notes that “urban wind turbines are not difficult to sell,” and confirms that most consumers are motivated by price, with little understanding of how performance of a wind turbine is affected by the site or the area’s wind speed. Issues such as the structural integrity of the building or the suitability of the site are given a cursory review at best.

Manufacturer data is available in the U.K., but verification is lacking, just as it is in the U.S. One problem Encroft encountered is that for predicting performance, the manufacturers used the wind database developed by the U.K. Department of Business, Enterprise, and Regulatory Reform. The database, known as NOABL (Numerical Objective Analysis of Boundary Layer), is a computer model used by some in the U.K.to quantify the wind resource for wind farms or small wind turbines mounted on actual towers above surrounding trees and buildings. The manufacturers of rooftop urban turbines also used the NOABL database to estimate their turbines’ performance. The database defines wind speeds at heights of 10, 25, and 45 meters above the ground level. However, the database algorithms have some fatal flaws so that when extrapolated down to the urban environment, a few feet above a roof line where urban turbines would be mounted, the database turns out to be completely useless at predicting wind speed. All of the urban turbines monitored in the project were mounted between six and 15 feet above the roofline.

All of the turbines in the study had kilowatt-hour meters installed between the inverter and the owners' electrical panels so that output of the turbine could be recorded. In addition to monitoring the kilowatt-hour performance of the installed wind turbines, the project also installed anemometers and monitored actual wind speed at hub height near the turbine. Encraft found that the average wind speeds monitored at the micro turbine sites were between 27% and 73% lower than those predicted by extrapolating down from the NOABL data. Bearing in mind that energy generated by a wind turbine is proportional to the cube of the wind speed, the average wind power available is only 2% to 39% of that predicted by NOABL, according to the interim report. You can imagine how poorly some of these urban turbines performed for their owners.

Finally, some data…

The project compared energy actually generated by the urban turbines to the manufacturers' performance predictions. The interim report found that "on average, all sites apart from the reference site have exported less than 500 Wh (½ kilowatt hour) per day." Some of the turbines, unable to generate more than the parasitic power losses required for the inverter, were actually negative energy producers at their low wind speed sites. That is, they consumed more electricity than they generated. At some sites, the predicted energy generation was sometimes well over 1,000% higher than what was actually generated.

To validate the fact that the poor performance was caused by over-predicting wind speeds in an urban environment and not just the result of an under-performing technology (i.e., the micro turbines), the project set up a reference site—that is, a control wind turbine. The 600-watt turbine was installed on a 15-foot tower, typical of most urban heights, but in a very open setting with a 14 mph average annual wind speed. An anemometer was sited upwind from the control turbine at hub height. Interestingly, the control site recorded a slightly wind speed than was predicted by NOABL, indicating that such models do indeed work, just not in the complex ground clutter characterized by the urban environment. The control turbine performed as expected, indicating that the underperformance problem is not one of micro turbine technology (at least not in this one case) but in predicting the wind resource available in the urban areas.

The following table summarizes the wind speed data

Location	Predicted wind speed (mps)	Monitored wind speed (mph	site description
Misty Farm (reference site)	**14.1**	**14.9**	**Rural**

Eden Court 1	14.4	14.4	14 story building
Lillington Road	11.2	4.5	Urban residential
Hills Close Gardens	10.1	4.3	Urban residential
Princes Drive	11.0	3.0	Industrial area
Warrington Road	10.5	4.7	Urban residential
Southorn Court 1	13.0	10.2	7 story building
Napier	12.6	7.4	University
Daventry Town Hall	12.1	6.8	Urban civic center
Ashton Court 2	13.0	9.2	7 story building
Southorn Court 2	13.0	11.1	7 story building
Daventry County Park	10.8	5.8	Urban park
Fountain Farm	11.9	7.0	Urban residential
Eden Court 2	14.6	14.7	14 story building
Nottingham	10.5	3.9	University
Antrobous Road	11.2	4.3	Urban residential
Summerfield Crescent	11.9	5.2	Urban residential
Park Farm	10.5	7.2	Semi-rural/urban
Nothamptomshire	10.3	7.5	Urban residential

What the data suggests is that wind speeds were consistently overestimated by either the manufacturers or installers of the urban wind turbines. Extrapolating down from a computer model height to the hub height above the building in the vast majority of instances resulted in considerably over-estimating the wind speed, and therefore the turbine performance. However, in addition to the reference site already described, several sites were found to have wind speeds close to those predicted by the NOABL database. Interestingly, though, as a closer look at the table above indicates, all of those wind systems were installed on seven- or 14-story apartment buildings towering above the urban environment where higher winds would be expected.

What's it all mean?

What conclusions can be drawn from this study? The authors concluded that the NOABL database cannot reliably be extrapolated down to estimate wind speeds at rooftop locations in an urban setting in order to predict turbine performance. The owner will very likely generate watts, not kilowatts, on a residential urban rooftop.

I have long argued against monitoring wind speeds for wind turbines in lieu of using wind maps and their databases. Given the high quality of wind maps we have available in the U.S. today, a trained wind site assessor can fairly accurately evaluate a site for its wind potential, provided that the wind turbine will be mounted on a tower considerably above the trees and buildings in the surrounding area.

However, rooftop urban settings is one area where I firmly believe that monitoring winds at the proposed hub height above the roof line is an absolute necessity if you want to understand how much electricity your urban turbine will generate. As supported by the Warwick Urban Wind Trial Project, doing otherwise is expensive guesswork that will invariably result in a disappointing outcome. Given the low wind speeds measured on rooftops in an otherwise good wind regime, one can only conclude that urban residential rooftops are unequivocally not good locations for wind turbines. Install a photovoltaic array instead.

The full interim report with all supporting data can be found at http://www.warwickwindtrials.org.uk/8.html The 23 sites will monitored for a full 12 months ending in the Fall or 2008.

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