The Renewable Energy is the Future of High-Rise Buildings

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Abstract

The high-rise as a building type has proliferated in the city centers throughout the major cities in the world. It has come about as a consequence of increasing land values and other land economy factors influencing the location of businesses.

The evolution of the last years resulted in tall buildings built using a wide spectrum of creative structural solutions. A major reason for regionally diverse solutions is the varying handling of energy resources. The construction industry is under growing pressure to incorporate renewable energy systems in the design and construction of new developments. The building enclosure is regarded as a perforated barrier or as an environmental filter. This filter functions like a sieve that enables selective exchanges between the external climate and the internal spaces that are designed to achieve the desired internal conditions. In those buildings adopting this design approach. some of the outside natural climatic elements. such as wind. rain and solar radiation. are sieved by their enclosure systems so that certain unwanted influences are excluded. while those which are desirable are admitted.

In this document. we summarize defining. estimating. and forecasting the Renewable Energy and their applications in high-rise buildings as a case study.

Buildings are more energy efficient. comfortable. and affordable that's the goal.

1. Introduction

Until recently, tall buildings have been viewed as mega-scale energy consumers with little regard for sustainable architecture. However, this is changing with a new generation of high-rise buildings that have been designed with energy conservation and sustainability as their principal criteria. ***(WCED 1989)***

A high performance tall building is one that achieves the peak efficiency of building functions while meeting the requirements of optimum performance employing green technologies. These technologies and innovations offer radical changes to the built environments in terms of energy usage, structural performance, and environmental effects. Designing a sustainable tall building, therefore, requires a 360-degree view of the entire building enterprise considering the local and global environment, the availability of renewable and non-renewable resources, community impact assessment, and the collaborative input of architects, planners, engineers, social scientists, behavioral scientists, and other community-based groups. ***(Donaldson, 2000)***

Thus it is an integrated process because of tall buildings' scale and the fact that green design affects so many different elements of a building, such as day lighting, which in turn concerns sitting, orientation, building form, facade design, floor to floor heights, interior finishes, electric lighting controls, and cooling loads, among other things. ***(Malin. 2006)***

The construction industry is under growing pressure to incorporate renewable energy systems in the design and construction of new developments, but this will require a big change in the industry's current attitudes and ways of working. ***(U.S. Energy, 2007)***

2. Renewable Energy Technologies

These are technologies that help to generate renewable energy using a renewable natural resource or by conservation of energy.

2.1. Types of Renewable Energy Technologies

They are hydroelectricity, biomass, geothermal, wind, photovoltaic, and solar thermal.

We can also add to them the following technologies:

Fuel cells, Energy conservation and energy efficiency products, Passive, solar/green, sustainable buildings, and energy-smart design, and day lighting. ***(Roger 2007)***

2.2. Strategies to Achieve Renewable Energy

The following are a few strategies that can be used as renewable energy

buildings technologies in tall building.

2.2.1. Harnessing Solar Energy

The sun's heat and light provide an abundant source of energy that can be harnessed in many ways. There are a variety of technologies that have been developed to take advantage of solar energy. These include concentrating solar power systems, passive solar heating and day lighting, photovoltaic systems, solar hot water e.g. Holloway Circus Tower, and solar process heat and space heating and cooling. www.nrel.gov

There are two categories of solar energy: passive and active

2.2.1.1. Passive Solar Energy

It is put into practice as a design strategy to accomplish direct or indirect space heating, day lighting, etc. Maximum advantage can be taken of daylight by shaping the plan arrangement of a building to suit the activities within. The orientation of the building in relation to the seasonal paths of the sun across the sky has a significant impact on the thermal value and performance. ***(Deshmukh, 1992)***

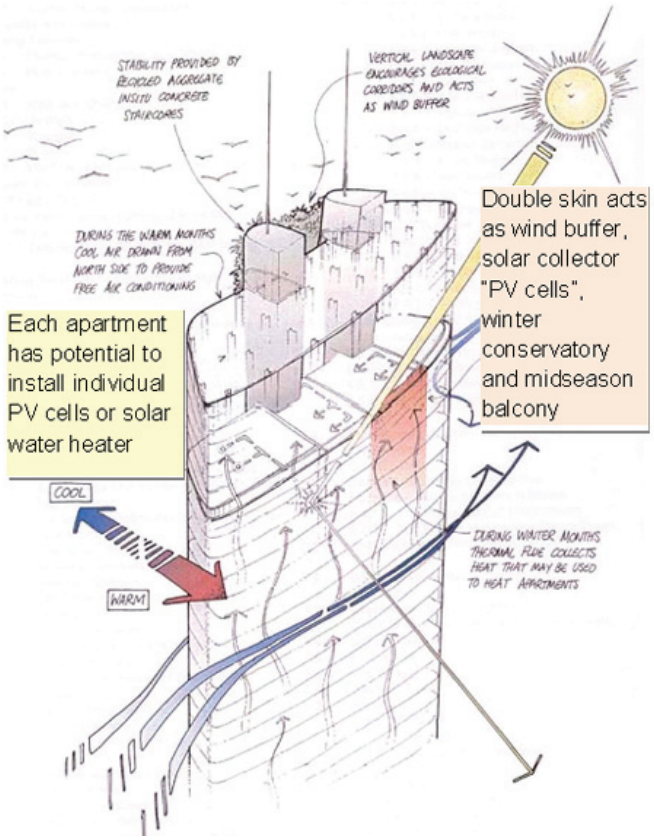


Figure-1: Green features of Holloway Circus Tower
Source: (Will, 2002)

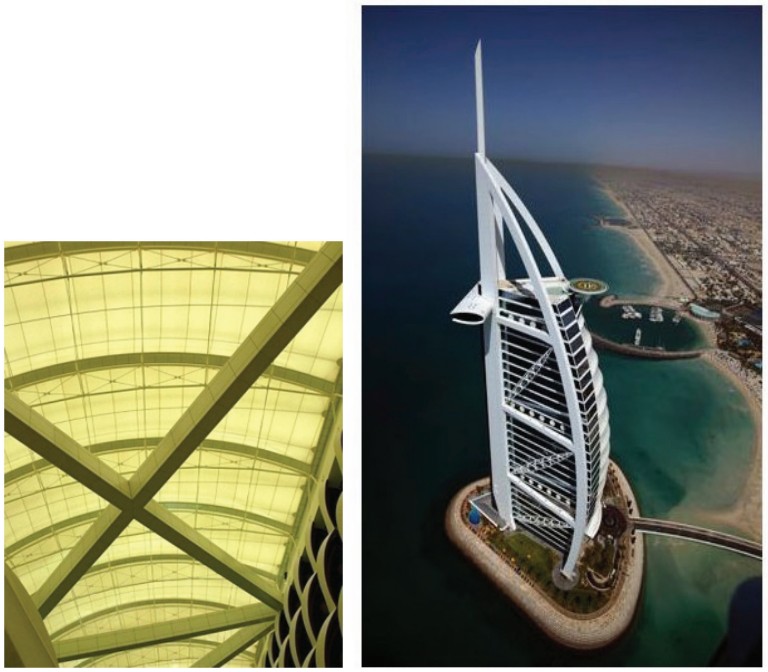


Figure-2: Membrane reduces glare and allows diffused lighting into atrium Burj Al Arab Source: http://en.wikipedia.org

The south side of a building always receives the most sunlight. Therefore, buildings designed for passive solar heating usually have large, south-facing windows. Many of the passive solar heating design features also provide day lighting. Too much solar heating and day lighting can be a problem during the hot summer months. Many design features help to keep passive solar buildings cool in the summer as the membrane in Burj Al-Arab hotel.

Such membrane reduces the glare. Also overhangs can be designed to shade windows when the sun is high in the summer. www.nrel.gov

The façade covers over 90 to 95 percent of the external building surface area in a tall building, that is, the roof area is almost insignificant compared to façade areas. Thus, the energy gain or loss for a tall building depends very much upon the materiality and technology employed in the façade treatment. Facades can also be advantageously used to control the internal conditions of the building, since it represents the building's envelope or "skin." ***(Behr2001)***

The fabric of the façade and the area assigned to windows is of ultimate concern ingathering sunlight, because the building enclosure is regarded as a perforated barrier or as an environmental filter.

This filter functions like a sieve that enables selective exchanges between the external climate and the internal spaces that are designed to achieve the desired

internal conditions. In those buildings adopting this design approach, some of the outside natural climatic elements, such as wind, rain and solar radiation, are sieved by their enclosural systems so that certain unwanted influences are excluded, while those which are desirable are admitted. The latest trend is the use of double skin, and occasionally triple skin, façade with ventilation system. Double glazing with argon-filled cavities, triple-glazing and glass coatings can increase U-values. ***(PANK, et 2002)***

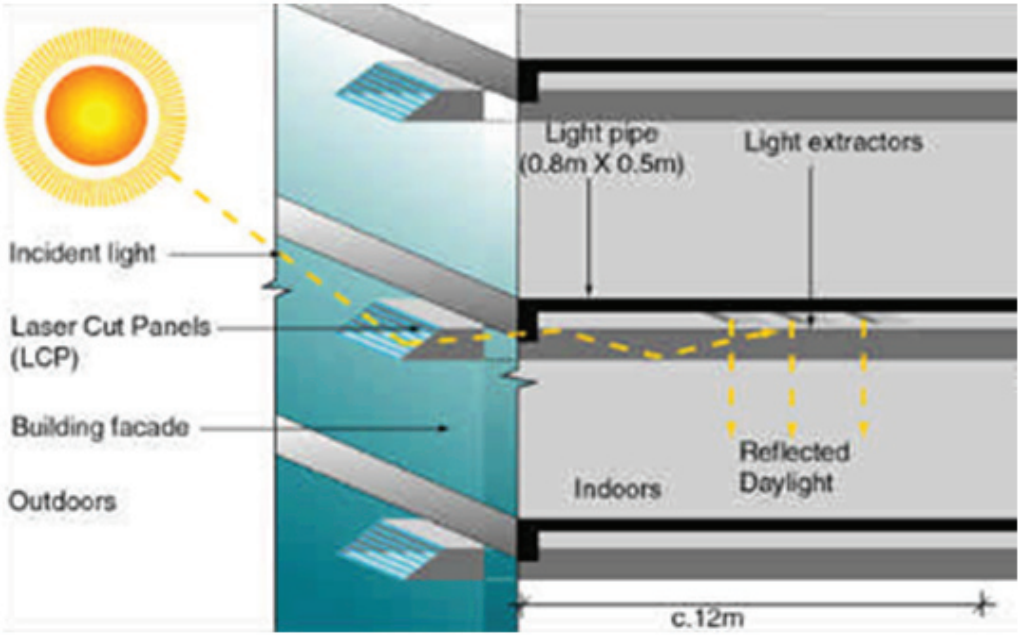


Figure-3: Diagram of Light-Pipe Source: (Ken et 2004)

One of the ways of natural lighting is the use of light pipes, which is a device, which can bring natural daylight both horizontally and vertically into spaces, which can hardly obtain natural daylight due to the location and orientation of the spaces within the building, without using any electrical or other sources of energy i.e. the light pipes are designed to channel sunlight into deep zone of building plan.

The Light-Tube is a box-tube structure (W 2m x H 0.8m x L 12m), and contains

internal mirror panels and laser-cut panels at the outer edge of the pipe.

The laser-cut panels functions as light collectors and deflects incident light from sun into the light-tube.

The laser-cut panels can redirect the light along the pipe, more directly along the axis of the pipe reducing the number of reflections.

Light extractors extract the required proportion of piped light into the inner zone Fig4.

A light spreading system (shown in Fig. 5) to distribute the light away from the area directly below the light pipe and more evenly over the zone. (***Ken et 2004)***

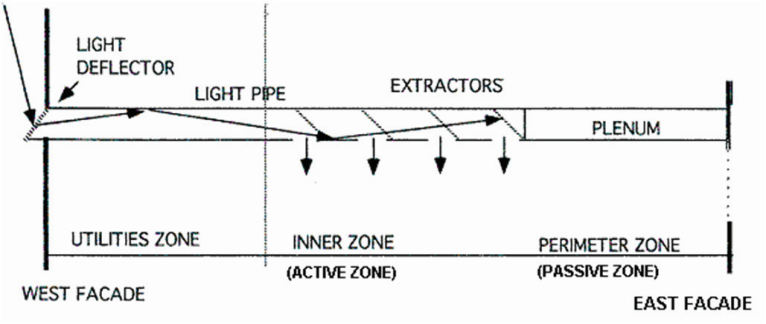


Figure-4: Section through light pipes Source: (Ken et 2004)

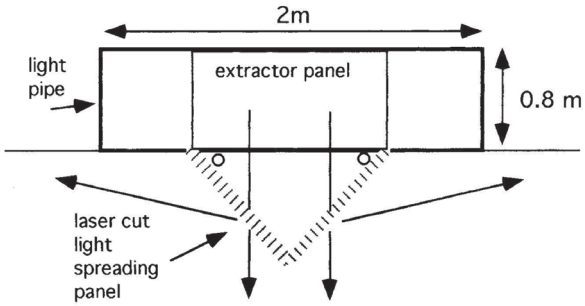
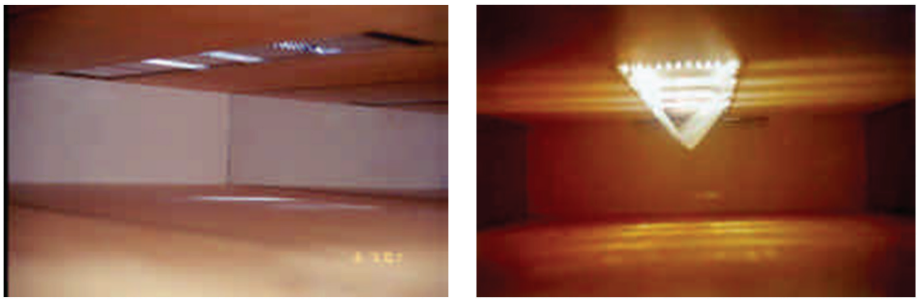


Figure-5: Laser cut light spreading panel Source: (Ken et 2004)



a) b)

Figure-6: lighting using light pipes
a) Distribution of the light without emitters.
b) Light redirected to the ceiling by LCP emitters.
Source: (Ken et 2004)

2.2.1.2. Active Solar Energy

Active solar energy is implemented through technical installations such as solar collectors and photovoltaic (PV) panels.*(IEA, 2003)*

The application of PV technology for tall buildings can be significant since they provide an opportunity for a clear Path of direct sunlight by towering over other buildings.

They are made of semiconducting materials similar to those used in these materials; the solar energy knocks electrons loose from their atoms, allowing

the electron to flow through the material to produce electricity. This process of converting light (photons) to electricity (voltage) is called the photovoltaic (PV) effect. www.nrel.gov

Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Thin film technology has made it possible for solar cells to now double as rooftop shingles, roof tiles, building facades e.g. Conde Nast Building, or the glazing for skylights or atria.

The performance of a solar cell is measured in terms of its efficiency at turning sunlight into electricity only sunlight of certain energies will work efficiently to create electricity, and much of it is reflected or absorbed by the material that make up the cell. Because of this, a typical commercial solar cell has an efficiency of 15%- about one-sixth of the sunlight striking the cell generates electricity.

Low efficiencies mean that larger arrays are needed, and that means higher cost. ***(Ali, and Armstrong, 2006)***



Figure-7: Sunlight-through photovoltaic technology-provides buildings with electricity Source: www.nrel.gov

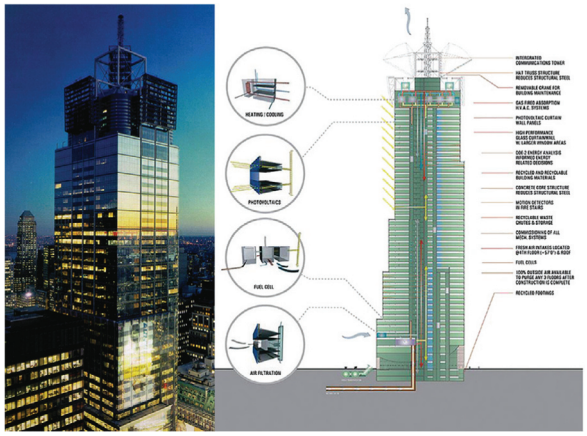


Figure-8: Elements of renewable Energy in Conde Nast Building, 4 Times Square
Source: (Ali, and Armstrong, 2006)

2.2.2. Fuel Cells

They are electromagnetic devices that generate electricity like batteries and can be considered as electrochemical internal combustion engines. They take continuous supply of fuel, usually hydrogen.

It is essentially a reactor that combines hydrogen and oxygen to produce electricity, heat, and water. Therefore, its environmental qualifications are immaculate.

2.2.2.1. Sources of Fuel Cells

The most efficient way of extracting hydrogen is from natural gas or methanol by using a reformer unit, which is then fed directly into the fuel cell.

They are classified by their type of electrolyte. One of the most common kinds of fuel cell is the proton exchange membrane fuel cell (PEMFC). Some other types are phosphoric acid fuel cell (PAFC), solid oxide fuel cell (SOFC), alkaline fuel cell (AFC), and molten carbonate fuel cell (MCFC).

2.2.2.2. Benefit of Fuel Cells

- They are clean, quiet and efficient with few moving parts.
- Fuel cells produce electricity with a very high operating efficiency, and their waste heat can also be used in CHP systems.
- They have advantages over other co-generation systems in that they are more efficient in producing electricity, produce fewer emissions, and make less noise.



Figure-9: Fuel cell
Source: (Stewart, 2006)

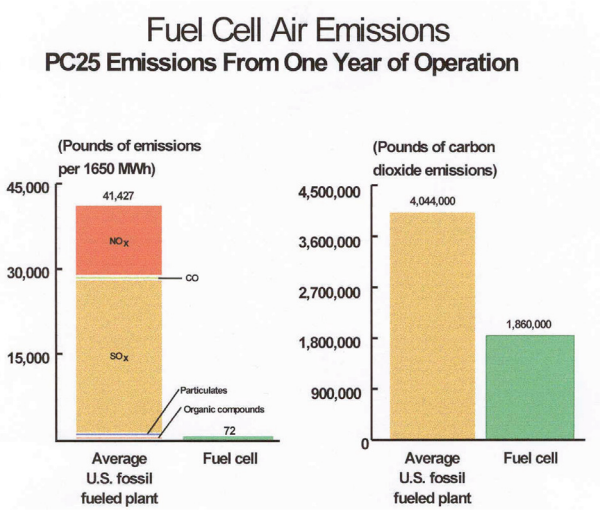


Figure-10: The efficiency of commercial fuel cell in the USA
Source: (Will, et la2002)

•It depends on renewable energy and will warrant an efficient electricity storage system. This remains a challenge at present.

•It has great potential as a carbon neutral energy source of the future. Fuel Cells for Buildings are a developing technology. ***(Ali, , and Armstrong 2008)***

2.2.3. Biomass Energy

In addition to solar and wind energy, another source is the bio energy.

It is the energy from plants and plant-derived materials-since people began burning wood to cook food and keep warm. Wood is still the largest biomass energy resource today, but other sources of biomass can also be used. These include food crops, grassy and woody plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes.

Even the fumes from landfills (which are methane, a natural gas) can be used as a biomass energy source. Biomass is the sum total of all the Earth's living matter within the biosphere. More specifically, it refers to the concept of growing plants as a source of energy. When biomass is converted to a fuel as a store of chemical energy the process is carbon neutral, that is, the carbon emitted when it is burnt quals the carbon absorbed during growth. www.nrel.gov

2.2.3.1. Sources of Biomass Energy

The main biomass feeds tocks for power are paper mill residue, lumber mill scrap, and municipal waste. In the near future agricultural residues such as corn straw will also be used. Biomass fuel, such as waste paper can be used for generating electricity and team for high-rise buildings.

A 73-story multi-use high-rise project was investigated by Alfred Swenson and Pao-Chi Chang of the Illinois Institute of Technology, Chicago in this regard. Substantial amounts of biomass are ubiquitous in tall office buildings in the form of paper, most of which is used only briefly and trashed.

Biomass fuel can be used with gas turbines. Biomass energy generation does not contribute to global warming. ***(Ali and Armstrong1995)***

2.2.3.2. Benefits of Using Biomass

The use of biomass energy has the potential to greatly reduce greenhouse gas emissions. Burning biomass releases about the same amount of carbon dioxide as burning fossil fuels. Biomass, releases carbon dioxide that is largely balanced

by the carbon dioxide captured in its own growth (depending how much energy was used to grow, harvest, and process the fuel). www.nrel.gov

2.2.4. Geothermal Energy *(heat from the earth)*

Geothermal energy is one of our most plentiful resources. They exist miles beneath the earth's surface in the hot rock and magma. The "geothermal gradient" i.e., the rate of increase of temperature according to depth in the ground, averages 2.5 to 3 C^o per 100m of depth. Modern drilling techniques can penetrate up to about 9.5 km.

The geothermal heat has to be brought to the surface. Water is pumped through boreholes and returned to surface to provide space heating-a process known as borehole heat exchange (BHE) system a significant area of innovation is the pairing of geothermal energy with heat pump technology. Development and refinement of this technology and its application to tall building design could prove to be more relevant than any other building type. ***(Smith, 2007)***

2.2.4.1. Sources of Geothermal

This heat can be drawn from several sources: hot water or steam reservoirs deep in the earth that are accessed by drilling; geothermal reservoirs located near the earth's surface, and the shallow ground near the Earth's surface that maintains a relatively constant temperature of 10°-15.6°C.

2.2.4.2. Benefits of Geothermal

- The use of the hot water and steam from reservoirs to drive generators and produce electricity
- Applying the heat produced from geothermal directly to various uses in buildings.
- Using the heat directly from the ground to provide heating and cooling in homes and other buildings. www.nrel.gov

2.2.5. Harvesting Wind Energy

Wind energy or wind power describes the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. www.eere.energy.gov

Wind is a renewable energy source which can be advantageously tapped at

higher altitudes of tall buildings where wind speed is considerably large. Tall buildings can be shaped to funnel wind into a zone containing wind turbines without having negative effects on the structure, its surroundings and the occupants. By such profiling of the structure, wind speed can be amplified that can produce more energy. In successfully exploiting wind energy in the built environment three major issues can be identified: Wind resource assessment and wind characterization around buildings, structural integration of wind turbines with buildings and special urban wind turbine design requirements.

Safe and reliable deployment of wind turbines in the highly turbulent built environment is specialized and technically challenging.



Figure-11: Steam of hot springs is geothermal energy ***Source:*** www.nrel.gov

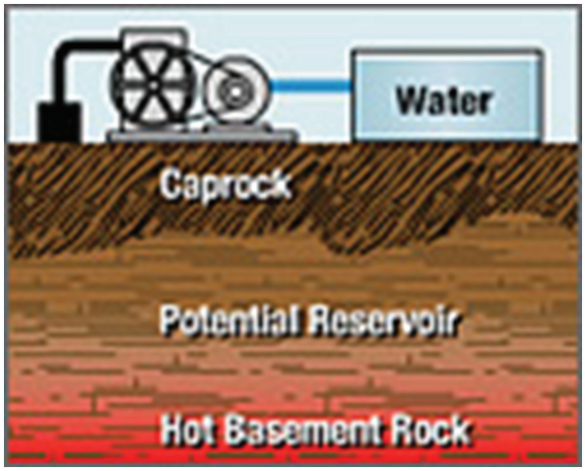


Figure-12: Geothermal system ***Source:*** www.nrel.gov

The design of such urban wind turbines is driven by the following requirements:

- Good performance in complex winds
- Safe operation in the urban environment
- Low noise level
- Simple, rugged design

- Minimized maintenance
- Aesthetic appearance

(G. Bussel1and S. Mertens 2005)

2.2.5.1. How do wind turbines make electricity?

The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity



Figure-13: Wind turbines
Source: http://en.wikipedia.org

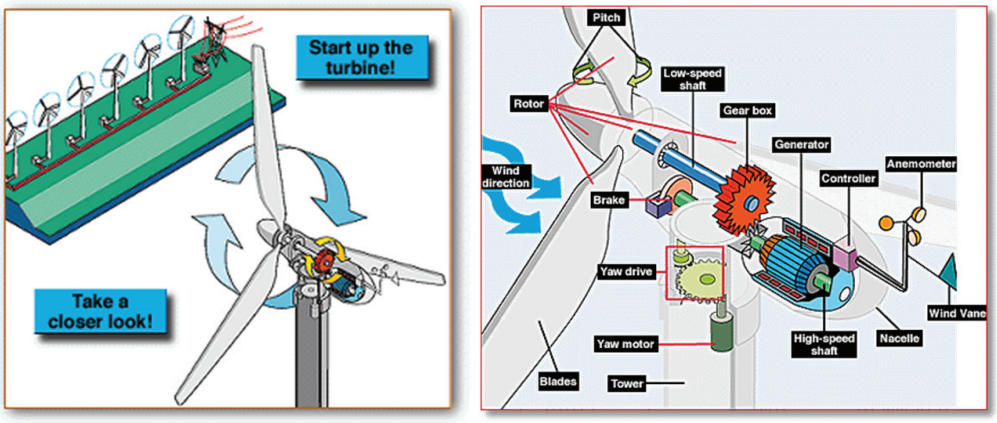


Figure-14: Components of wind turbine
Source: www.eere.energy.gov

2.2.5.2. Wind turbine energy

The built environment offers a new and challenging opportunity for generating

green electricity from the wind. In contrast to sites where large scale production units using (multi) megawatt horizontal axis wind turbines are operating in wind farm clusters, the built environment requires a totally different design.

Table-1: Types of wind turbine energy

Source: (G.J.W. van Bussel1, S.M. Mertens 2005)

	Horizontal axis wind turbine (HAWT)	Vertical axis wind turbine (VAWT)
Definition	The main rotor shaft arranged horizontally. They make use of yawing system to track variation in wind direction  Figure-15: Horizontal axis wind turbine Source: www.eere.energy.gov	The main rotor shaft arranged vertically. There is a wider range of operating principles. There are two major operating principles: 1. The drag driven devices 2. The application of aerodynamic lift for torque generation.  Figure-16: High solidity and predominantly drag driven VAWT's of various make. Source: www.eere.energy.gov  Figure-17: Lift driven VAWT's of various make Source: www.eere.energy.gov
Using in tall buildings	 Figure-18: Bahrain World Trade Center Source: www.designbuild-network.com	 Figure-19: The Pearl River Tower Source: www.worldarchitecturenews.com

Table-2: Advantage and Disadvantage of wind turbine energy
Source: (G.J.W. van Bussel1, S.M. Mertens 2005)

	Horizontal axis wind turbine (HAWT)	Vertical axis wind turbine (VAWT)
Advantages	•Variable blade pitch, allowing the angle of attack to be remotely adjusted gives greater control, so the turbine collects the maximum amount of wind energy for the time of day and season. •The tall tower base allows access to stronger wind in sites with wind shear. In some wind shear sites, every ten meters up, the wind speed can increase by 20% and the power output by 34%. •High efficiency, since the blades always moves perpendicularly to the wind, receiving power through the whole rotation.	•A massive tower structure is less frequently used, as VAWTs are more frequently mounted with the lower bearing mounted near the ground. •Designs without yaw mechanisms are possible with fixed pitch rotor designs. •VAWTs have lower wind startup speeds than HAWTs. Typically, they start creating electricity at 6 m.p.h. (10 km/h). •VAWTs may have a lower noise signature.
disadvantages	•The tall towers and blades up to 90 meters long are difficult to transport. Transportation can now cost 20% of equipment costs. •Tall HAWTs are difficult to install, needing very tall and expensive cranes and skilled operators. •Massive tower construction is required to support the heavy blades, gearbox, and generator. •Their height makes them obtrusively visible across large areas, disrupting the appearance of the landscape and sometimes creating local opposition. •HAWTs require an additional yaw control mechanism to turn the blades toward the wind. •When placed on top of buildings this cause inherent loss in efficiency since the yaw system, is not able to follow these fast and extensive variations in wind direction.	•Most VAWTs produce energy at only 50% of the efficiency of HAWTs in large part because of the additional drag that they have as their blades rotate into the wind. Versions that reduce drag produce more energy, especially those that funnel wind into the collector area. •While VAWTs' parts are located on the ground, they are also located under the weight of the structure above it, which can make changing out parts nearly impossible without dismantling the structure if not designed properly. •All vertical axis wind turbines, involve various types of reciprocating actions, requiring airfoil surfaces to backtrack against the wind for part of the cycle. Backtracking against the wind leads to inherently lower efficiency.

3. Case Study

3.1. Bahrain World Trade Center

3.1.1. Fact Sheet http://en.wikipedia.org

Location	Manama, Bahrain
Status	Complete
Groundbreaking	2004
Opening	2008
Use	Commercial
Height	
Antenna/Spire	240 m (787 ft)
Technical details	
Floor count	50
Architect	Shaun Killa

The building is the first skyscraper in the world to integrate wind turbines into its design.

They were inspired by Arabian wind towers, or Al Barajeel, which rest atop the main rooms of traditional mosques and houses to provide natural ventilation. www.worldarchitecturenews.com

The 50-floor structure is constructed next to the King Faisal Highway. The project of the building has received several awards for sustainability.

BWTC designer Shaun Killa said that:

"*Solar panels available at the time of construction lost their efficiency at high temperatures, making wind power more viable in Bahrain, an island state in the Gulf next to Saudi Arabia.*

Bahrain always has a tremendous amount of wind every morning when the sun comes up it heats the desert in Saudi Arabia, which draws in air from the Gulf. The wind in Bahrain is extremely consistent," www.reuters.com

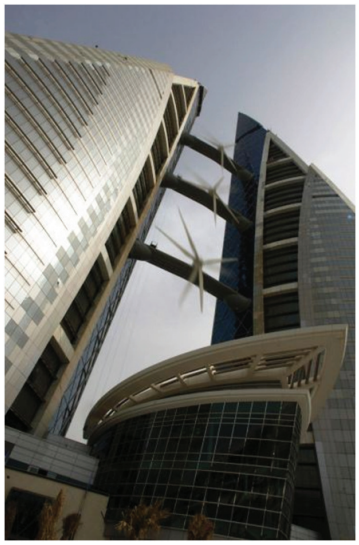


Figure-20: The towers are inspired by the Arabian wind towers (Al Barajeel)
Source: www.worldarchitecturenews.com



Figure-21: The two towers funnels the wind between them accelerating its velocity.
Source: www.designbuild-network.com

3.1.2. Structural details

Three bridges connect the towers; each holding one large wind turbine with a nameplate capacity of (225kW) each, totaling to (675kW) of wind energy production. These turbines, each measuring (29 m) in diameter, face north, which is the direction from which air from the Persian Gulf, blows in.

The three wind turbines, mounted at 60m, 98m and 136m high between the two towers.

The sail-shaped buildings on either side are designed to funnel wind through the gap to provide the maximum amount of wind passing through the turbines.

They act as aerofoil, funneling and accelerating the wind velocity between them.

The vertical sculpting of the towers also progressively reduces the pressure so that when combined with the rising velocity of the onshore breeze at increasing heights, a near equal regime of wind velocity on each turbine is achieved.

This was confirmed by wind tunnel tests, which showed that the buildings create an 'S'-shaped flow, ensuring that any wind coming within a 45° angle to either side of the central axis will create a wind stream that remains perpendicular to the turbines. This significantly increases their potential to generate electricity. The wind turbines are expected to provide 11% to 15% of the towers' total power consumption, but excess power is generated when the buildings power requirement falls, such as overnight and at weekends. A project to link the electricity grids of the six GCC nations to create a more functional and efficient" super grid" is due for completion in 2010

The turbines' will operate for 50% of the time with full power being generated at a wind speed of 15 to 20m/s.



Figure-22: Three turbines supported by bridges situated at heights 60, 96 and 132m ***Source: (BWTC, 2008)***



Figure-23: Three wind turbines at the center of the two skyscrapers
Source: http://en.wikipedia.org

The generators are of a four-pole 400V asynchronous induction type, which require little maintenance and can be controlled by centers established in the towers.

3.1.3. Other sustainable features

The building also incorporates a large number of other sustainable features that make it environmentally responsive in reducing carbon emissions. The deep gravel roofs in some locations provide kinetic insulation, while balconies to the sloping elevations with overhangs provide shading. Dense concrete core and floor slabs will level loads and reduce peak demand with associated reductions in air and chilled water transport systems.

There will also be water recycling, connection to the district cooling system, thermal insulation, reflection pools for evaporative cooling, low-leakage

windows and thermal glass with a low solar gain.

Including a heat recovery system, windows that can be opened to allow for natural ventilation, grey-water recycling, solar photovoltaic (PV)-powered outdoor lighting, and shading on the external glass façade.www.designbuild-network.com



Figure-24: Wind turbine
Source: (BWTC, 2008)

3.2. The Pearl River Tower

3.2.1. Fact Sheethttp://en.wikipedia.org

Location	Guangzhou GD China
Status	Under construction
Groundbreaking	2006
Opening	2010
Use	Mixed use
Height	
Antenna/Spire	309.7 m
Technical details	
Floor count	71
Architect	Skidmore. Owings & Merrill (SOM).

The Pearl River Tower is tall "net-zero energy" building.

It has a curved glass façade that directs air flow through narrow openings in the facade that will drive large, stainless steel wind turbines to generate electrical energy. The building's aerodynamic shape, which resembles airplane wings turned verticallywww.worldarchitecturenews.com

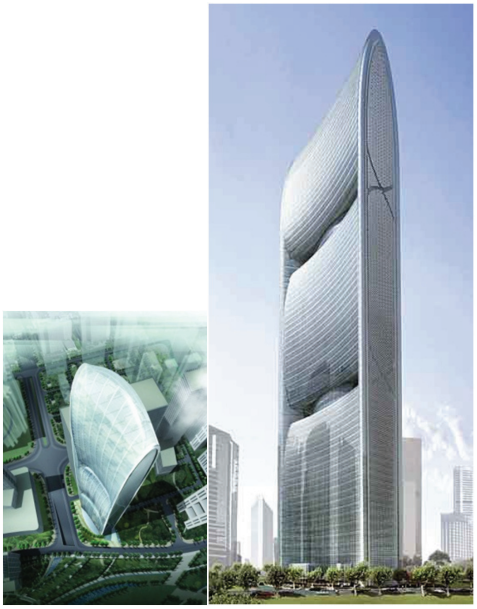


Figure-25: The Pearl River Tower
Source: www.worldarchitecturenews.com

SOM says**:** '*It will be one of the greenest buildings in the world".*

Gorden Gill says Talking about the sustainability strategy behind Pearl River Tower "*is like pulling on a thread - everything is connected in some way .It utilizes proven technologies assembling them symbiotically and gaining from the interrelationships. Pearl River Tower will draw on its riverside location in humid sun-rich Guangzhou. The tower will harvest wind, humidity, and solar power from the environment and use it to maximum efficiency through myriad interwoven systems. The three big ideas are really the combination of the external wall, the underfloor radiant system, and the ventilation these three interconnected systems will reduce typical energy consumption by about 40 percent.* ***(Stewart, 2006)***

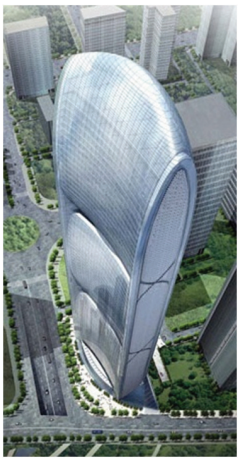


Figure-26: Lay out of the Pearl River Tower
Source: www.som.com:80

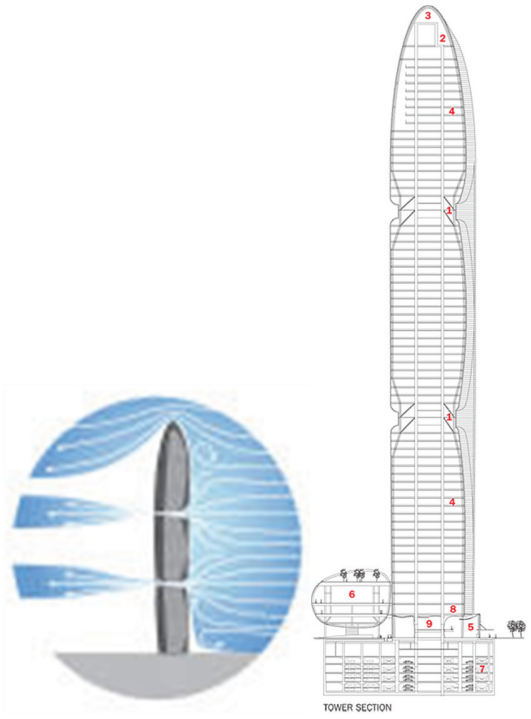


Figure-27: Section of the Pearl River Tower
Source: http://archrecord.construction.com

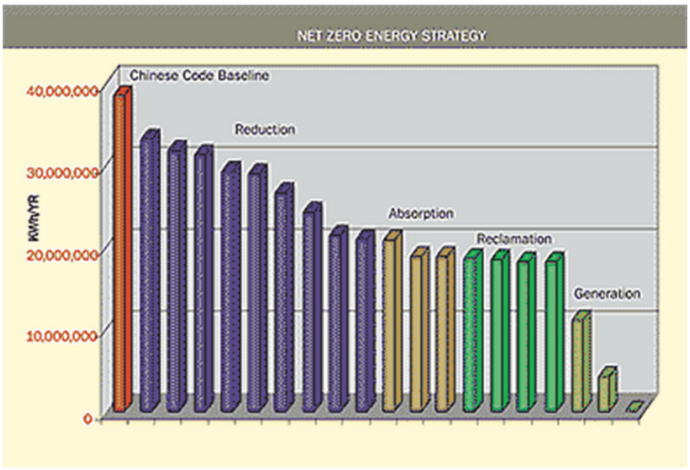


Figure-28: Net zero energy strategy
Source: http://archrecord.construction.com

3.2.2. Structure Detail

The project green elements include a water-retention area, basement fuel cells which produce electricity by extracting hydrogen from natural gas, façade-integrated photovoltaic ***Armstrong 2008)***

A condensate reclamation system that collects water and reuses it and stack ventilation, which captures and uses heat caught between the buildings double layer façade .The buildings curved shapes form two apertures where air is

directed into wind turbines. http://archrecord.construction.com

"There is no silver bullet," Frechette says. "What we have is a series of small steps that get you to something that makes a difference." These divide into four categories: reduction, reclamation, absorption, and generation.

3.2.2.1. Reduction

The designers began by reducing the buildings energy consumption through a combination of;

a) The buildings site orientation by rotating to the east so the tower takes the advantage of midday sun while the effects of late-day sun on the larger southern horizontal exposure are minimized.

b) A high performance building envelope. The tower contains several different exterior envelopes. The south façade s low –e-glass, double layer curtain wall system and integrated shades shield the interior from unwanted heat and glare which leads to less demand on HVAC. The double wall construction offers insulation and a critical way station between indoors and outdoors.

c) Day lighting. The façade is angled to take full advantage of natural day light. The top floor business club has an operable sky light for ventilation.

d) The façade s shape has a purpose, its curves bend with natural wind pressure to reinforce the overall structure s stability.

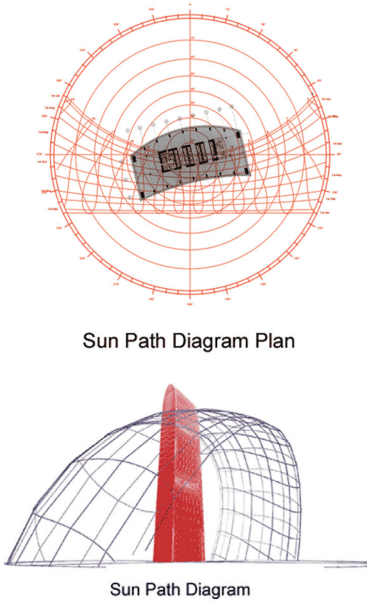


Figure-29: Sun path diagram
Source: http://archrecord.construction.com

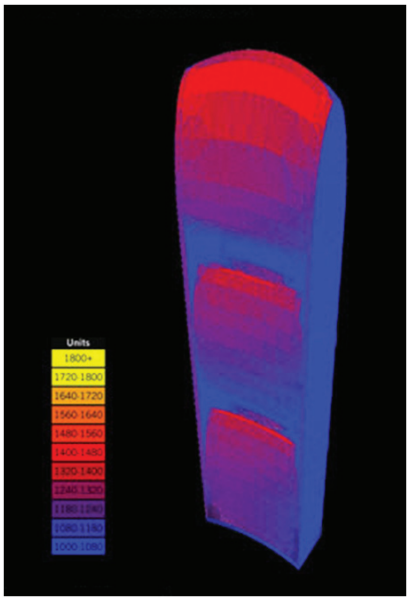


Figure-30: Solar radiation
Source: www.som.com

3.2.2.2. Reclamation and absorption

The tower reclaims its energy by routing each floor's exhaust air into the south side's double-layer curtain-wall cavity. (i.e. exhaust air harvest excess heat from each floor).

This thermal barrier of hot dry air can then be reused on the mechanical floor for passive dehumidification (i.e. energy is in turn used to pre-cool incoming air which produces condensation that supplement the building s water needs.

The incoming air which is dehumidified and pre-cooled makes it enough for the interior climate to introduce directly via under floor displacement ventilation without mixing Many other systems perform double duty, including the chilled slab concrete vaulted ceilings in the typical offices that enhance day lighting, as well as cool the air drifting up from the under floor ventilation system.

The main absorption strategy takes advantage of a geothermal heat sink, so 100 degrees Fahrenheit water in the mechanical system's return loop can be cooled to 75 degrees Fahrenheit prior to feeding the cooling towers. Cool water runs underneath each floor slab .As heat from the occupants and equipment build, it is propelled upward by the displacement system, hits the chilled slab and cycles downward creating a convection tumble that circulates air through the space.



Figure-31: High performance façade
Source: (Stewart, 2006)

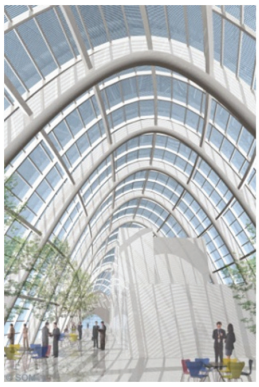


Figure-32: Operable skylight at the top floor business club
Source: www.som.com

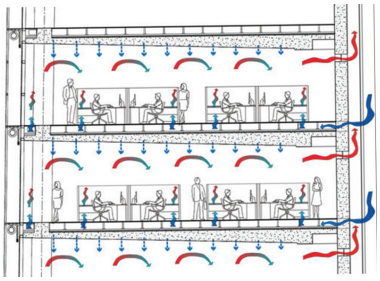


Figure-33: Under floor ventilation with radiant cooling
Source: (Stewart, 2006)

3.2.2.3. Generation

According to Rob Bolin, SOM's associate director of sustainable design, the first three strategies reduce the building's energy use by nearly 65 percent over a baseline of Chinese building codes. To reach the final goal of net zero energy, the design team incorporated three power-generating technologies: wind, integrated photovoltaic, and fuel cells.

Fuel cells generate electricity from natural gas, avoiding losses of as much as two thirds that occur when transporting electricity from faraway grids .Rather than combusting the gas, which would emit harmful sulfur dioxide and nitrogen.

Wind Power

Structural curves funnel natural wind currents at their maximum velocity into turbines located on two mechanical floors. That energy can be used directly or stored in batteries for later. Isolating the wind turbines on these mechanical floors minimizes noise and vibration and simplifies maintenance.

(above middle and right) indicate how daylight is maximized on the building's south side, while byby far the most innovative of these elements, the wind turbines exploit the prevailing winds from the south, which generate a negative pressure at the rear, or north side, of the building.

The tower's curvilinear structure helps to force air through four turbine inlets in the facade, which SOM's wind studies have predicted will speed up the wind's velocity two-and-a-half times. Frechette estimates the turbines will produce nearly 15 times more electricity than a typical stand-alone wind generator. http://archrecord.construction.com

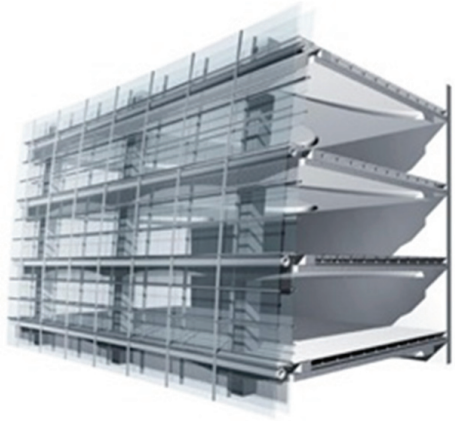


Figure-34: Exhaust air passes through the double-wall façade Source: (Stewart, 2006)

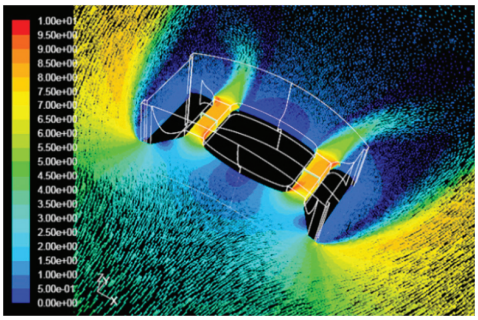


Figure-35: Velocity vector colored by velocity magnitude ***Source:*** www.som.com

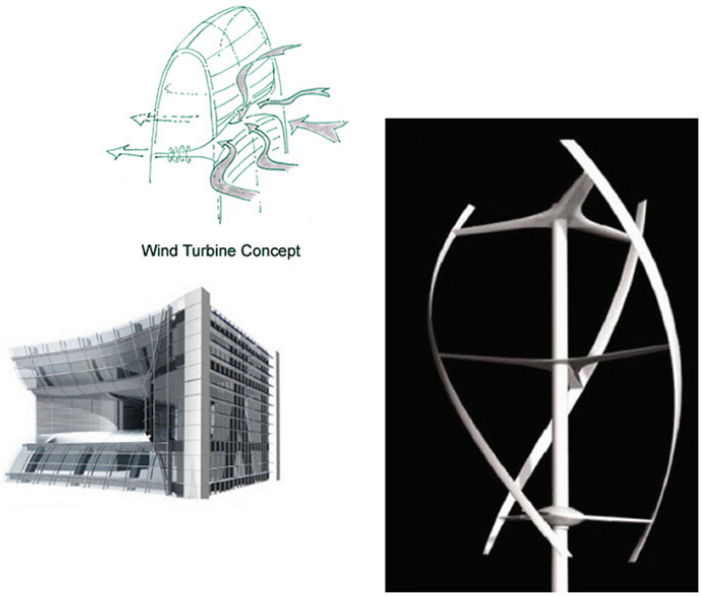


Figure-36: Wind turbine ***Source:*** www.som.com

4. Conclusions

▪"We must begin fundamental changes in our energy use now in order to avoid human-made climate disasters."

▪These technologies concentrating solar power, photovoltaic, wind power, biomass, biofuels, and geothermal power can displace approximately 1.2 billion tons of carbon emissions annually by the year 2030 the magnitude of reduction that scientists believe is necessary to prevent the most dangerous consequences of climate change.

▪The use of passive solar heating and day lighting design strategies can help both homes and commercial buildings operate more efficiently and make them more pleasant and comfortable places in which to live and work.

▪Concentrating solar power systems have the potential to help meet growing energy needs and provide diversity and reliability in energy supplies.

▪Using biomass energy reduces the level of dependence on imported petroleum and making the 21st century one of an increasingly sustainable, domestic, and environmentally responsible biomass economy.

▪Wind energy is fueled by the wind, so it's a clean renewable source of energy. It is one of the lowest-priced renewable energy technologies available today; its use will reduce Greenhouse gas emission by reducing the use of other energy resources.

▪Wind energy provides about 35% of the renewable energy contribution, while the rest is divided about evenly among the other technologies.

▪Tall buildings consume massive energy; designers of the next generation of tall buildings will incrementally aim for “zero energy” design. In this approach climate is used to advantage and the building becomes a source of power. It is possible that tall buildings will some day even produce excess energy and transfer the excess to the city’s power grid for use in other ways.

5. Recommendations

▪Researches need to be incorporated into the planning and design of tall buildings that will provide a comprehensive approach to understanding and predicting the life cycle costs, energy use, and performance of tall buildings and their impact on their urban habitats as applied to sustainability-both from the viewpoint of energy and resource consumption as well as Socio-cultural factors.

▪The next generation of buildings, whether residential, commercial, or institutional, should aim for “zero energy” buildings in which there will be no need to draw energy from a region’s power grid. In this approach, climate and environment are used to advantage rather than being treated as adversaries and buildings become sources of energy, like batteries**.**

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الطاقة المتجددة مستقبل ناطحات السحاب

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الملخص:

تعتبر ناطحات السحاب أحد النظم البنائية التى تتنامى فى مراكز المدن على مستوى العال، فهي نتاج للزيادة المتطردة لقيمة الأرض إضافة الى عوامل إقتصادية أخرى مؤثرة على بيئة البناء.

ان التقدم فى السنوات القليلة الماضية ادى الى ابداعات انشائية فى ناطحات السحاب كان من مردودها زيادة الضغوط على صناعة البناء لاستثمار نظم الطاقة المتجددة فى تصميم وانشاء المشروعات الجديدة والعمل على ايجاد حلول جديدة لموارد الطاقة المتجددة، ومنها التعامل مع مع غلاف المبنى على أنه حائط ستائرى مثقب يعمل كمرشح بيئى بين البيئة الخارجية والفراغ الداخلى لخلق بيئة داخلية منشودة.

من هنا كان تبنى ناطحات السحاب للمدخل التصميمى البيئى فى التعامل مع عناصر المناخ الخارجية من أشعة شمسية ورياح وأمطار تتخلل الغلاف الخارجى وما ينتج عنه من عمل الغلاف كمصفاة تسمح بما هو مرغوب وتحجز ماهو غير مرغوب من عوامل البيئة الخارجية.

وفى هذا المقال نتطرق الى الطاقات المتجددة من تعريفها واستخدامها واستغلالها فى ناطحات السحاب كحالة دراسة وذلك لتحقيق الادارة الاقتصادية للمبنى والراحة والكفاية.