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Sustainable era of new vertical city

Mohamed Salah Gharib El sayed*

Abstract

Tall buildings have been used to show off power and wealth; to honor leaders or religious beliefs; to stretch the limits of what's possible; and even as simple competition among owners, families, architects, and builders.
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.
Development of new technology occurs based upon necessity and technology evolves towards enhanced efficiency.
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 that enables selective exchanges between the external climate and the internal spaces.
This paper encompasses the development spectrum of tall buildings. The evolution of tall buildings' structure systems and technological driving force behind tall building development are reviewed.
Buildings are more energy efficient, comfortable, and affordable that's the goal.

Key words

Renewable energy – Solar panels – Wind turbine – Fuel cells – Biomass energy - Geothermal

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

* Lecturer in Military Technical College

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 building envelopes, this 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 energy.

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*

A main source of renewable energy comes from sun and wind.
Because climates were created before buildings and likewise climates and environment were created before cultures. It is therefore more natural and more economic and realistic to work with the climate rather than against it. By logically applying design principles that capture natural breezes and the sun`s energy, electricity used in buildings can be reduced considerably. ***(Yeang, 1999)***
In terms of climate, the design of tall buildings must respond to the geographical conditions of the city, adapt to the temperature and wind conditions that may affect the building. ***(Ali, 2006)***
With the surge in renewed interest in high rise living and in the tower building type, architects are taking on the task of re-conceptualizing and re-imaging tower design. Some of the issues are to increase lighting as light pipe transmission or to increase lighting and consume energy as sky gardens, atria, and vertical landscaping, or to produce power and electricity as wind turbines. ***(Land, 2005)***

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, and space heating and cooling e.g. Holloway Circus Tower. **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)***
- 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.

Figure-1: Membrane reduces glare and allows diffused lighting into atrium Burj Al Arab
Source: **http://en.wikipedia.org**

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.

- The latest trend is the use of double skin, and occasionally triple skin, façade with ventilation system.
- Double-skin façade is intended to mean a system in which two sk ins, two layers of glass are separated by a significant amount of air space; a second glass façade is placed in front of the first. These two sheets of glass act as insulation between the outside and inside enabling the air to circulate between the cavity of the two façade skin providing good air circulation, thermal and acoustic performance. ***(Yeang, 1999)***
- Air in the intermediate space is warmed up due solar radiation. With openings in the façade, the flow of air through the intermediate space is activated by stack effect. In summer high temperature air in the intermediate space is exhausted with the airflow to reduce cooling load. In winter the openings are closed to protect heat escaping from the occupant space. ***(Gratia et al, 2004)***

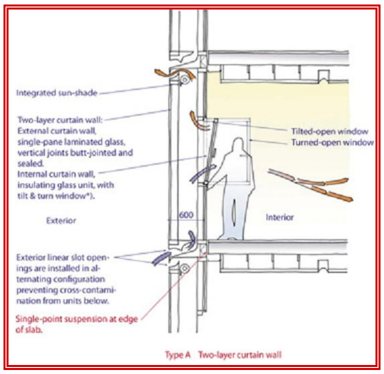


Figure-2: Two- layer wall, section diagram
Source: (Olt and Rothwell 2008)

Double glazing with argon-filled cavities, triple-glazing and glass coatings can increase U-values**.** ***(PANK, et 2002)***

- 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.

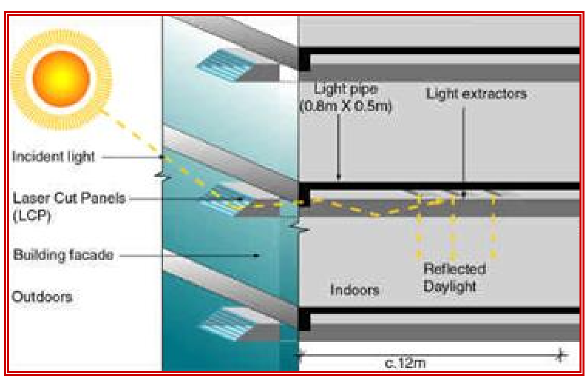
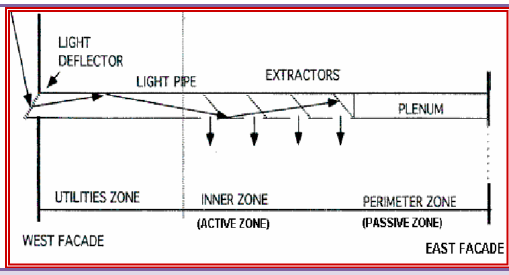
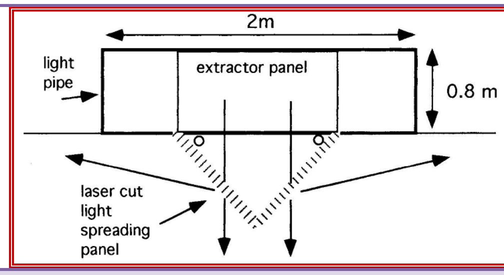


Figure-3: Diagram of Light-Pipe
Source: (Ken et 2004)

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. A light spreading system distributes the light away from the area directly below the light pipe and more evenly over the zone. ***(Ken et 2004)***





Section through light pipes *Laser cut light spreading panel*

Figure-4: Light Pipes System

Source: ***(Ken et 2004)***

Distribution of the light without emitters. *Light redirected to the ceiling by LCP emitters.*

Figure-5: Lighting Using Light Pipes

Source: ***(Ken et 2004)***

In this way the working floors are naturally lit from both sides: from the exterior windows and from the middle "light pipe". ***(Land, 2005)***

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 be used a s rooftop shingles, roof tiles, building facades e.g. Conde Nast Building

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 electric ity, 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-6: Sunlight-through photovoltaic technology-provides buildings with electricity
Source: **www.nrel.gov**

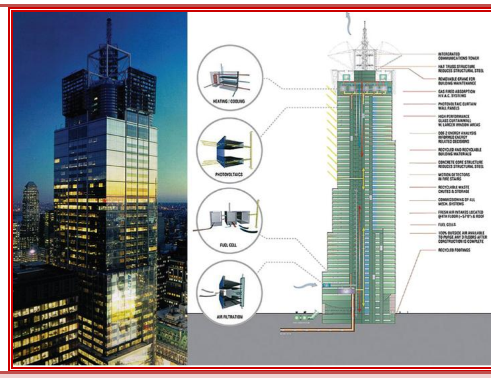


Figure-7: Elements of renewable Energy in Conde Nast Building, 4 Times Square
Source: (Ali, and Armstrong, 2006)

The panels can become inefficient in high ambient heat, and the significant dust content in the air can quickly make them dirty. ***(IEA, 2003)***

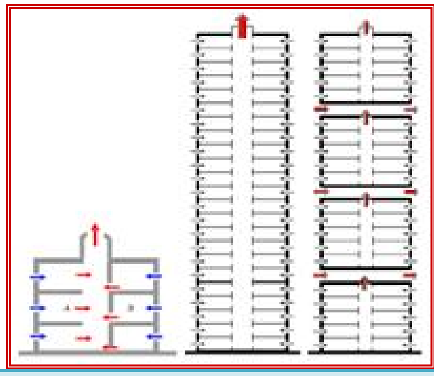
2.2.2. Wind power

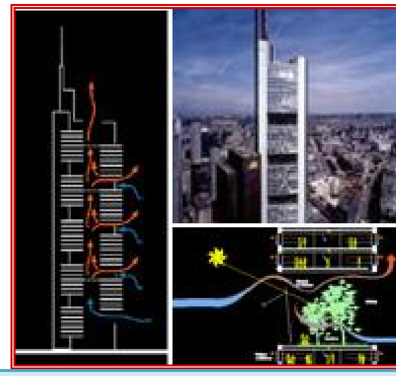
2.2.2.1. Natural Ventilation

There is in principle an opportunity to use the amplified winds around tall towers to naturally ventilate the building. When the spaces in a building are connected by large internal openings, they effectively form a single-cell, with the flow through any opening dependent on the flow through the other openings. Such strategy, based on the use of an atrium which is used to generate inward flow of fresh air into all of the occupied floors or the building is divided into several segments that are isolated from one another by open spaces.

The design problem is now to achieve the required flow directions and magnitudes for each segment. This is still likely to be more challenging than the equivalent low-rise building, because of aerodynamic effects around the outlet of each segment, which will depend on wind direction. Some novel approach, such as the axi-symmetric venture considered by Daniels et al (1993), may be necessary.

Tall buildings of this nature already exist, including the Commerzbank by Norman Foster. The open space can be in the form of a "skycourt". ***(Etheridge, and Ford, 2008)***





Ventilation Patterns using an Atrium-Illustration of segmentation of a Tall Building — Section Through Commerzbank Office/ Sky Court

Figure-8: Systems of ventilation patterns of tall Buildings
Source: *(Etheridge, and Ford, 2008)*

2.2.2.2. Harvesting Wind Energy

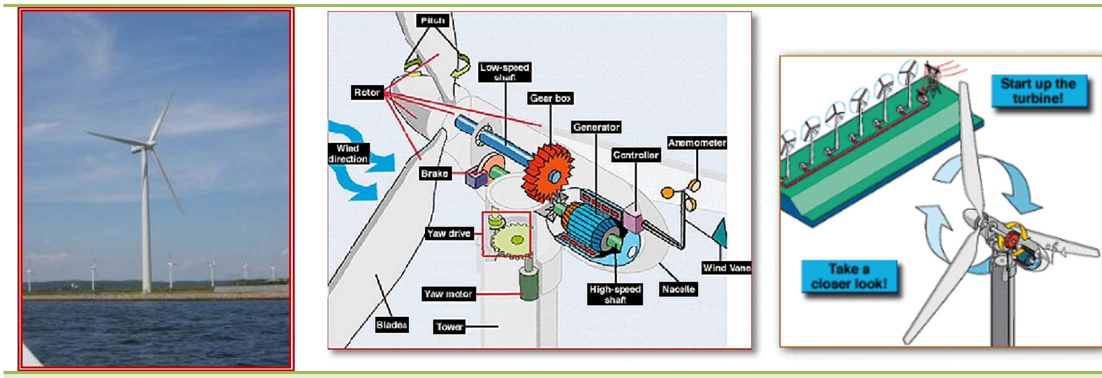
Wind energy or wind power describes the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energ y in the wind into mechanical power. **www.eere.energy.gov**
Wind is a renewable energy source which can be advantageously tapped at higher altitudes of tall buildings where wind speed is considerably large. Tall bui ldings 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 de sign requirements.
Safe and reliable deployment of wind turbines in the highly turbulent built environment is specialized and technically challenging.

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)***

How Do Wind Turbines Make Electricity?

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



Wind turbines — Components of wind turbine

Figure-9: Wind turbines

Source: www.eere.energy.gov

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.

It is possible to use of the building as the platform for wind turbines for generating energy. Building form have been modeled to intercept concentr ate and accelerate wind flow to drive appropriately designed and located rotors and turbine. ***(Irwin, et la 2008)***

Top mounted wind turbine	Inserted wind turbine	Middle wind turbine
		
Moscow Dynamic Tower ***Moscow, Russia*** **http://gizmodo.com/photogallery/dynamictower**	Clean Technology Tower ***Chicago, USA*** **http://www.inhabitat.com/wp-content/uploads/cleantech_1.jpg&imgrefurl**	Bahrain World Trade Center ***Manama, Bahrain*** **http://noisetank.com/hugeasscity/images/Bahrain_World_Trade_Center.jpg&imgrefurl**

Figure-10: Types of Wind Turbine

2.2.3. *Other Sources of Renewable Energy*

Type	Sources	Benefit

	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.	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).	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. 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.
	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 equals the carbon absorbed during growth.	The main biomass feed stocks for powers 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 steam 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)***	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** .
	Geothermal Energy (heat from the earth)	
Geothermal energy is one of our most plentiful resources. They exist miles beneath the earth's	This heat can be drawn from several sources: hot water or steam reservoirs deep in the earth	The use of the hot water and steam from reservoirs to drive generators and produce electricity

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 per 100 m 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)*

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.

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

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

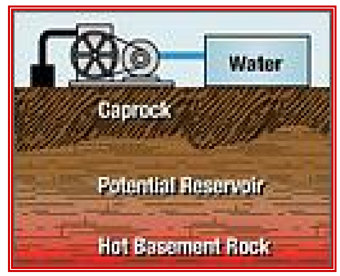
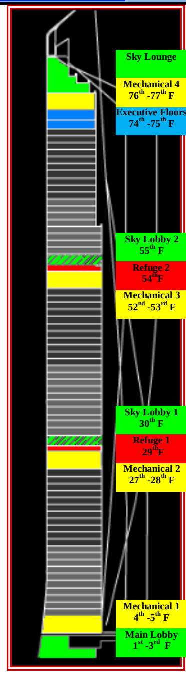
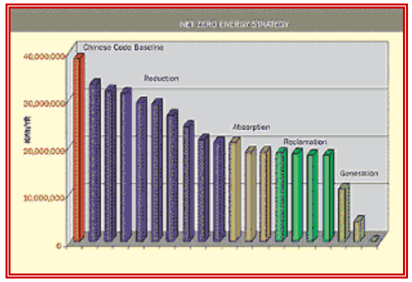
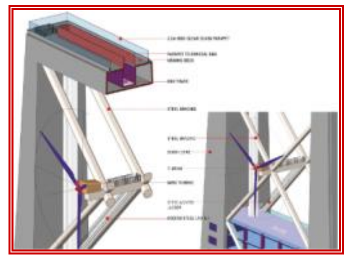
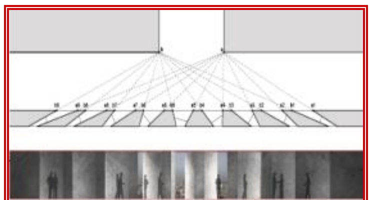
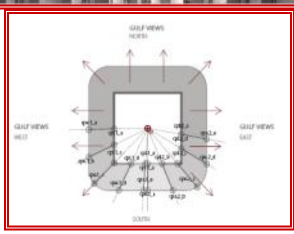


Figure-12: Geothermal system
Source: www.nrel.gov

3. Case Studies

POINT OF COMPARISION		AL HAMRA TOWER HTTP://WWW.ALHAMRA.COM.KW/	BURJ KHALIFA HTTP://WWW.BURJDUBAI.COM/	PEARL RIVER TOWER HTTP://WWW.SOM.COM	LIGHT HOUSE TOWER ATKINS MIDDLE EAST COMMUNICATIONS,2007
FACT SHEET	**Location**	Kuwait city, Kuwait	Dubai/ UAE	Guangzhou, GD China	Dubai/ UAE
	Status	Completed 2011	Completed 2010	Completed 2011	Under construction
	Started	2004	September 2004	28th September 2006	April 2008
	Finished	11th November 2011	4th January 2010	2011	Estimated completion 2012
	Hieght	412 m	829.84 m	309.7m	402 m
	Floors	77 floors - 2Basement	163 floors - 2 parking levels in the basement	71 floors	164 floors
	Type	Mixed-used	Mixed-used	Office and conference	Office
	Shape				
	Architect	SOM - Skidmore, Owings and Merrill	SOM - Skidmore, Owings and Merrill	Gordon Gilla and SOM - Skidmore, Owings and Merrill	Shaun Killa.

	Al Hamra Tower http://www.alhamra.com.kw/	Burj Khalifa http://www.burjdubai.com/	Pearl River Tower http://www.som.com	Light House Tower atkins Middle East Communications,2007
NEW IDEAS	 ▪ The tower will become the tallest building in Kuwait. ▪ The Leica Geosystems Core Wall Survey Control System, to exactly know how much the building is off from its design position, and at the same time to know the precise position of the total station. ▪ Tower will have state of the art "smart building" technology as a built in backbone network which offers maximum flexibility by integrating all voice, data, access control, surveillance, fire alarm, and building automation systems. ▪ Two intermediate refuge floors to ensure safe and timely evacuation in case of emergency	▪ It is the tallest freestanding structure, building with highest number of floors. ▪ The highest vertical concrete pumping for a building or any construction. ▪ It will have the highest elevators installation. ▪ Observatory elevators (double deck cabs) will have the world's highest travel distance and will be the fastest in the world. ▪ Building service elevator will be the tallest in the world. ▪ It is the 1st mega-high rise in which certain elevators will be programmed to permit controlled evacuation for a certain fire or security events. The elevators identified for 'lifeboat' emergency operation are the three high-speed shuttles. They should be located in as secure positions as possible, generally within the structural core, and enclosed in robust, fire-rated construction. Their passenger pick-up location should be on a floor that can accommodate crowds and be related to the areas of refuge associated with the exit stairs. ▪ It is designed with four refuge shelters every 30floor emergencies such as a fire or terrorist attack. ▪ A combination of GPS survey techniques, Automatic Total Station, clinometers readings and mathematical modeling will provide a means to drive the construction of the world's tallest building as a straight structural element and provided a wealth of data on building movement. There are 200 m spectacular dancing fountains at the foot of Burj Khalifa.	▪ It will be one of the greenest buildings in the world The Pearl River Tower is tall "net-zero energy Building.". ▪ According to Rob Bolin, SOM's associate director of sustainable design, the reduction, absorption and reclamation 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  ***Strategies to Raech net Zero Energy***	• It is among the 10 tallest office towers. • The tower is tall and slim a geometric shape sculpted by sunlight and wind. • Tower will become a benchmark in this region with regard to energy efficiency and renewable energy sources. • It is set to become a prototype for low-carbon towers within the region and a model for more sustainable developments in the future. • It will incorporate the highest ever installation of wind turbines above ground. The apex of the tower features a viewing deck offering uninterrupted vistas of Dubai's urban fabric. 

	Al Hamra Tower http://www.alhamra.com.kw/	**Burj Khalifa** http://www.burjdubai.com/	**Pearl River Tower** http://www.som.com	**Light House Tower** atkins Middle East Communications,2007
GREEN ARCHITECTURE	 • The tower reacts with the environment with its transparent envelope facing north and its solid wall facing south. Thus minimizing solar heat gain. • Also the geometry of the interior wall responds to the need to minimize solar heat gain protecting the building from critical environmental conditions.  	▪ The combination of the coatings results in a glass that allows more than 20% of the visible light into the building and floor-to-ceiling views, while allowing less than 16% of the associated heat, an important feature in the strong light and extreme desert climate of Dubai. ▪ Environmental control is accomplished firstly by placing computer-controlled, motorized, metallic sunshades between the double walls of glass, and secondly by ventilating the heat built up within the void to the outside. ▪ The tower will have a condensate collection system which will use the hot and humid outside air, combined with the cooling requirements of the building and will result in a significant amount of condensation of moisture from the air. This condensed water will be collected and drained in a separate piping system down to a holding tank located in the basement car park. This water will then be pumped into the site irrigation system for use on the tower's landscape plantings.	***1. Reduction*** ▪ The buildings site orientation by rotating to the east so the tower takes the advantage of midday sun. ▪ A high performance building envelope. The tower contains several different exterior envelopes. The south façade 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.  ▪ Day lighting. The façade is angled to take full advantage of natural day light. ▪ The façade shape reinforces the overall structure stability. ***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).	The tower aims to reducing its total energy consumption by up to 65% and its water consumption by up to 30%. *This is achieved by:* • Narrow plan creates incredible day lighting. • High performance façade reduces heat transfer but allows light. The north-west intelligent façade system has interstitial blinds redirecting solar heat and maintaining daylight and views with photo voltaic panels integrated in the façade. While the south-east intelligent façade is double glazed with solar shading overhangs to cut direct solar load and photo-voltaic panels integrated in the façade. • Harnessing wind energy is done by three horizontal wind turbines at the upper portion of the tower. • The double-decked regenerative breaking elevators where their descending motion produces 30% of the energy required for a simultaneous ascending elevator. • Ventilation systems recover heat and cooling. • Sensors ensure lighting is only used when required through motion and solar sensors. The less artificial light, the less heat built –up. Water consumption is minimized with the use of efficient fittings and appliances. The building is specified to have waterless urinals ,dual flush toilets ,flow restrictors on taps, grey water recycling, condensate collection from chiller units to name a few of the water saving measures.

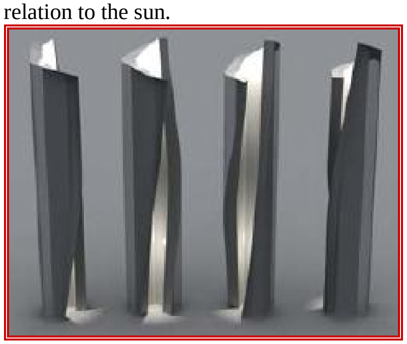
GREEN ARCHITECTURE

Al Hamra Tower

http://www.alhamra.com.kw/

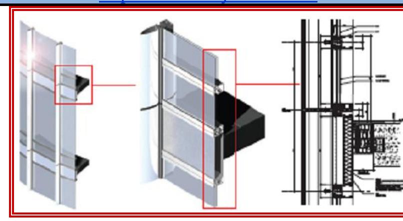
The façade is a cloak like glass façade. It will have white glass which is different from the green and blue glasses commonly use in building.

Chiseled design is used with the aim of maximizing gulf views and minimizing solar heat gain. Openings are based on the relationship of envelope and its position in relation to the sun.



Burj Khalifa

http://www.burjdubai.com/



The high performance glass is an insulating unit consisting of two pieces of clear glass with a 16 mm air space. The outer panel has a silver metallic coating deposited on its inner surface to help prevent solar energy from entering, and the inner panel has a metallic low emissive type coating, that reflects the long wave radiation that comes off the earth's surface as heat at night also facing the air space.

Pearl River Tower

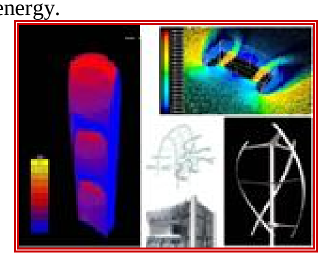
http://www.som.com

to be reused on the mechanical floor for passive dehumidification and pre-cool of incoming air 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.

3. Generation

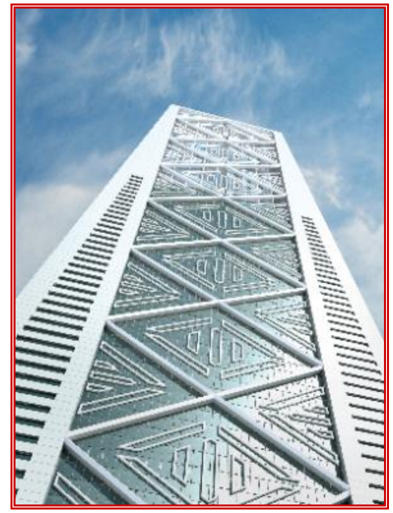
- It has a curved glass façade that directs air flow through narrow openings in the facade that will drive large, stainless steel wind turbines to generate electrical energy.



- Basement fuel cells which produce electricity by extracting hydrogen from natural gas.
- Façade-integrated photovoltaic.

Light House Tower

Atkins Middle East Communications,2007



Mashrabiya screens of the region are the traditional carved lattice shutters forming a decorative screen between inside and outside to protect against harsh heat and light.

It is designed to form logo of DIFC creating elegant pattern

4. Conclusion and Recommendation

4.1. 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, bio - fuels, 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.
- 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 someday even produce excess energy and transfer the excess to the city's power grid for use in other ways.

4.2. Recommendations

- The nature of the challenge and what should be the long range priorities and new technologies required, are imperfectly understood at this time. We are only at the beginning of a new chapter in defining and developing future, renewable energy technologies.
- 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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