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Harvesting Wind Energy from Tall Buildings

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Abstract— **Integrating wind energy systems into building design is a small but growing trend, and high rises with their elevated wind speeds seem particularly suited to the technology. Technology innovation can further reduce the cost of wind energy. Current wind turbine technology has been developed largely for onshore applications. Designs that incorporate wind turbines are increasingly being seen on the drawing boards for skyscrapers across the globe. The project forms a testing ground for new architectural strategies for a place-based approach of wind turbine implementation in buildings and the urban environment. When assessing the merit of building integrated wind turbines, it is important to consider that wind conditions near the building surface will be very different from the general wind conditions in the region, due to both the influence of neighboring structures and the effects of the building itself.**

***Keywords*— skyscrapers, wind effect, wind turbine, building structure.**

I. Introduction

The project described in this paper explores ideas for building-integrated wind energy (BIWE) in India the project combines technical, environmental and aesthetic research and design studies by an interdisciplinary team of architect's architectural engineers, aerospace engineers, landscape architects, and meteorologists.

The project forms a testing ground for new architectural strategies for a place-based approach of wind turbine implementation in buildings and the urban environment. While current research focuses primarily on technical performance and the economics of wind turbines, this project combines research on wind behavior around buildings with design investigations of wind-optimized building forms and the aesthetic potential of turbine integration in architecture. The project links exploratory research to the education for sustainable architecture and technology. The project's primary objective is to combine research on wind behavior around buildings and in the urban environment with design investigations of wind-optimized building forms and the potential of turbine integration in architecture.

II. Technology development and status

Basic design principles

Generating electricity from the wind requires that the kinetic energy of moving air be converted to mechanical and then electrical energy, thus the engineering challenge for the wind energy industry is to design cost effective wind turbines and power plants to perform this conversion. The amount of kinetic energy in the wind that is theoretically available for extraction increases with the cube of wind speed. However, a turbine a portion of that available energy. Only captures

III. BUILDING CONSTRUCTION

Middle-rise buildings, defined as buildings with four to seven stories, form a common building type in urban and semi-urban locations and their size allows the integration of small wind turbines that can exploit minimum wind speeds. Skyscrapers are potentially able to harvest far more wind energy. As the cost of electricity rises, the incentive to harvest local renewable energy without transmission loss will increase. To prepare for this time, the problems of wind turbine installation on buildings and in the urban environment need to be creatively addressed in research and design inquiry to improve technical output as well as aesthetic integration for a meaningful environment. Tall building designers are showing an increasing interest in reducing the environmental impact of the construction and operation of their buildings.

IV. PROFIT GAINING TECHNIQUE

One of the approaches currently used, is the incorporation of on-site power generation. This is primarily achieved by integrating solar and wind devices into the design of the building. The requirements for optimizing the performance on wind generators in an urban environment are quite different from those pertaining to wind farms in open sites. This entails the use of different design approaches to assess the optimum placement of wind turbines within the building envelope, the most suitable generator types for the building environment, and to estimate annual energy production for the wind turbines.

Image 1 -- turbine installed on roof of a building

FACTORS TO KEEP IN MIND WHILE DESIGNING BUILDING INTEGRATED TURBINES

A. *Absolute Height of Building*- Height of Building above general heights of surrounding buildings. The building should be the highest of all other building so as to gain maximum amount of wind and pass through the turbine blades.

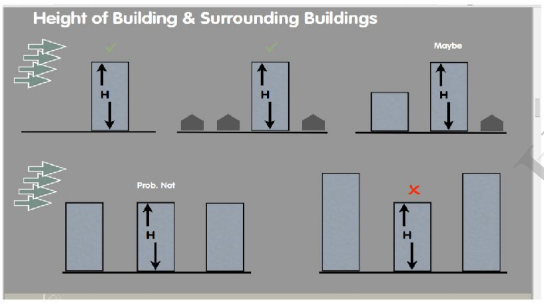

Image 2 – Height of Building and Surrounding Building

B. *Orientation of the building*- the building since receive wind from all sides. Turbine should be placed such that it let pass through maximum wind. Tall buildings in urban areas work well when:

- Isolated rather than in groups
- Long elevations facing dominant wind directions

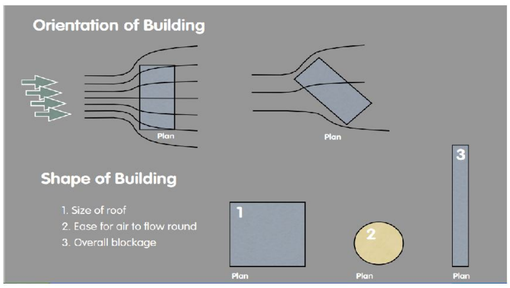

Image 3 – Orientation Of Building

WIND CLIMATE

When contemplating the incorporation of wind power generation into a tall building design,

The first consideration must be the local wind climate of the area. Bluntly, if there is not

Sufficient wind resource in the area, then the potential for successful use of turbines will be

Very limited. Wind conditions in urban environments tend to be very different. Turbines work most efficiently in low-turbulence environments; therefore care needs to be taken in specifying turbine types that will cope with both existing turbulence levels and potential future changes as a result of urban development. Urban development is likely to pose one of the greatest challenges to increasing use of turbines on tall buildings. In city center locations, height restrictions often mean that many tall buildings are of similar heights. Even if a building is very tall, if all the surrounding buildings are of similar height then the potential for efficient turbine installation is significantly reduced.

When wind turbine integration at a particular site is considered, the understanding of wind direction, velocity, and frequency is the most important part of a site assessment

As discussed in the previous sections, it is desirable to locate turbines in regions of high wind speed and low turbulence. Describing the wind flow around tall buildings can be quite

Complex and has been studied in depth for many years. There will be positive pressure on the windward face and negative pressure on the side and leeward faces. As air naturally flows from areas of high pressure to areas of low pressure, the most effective locations for wind turbines will be either in the accelerated shear layers around the edge and top of the building, or in specially developed passages linking the areas of positive and negative pressure. Note that wind speeds close to the center of a flat roof may be low as this area is often in a region of separated flow. Whereas with a pitched or tiered roof, the center may be the location of the greatest wind resource. The table shows annual wind speed of Jodhpur:

Wind Speed	
Annual Average: **4.30**	
Monthly Average	
Jan	**3.97**
Feb	**4.24**
Mar	**4.17**
Apr	**4.63**
May	**5.25**
Jun	**5.51**
Jul	**4.55**
Aug	**3.89**
Sep	**4.04**
Oct	**3.70**
Nov	**3.79**
Dec	**3.90**

Table --

V. WIND POWER DENSITY

In order to estimate how much energy a specific turbine will be expected to produce at a
Given location, the wind resource at that location must be identified. A wind turbine works by
Extracting kinetic energy out of the wind and converting it to mechanical and then electrical
Energy.
The power that is available in the wind to be converted to electrical energy is defined in the following relationships

$P_w = ½ \rho U^3 A$

$PD = P_w/A$

$PD = ½ \rho U^3$

PD -Power density, W/m2;

PW- Power available in the wind, W;
ρ - Air density, kg/m3;

U - Wind speed approaching the wind turbine, m/s; and
A- Projected area of the turbine perpendicular to the approaching wind, m^2.

Since the potential power production is proportional to the

Image 4&5 – Types of Vertical Axis Wind Turbines

wind speed cubed, the annual
Average wind power density cannot be defined by strictly using the mean annual wind speed. Rather some knowledge of the distribution of wind speeds must be known to accurately estimate the annual average wind power density (*PD*).

VI. WIND ENVIRONMENT CHARACTERIZATION

In order to determine the appropriateness of installing wind turbines at the site, it is not only
Important to evaluate the wind power density, but also to characterize the wind environment in terms of flow vectors, gradients, and turbulence intensities.

VII. WIND TURBINE SELECTION PROCESS

The wind power density calculations described above were combined with manufacturer published power production curves for four different wind turbines to determine annual energy production (AEP) values. All four of the turbine evaluated can be described as vertical axis wind turbines.

VIII. UNIQUE DESIGN FEATURES

A. Unique patent pending design
B. Rugged aluminum and steel construction for any environment
C. Modular, 3D blade for easy assembly and toughness (turbines do not flex or twist)
D. Helical turbine for smooth power production
E. Design gives silent operation at less than 5 decibels above background noise
F. Completely safe for bats and birds
G. Small and inexpensive
H. Captures wind from every direction at speeds as low as 10 mph (spins like a gyro-more stable the faster it spins)
I. Captivating to the eye

IX. BASIC NEED OF BUILDING INTEGRATED WIND TURBINE AND HOW CAN IT BE USEFUL TO US

Wind power is the fastest-growing source of megawatts thanks to the jumbo-jet-sized turbines sprouting en masse worldwide.
But it also has a significant presence in the city, where gusts regularly send umbrellas to landfills. Rather than considering it a nuisance, architects increasingly view urban wind as a renewable resource for on-building power generation.

As a developing country, India needs regenerating resources. Due to high wind speed in most of the parts of country it is considered to be a better resource in parallel to solar energy. Due to urbanization, and growing new trends in buildings given by engineers providing comfortable, hazardous free environment n usage of land as much possible is done. Multistory building is best example to it. Due to extreme power cuts generation of power at the same site is easier to be rectified at the time of damage n can generate ample amount of electricity to run our work forums.

Example:

Architects, meanwhile, are looking beyond rooftops toward building designs that enhance their BIWP potential. Such buildings are sculpted to accelerate wind and maximize BIWP output. They are exciting visual statements, though a dearth of performance data makes their success hard to assess.

The first high-profile accelerator design was the Bahrain World Trade Center (WTC), completed in 2008 with three 95-foot-diameter horizontal-axis turbines mounted on bridge ways between twin 50-story towers. Danish turbine manufacturer Norwin provided the 225-kilowatt (kW) turbines, which architect Atkins Global predicted would generate up to 1,300 megawatt-hours (mWh) per year. That would be 200 times greater than Twelve West's BIWP output and would satisfy 11 to 15 percent of the building's consumption.

Image 6 -- baharian world trade Centre – first building integrated wind turbine generator

X. LIMITATIONS

A. *Airflow turbulences:* Urban and suburban areas deal with much higher airflow turbulences than open fields. Turbines can capture most efficiently laminar, non-turbulent winds. Currently, turbines cannot effectively harvest highly turbulent airflow and the region of high turbulence in the flow around buildings has generally much lower wind speeds and thus wind power densities. An additional complication is that this region shifts locations on the building with changes in wind direction. When integrating turbines in a design, it is useful to study turbulences around buildings and on roofs, for example with Computational Fluid Dynamics (CFD) software, and to avoid the placement of turbines at building parts with high turbulences. Locating wind turbines around 30 feet above potential obstacles like trees or buildings is a common rule of thumb for harvesting laminar winds.

B. *Turbine impact on building structure:* Turbine weight must be considered in the dimensioning of a building structure. The turbine rotation causes vibrations in the mast or substructure that need to be addressed as an additional load for the structure.

XI. ADVANTAGES

While all of these aspects need to be carefully addressed, there are some advantages of small turbines integrated in Buildings and the urban environment as compared to larger turbines installed in open fields that are worth considering. First, no or less land or water area is needed for BIWE projects. This also implies that there are no additional access roads needed, reducing secondary impacts of farmland reduction and forest fragmentation. Although the costs for additional building structure to carry turbine weight and vibration load are currently larger than for freestanding turbine towers, smaller substructures can be used and foundations or masts might not be necessary at all, thus material use can be reduced. The transportation and installation of small turbines is easier as compared to big turbines. BIWE uses short-distance cabling and allows for a short-distance grid connection. And finally, the scale of small turbines allows for a more subtle aesthetic impact on the environment in comparison to large turbines.

Image 7 -- types of orientation of installing turbine

XII. CONCLUSION

When assessing the merit of building integrated wind turbines, it is important to consider that wind conditions near the building surface will be very different from the general
Wind conditions in the region, due to both the influence of neighboring structures and the
Effects of the building itself. The winds will typically be gustier (turbulence intensity)
And uneven across the turbine blades (wind shear), which can significantly affect the turbine's performance. Improperly located, a wind turbine in this environment may be subjected to an inadequate wind resource, resulting in less than optimum power production, and/or an environment that the turbine is not designed to withstand. Through the use of an atmospheric
Boundary layer wind tunnel, the building design team is able to identify the wind resource and
Wind flow characteristics at the proposed turbine location(s) during the design process so
That an accurate assessment can be made of the potential power performance and survivability
Of the wind turbine before the building is constructed.

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