Regulating Urban Rooftop Wind Turbines

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Towards the end of 2008, the New York City (NYC) Buildings Department (DOB) became aware that wind turbines had been installed on a couple of rooftops. The department is and has been firmly in favor of sustainable initiatives, but there were concerns these installations had insufficient engineering control. New York City's high density of buildings and pedestrian traffic create a condition where any loose and free-falling piece of equipment may result in a severe accident. The DOB considered regulations appropriate to the situation. In fact, several other sustainable initiatives, such as rooftop solar panels and green roofs, also led to changes in code or legislation. Wind turbine's specific regulations should be of interest to structural engineers as they may be commissioned to participate in the selection of the type of turbine and to design the supporting installations (e.g. independent foundations, roof supporting structures, guys or even masts).

Since, in 2008, there were no existing regulations for the installation of wind turbines in large United States cities, the NYC regulation had to be developed from scratch. The research found general news articles about public concern with the safety of rooftop wind turbines and reports of accidents in engineering publications attributed to lack of long-term reliability of the turbine's blades and support structure. The department's primary mission, public safety, required a method to certify the reliability of the turbine equipment, the safety of the installation, and the suitability of the supporting structure. In 2009, the DOB issued Bulletin 2009-015 describing a protocol for testing and approval acceptance criteria of wind turbines. Under certain limitations, it allowed for the approval of pilot projects. The bulletin was the result of the collaboration of professionals from several DOB units (Sustainability, Technical Certification and Research, Structural, Zoning). The DOB continued work towards a simplified approval process. Familiarization with the issues was achieved by talking to manufacturers and utilities, and by studying any existing standards. A *Commissioner's Forum on Urban Wind Turbines* in 2010 was attended by specialized engineers, manufacturers, and several international guests. Pertinent to DOB's research was the presentation by Dutch planning officials who described their experience with bottlenecks (public acceptance, long approval process) and their proposals to improve the process (agreements between neighbors, a method of location selection for adequate wind) or participate in design peer reviews.

Superseding the previous Bulletin, Technical Buildings Bulletin 2011-004 allowed a simplified protocol for the approval of wind turbine installations. The bulletin relies heavily on the International Electrotechnical Commission's (IEC) extensive set of standards. The 2011-04 Bulletin protocol is relatively simple for turbines whose sweep area is less than 7 meters^2 (labeled as 3 meters diameter in the bulletin text) as long as "Testing certification and listing or labeling shall be by a third-party testing laboratory accredited under International Organization of Standardization/ Electrotechnical Commission's (ISO/IEC) Standard 17025-2005." The certification ensures the reliability of the proposed turbine as it covers safety and function tests, power performance measurements, duration test, and environmental tests. In such cases, the application needs to undergo only a limited review by the third-party testing laboratory and the installation can be signed off by a New York State Licensed Professional (Engineer or Architect applicant) in lieu of a DOB inspector. Any turbine exceeding a 7 meter^2 sweep-area requires a peer review that would cover structural, electrical, mechanical, noise design, and installation. In all cases, the turbine's owner needs to submit, for approval, a monitoring plan for the installation. The DOB bulletin requires monthly monitoring in the first year after installation and biannual after that. This monitoring is to focus on conditions that may lead to public safety hazards (integrity of the turbine and support system, blades condition, shutdown system, etc.).

Wind turbines used for electrical micro-generation are referred to as small wind turbines (SWT) and are defined by IEC and by the American Wind Energy Association (AWEA) as "a system of 200 meter^2 (2153 feet^2) rotor swept area or less that converts kinetic energy in the wind into electrical energy." Note that the term "small" is for comparison with other types of turbines and does not refer to the size of blades. In fact, according to Underwriter's Laboratories, SWTs are intended to be stand-alone (not grid connected) and are "wind turbines where a user or service person cannot or is not intended to enter the turbine to operate it or perform maintenance." The DOB's choice to restrict the use of the simplified procedure to turbines with sweep area less than 7 meters^2 was mostly derived from the results of previous pilot installations as well as from the IEC International Standard 61400-2, *Design Requirements for Small Wind Turbines*.

To allow product standardization to cover most applications, the IEC 61400-2 created four SWT classes that are defined in terms of wind speed and turbulence parameters.

In practical terms, a manufacturer will perform the structural design of a type of wind turbine to meet one of the four SWT classes as listed and prescribed in Tables 1 and 2 of IEC 61400-2. The turbine type will include this class in its label. Specific values bound each class for V_{ave}, annual average wind speed at hub height and Vref, reference wind speed averaged over 10 minutes. Note that, with the exception of turbines with sweep area less than 2 meters^2, the manufacturer's structural design needs to include the mast. "The values of wind speed and turbulence parameters are intended to represent the characteristic values of many different sites and do not give a precise representation of any specific site." To guide the prospective owner in the selection of the turbine type adequate to the local project site, the structural engineer needs to understand the standard's treatment of extreme wind conditions and relate it to the specifications of the NYC Building Code. The standard lists the required wind load cases to be used in the design for operating and extreme wind conditions. IEC indicates that during extreme winds, the turbine is expected to be parked (stand still or idling) and the design shall use the V_{e50}, which is the extreme expected 50-year 3-second wind speed (IEC provides a formula that relates V_{e50} to V_{ref}). In addition, IEC 61400-2 places serious emphasis on the design for fatigue. It also enumerates the type of tests and verification required. Rooftop turbines are usually SWTs with rotor sweep areas smaller than 2 meters^2. For this subset of SWTs (less than 2 meters^2), the manufacturer is not required by IEC standards to include the support structure as part of the delivered system. The manufacturer needs to provide installation instructions and to specify various clearances, maximum allowable tower top deflections, and loads. The support structure, including all elements in the load path, remains to be designed by the local structural engineer using manufacturer's data, instructions, and specifications.

The DOB Bulletin is not specific to rooftop installations but, clearly, this is the most common application given the size of the turbine and NYC conditions. Up to this date, no accident has been recorded, but there were several complaints about wind turbine noise. A City Council (NYC) local law that is about to take effect allows the noise level to reach a maximum of 5 decibels above the ambient sound level at the property line.

In recent years, a limited number of wind turbines were installed. There is no information on their power efficiency. It is expected that those installed on high rooftops will be more productive. There are significant opportunities in NYC where there are about 500 buildings taller than 500 feet. To encourage the development of clean energy production, a newly enacted local law requires a "wind resource assessment" that will map areas where winds have an average speed of at least 11 miles per hour for at least three months a year.

Some definitions from IEC:

Swept area – projected area perpendicular to the wind direction that a rotor will describe during one complete rotation.

Support structure (for wind turbines) – part of the wind turbine comprising the tower and the foundation

Reference wind speed (V_{ref}) – basic parameter for wind speed used for defining SWT classes. Other design-related climatic parameters are derived from the reference wind speed and other basic SWT class parameters

Small wind turbine (SWT) – a system of 200 meter^2 rotor swept area or less that converts kinetic energy in the wind into electrical energy

Parking – situation to which a wind turbine returns after a normal shutdown▪

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