Survey of Urban Wind Energy Technology

Submitted by: Charles Miles
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Introduction

Rising concerns about global warming, air pollution and the rising cost of energy have increased interest in developing renewable energy sources. Wind energy systems have been under development since the early 1980's. Wind energy systems offer a number of advantages to fossil fuel fired systems:

Clean energy
Renewable almost unlimited supply
Domestic
Growth in Public Support
Cost efficient

Costs for power produced have fallen from $.30/KWH in the early 1980's to the current cost of $.05/KWH.

For the last 25 years, development of wind energy systems has concentrated on utility scale horizontal axis systems with high wind loads located away from urban areas. There have been several generations of development and improvement in wind energy technology. Performance of the systems is dependent on horizontal nonturbulent wind profiles. A major deterrent to the continued development of wind energy at remote sites is the limited capacity of the national electric distribution grid.

There has also been development of small wind turbines. Most of the designs have been of horizontal axis turbines, but there have been some vertical axis systems. They generally have been deployed in remote areas and on small farms. Again these systems are dependent on horizontal nonturbulent wind profiles. Recently, there has been innovations in the design of small turbines that can facilitate their deployment in urban environments. Because these small wind turbines produce DC power, these systems can be integrated with photovoltaic systems and can use the same equipment for attachment to the power grid. The issues involved with using these systems in urban environments are: 1) noise, 2) aesthetics, 3) integration into architectural systems, and 4) efficient use of the available wind resource.

Wind Energy in Urban Environments

The urban environment has unique challenges to the development of wind energy systems. Wind profiles in urban areas tend to be more turbulent and not along a single axis. The presence of buildings increases the turbulence of the flow and the wind flowing over the building is accelerated in the same manner that air is when it flows over the top of an airplane wing. This also changes the direction of the flow from horizontal to slightly upward. Aesthetics are a concern. Many people find the design of a conventional wind turbine unattractive. There is concern for the safety of birds and other wildlife. To be effective, these systems must be easy to integrate with the architecture of urban environments. The conventional horizontal axis wind turbine does not integrate easily with architectural designs.

This survey will cover both large and small wind turbines, but will focus on unique designs for architecturally integrated small wind systems.

Urban Wind Energy Economic Potential

The economic viability of urban wind energy systems is dependent upon the price of the system, the cost of electricity, and the local wind velocity. Sacramento has and annual mean wind velocity of about 10 mph. This is on the low side for economic viability. Many other cities such as New York, Chicago, Boston, Houston, and San Francisco have an annual mean wind velocity between 10 and 12 mph. Cities normally have higher than average electricity rates and the presence of buildings tends to accelerate the wind. The market is large enough to be attractive to wind energy systems that are designed to take advantage of these urban environments.

Large Conventional Systems

There are several approaches to integrating large scale wind energy into urban settings. First is to place the conventional systems in the periphery of the urban area and in locations where noise and size are not major issues. The area around airports and industrial sites are examples of this approach. Another approach is to integrate the large solar system into the design of the building. Figure 1 illustrates an example of this. The curved surface of the building acts as a concentrator for the wind turbines. This approach requires a lot of planning and does not take full advantage of wind in the urban environment.

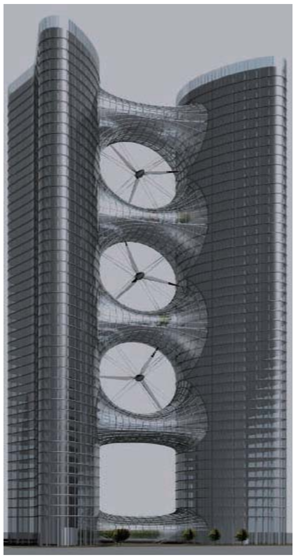
Figure 1

Small Conventional Systems

Conventional wind turbines have been smaller versions of the large utility size turbines. Recently several companies have conducted research and development into making micro wind turbines more efficient. There are several problems with conventional systems: 1) They can be noisy if not designed correctly. 2) They may pose a danger to birds and other wildlife. 3) They do not efficiently convert wind energy that is not parallel to the axis or is turbulent.

Figures 2 and 3 show typical installations of conventional wind turbines. The turbines are elevated above the level of the roof to catch the horizontal wind flow. These systems are not good at catching the accelerated wind flowing over the building.


Figure 2


Figure 3


Figure 4


Figure 5

AeroVironment Wind Energy System

AeroVironment is a high technology company that has developed slow speed unmanned vehicles. The includes the Helios which used photovoltaic power to set a new altitude record of 96,000 feet. They used expertise in slow speed flight to design architecturally integrated micro wind systems. Figure 4 shows the first version. Figure 5 shows the second version of the system. The second version has the turbines pointed slightly down. This will enable the system to catch the accelerated wind as it passes over the building. The turbines can also rotate to catch changes in wind direction. The turbines are 6 feet in diameter and generate 400 watts at design conditions. There is a third generation being designed that will be more efficient and operate a lower wind speeds.


Figure 6


Figure 7

Windside Wind Energy System

Windside is a Finnish company that has developed some innovative vertical axis wind turbines. The company won the EEP Gold Metal Award in Paris in 2005 for a small scale turbine design. These turbines are very quiet, produce power at low wind speeds (5 mph) and are not harmful to birds and wildlife. The turbines respond to wind in all directions and are able to hand turbulent and gusty wind conditions. Typical size for a turbine is 1meter in diameter and 4 meters tall.

The turbines, because of their unique vertical design, can be used in places not previous considered for wind energy such as: 1) cell phone towers, 2) posts for street and traffic lights, 3) flag poles, 4) vertical columns in parks and landscaping. Figures 6 and 7 show installations of this system.

Aerotechture Wind Energy System

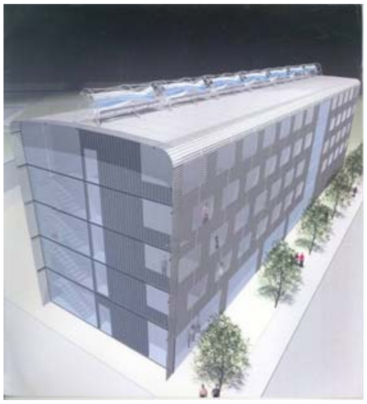

Figure 8

Aerotechture is a company based in Chicago, Illinois. The design of its wind turbine is based upon Savonius and Darrieus turbine designs. The combination of these design along with the use of light weight plastic materials, produces a turbine that will produce power at low speeds, produces very little noise and vibration, and can withstand high wind velocities. The turbine is also safe for birds and wildlife. This wind turbine can be used in both horizontal and vertical orientations. Figure 8 shows the system mounted horizontally on a building. Note the rounded corners on the top edge of the building to direct the wind flow to the turbines.

Figure 9

An interesting feature of this system is that the turbines can be strung together horizontally. Figure 9 shows a concept of this system mounted on the Golden Gate Bridge. This concept opens up a number of potential applications for this system.

Conclusions

Wind energy systems can be economically implemented in the urban environment. These systems place the energy source close to the electrical load. This eliminates the need to expand the high voltage electricity network to provide electricity for these loads. The urban environment is more secure because it can provide a larger portion of its energy needs. Unique solutions for the application of wind energy technology in urban environments have been and are being developed. The systems allow the designer to architecturally integrate the wind energy system into the building. Since small wind energy systems produce DC power, these systems can also be integrated with photovoltaic systems. This provides even more flexibility since the renewable energy system can be composed of modules of small wind turbines and photovoltaic collectors dependent upon the renewable resources and loads at the site.

Figure 10 illustrates a concept design for renewable energy integrated into a building. The north side of the building is glass to provide day lighting. The wind energy system is located on the north edge of the roof and is architecturally integrated into the building. The south facing roof can be used for photovoltaic and thermal energy collector systems.

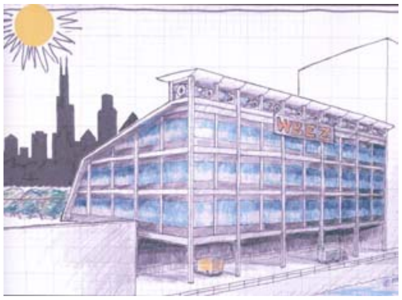

Figure 10

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