PEARL RIVER TOWER, Guangzhou, China

Architect : **Skidmore Owings & Merril**
Location : **Guangzhou**
Client : **China National Tobacco Company**
Area o f bldg : **212,165 sqm**
Height of bldg: **71 storeys, 310m**

Climate of Guangzhou:

- Harsh climate with poor air quality
- hot and very humid – sub-tropical

The Chinese government set the goal of reducing carbon emission by 10% by the end of 2010. Guangzhou experiences some of the worst air pollution & is the major focus of an environmental initiative.

STRATEGIES FOR SEEKING ZERO-ENERGY:

Aim was to build a '***Transformed, Integrated, High Performance, Environmentally Responsible Design'***. ***'High performance'*** to mean a structures whose ***'energy saving systems'*** would work together in an integrated manner to consume nearly 60% less energy than a traditional building.
This was done using the following

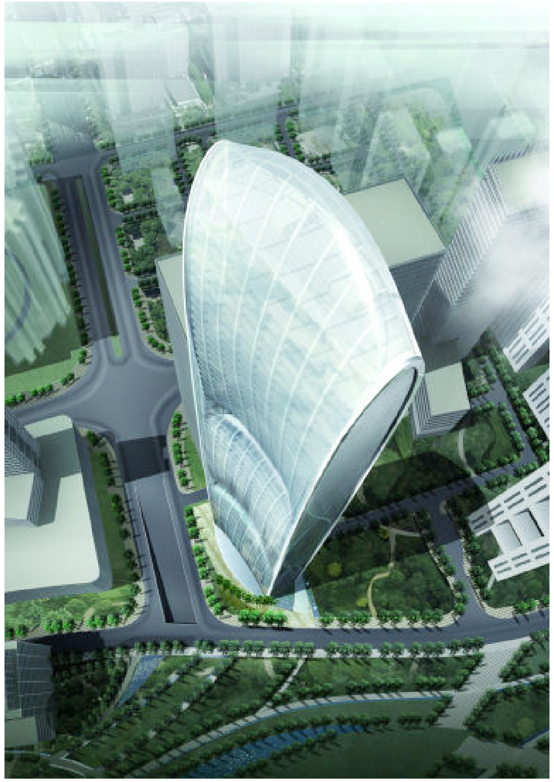
'4' steps:

Step 1 : **Reduction**

Step 2 : **Reclamation**

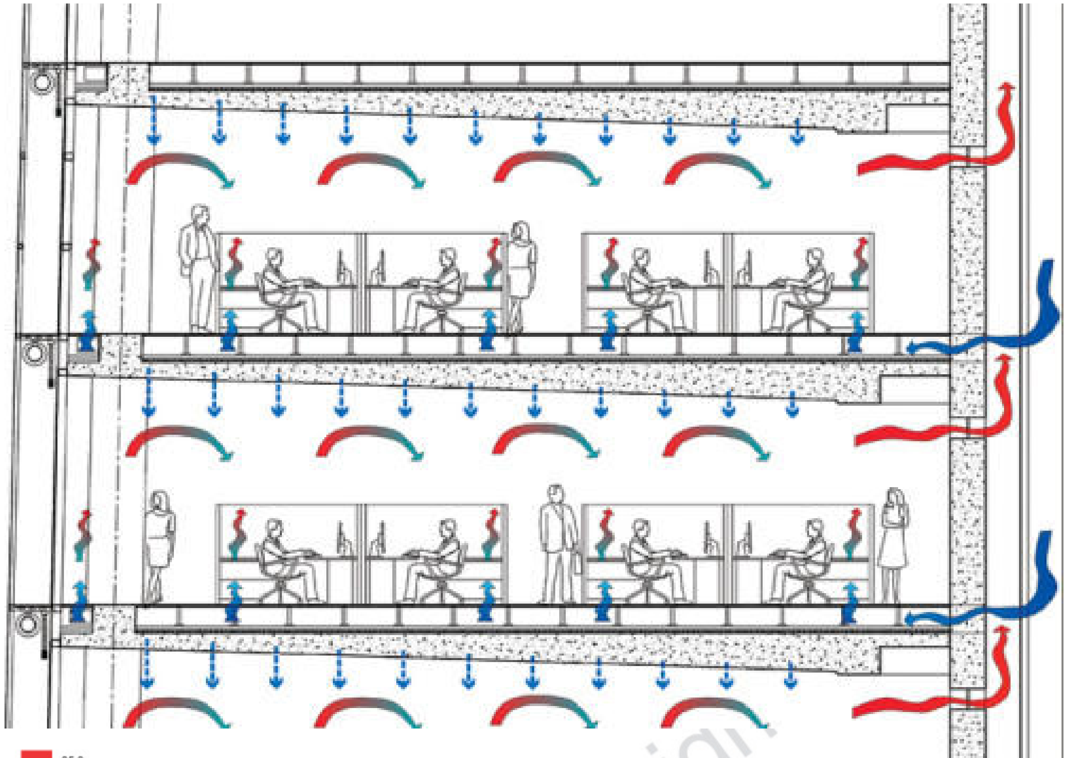
Step 3 : **Passive Absorption**

Step 4 : **Generation**



PEARL RIVER TOWER, Guangzhou, China

REDUCTION:



radiant cooling

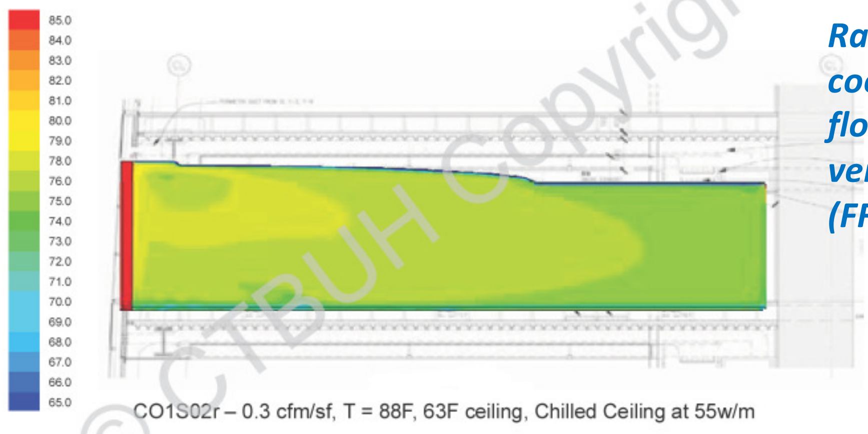
▪*"chilled radiant"* ceiling through perimeter chilled beams is used instead of normal ventilation and air conditioning.

▪Cold water pumped (at approx 14.5deg C) through ***copper pipes in the slab*** which cool curved metal plates used for the ceiling system and metal fins for the perimeter, consequently cooling the surrounding air.

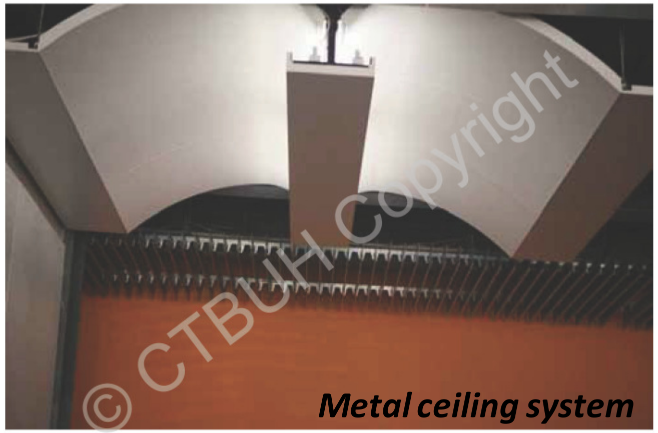
▪ chilled air cools the office space below and above.

displacement ventilation

▪provides only ***fresh air*** that is cooled by the chilled-water system and delivered via a ***raised access floor***.

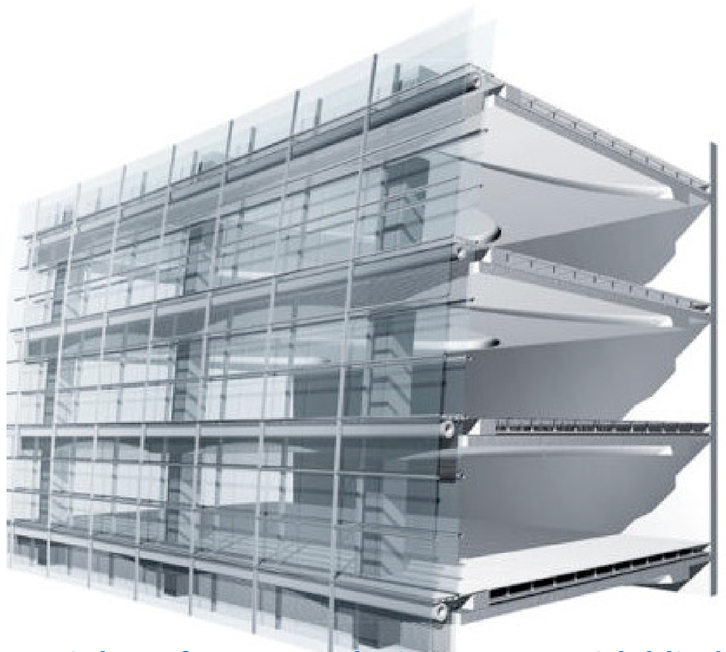


Radiant cooling with floor fed ventilation (FFV)

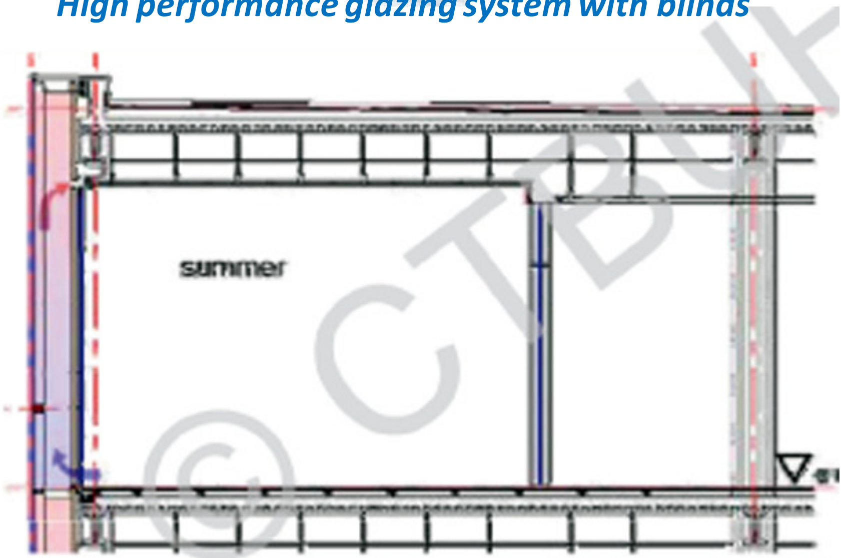


Metal ceiling system

PEARL RIVER TOWER, Guangzhou, China



High performance glazing system with blinds



Ventilated façade system

high performance glazing

▪ *internally ventilated double wall* with blinds on ***northern & southern*** façade

▪façade on the ***eastern and western sides*** is made of *triple glazed glass* which helps insulate the building's interior.

high efficiency plan

▪***shallow floor plate*** for easier cooling keeping workspaces as close to the perimeter windows.

▪The building presents a ***minimal profile to the rising and setting sun*** and due to the high solar angles from its low latitude, absorbs minimal solar radiation during the hottest portion of the day.

day light responsive controls

▪maximizing the use of natural light by the use of lighting controls that respond to light, integrated into the system of the blinds.

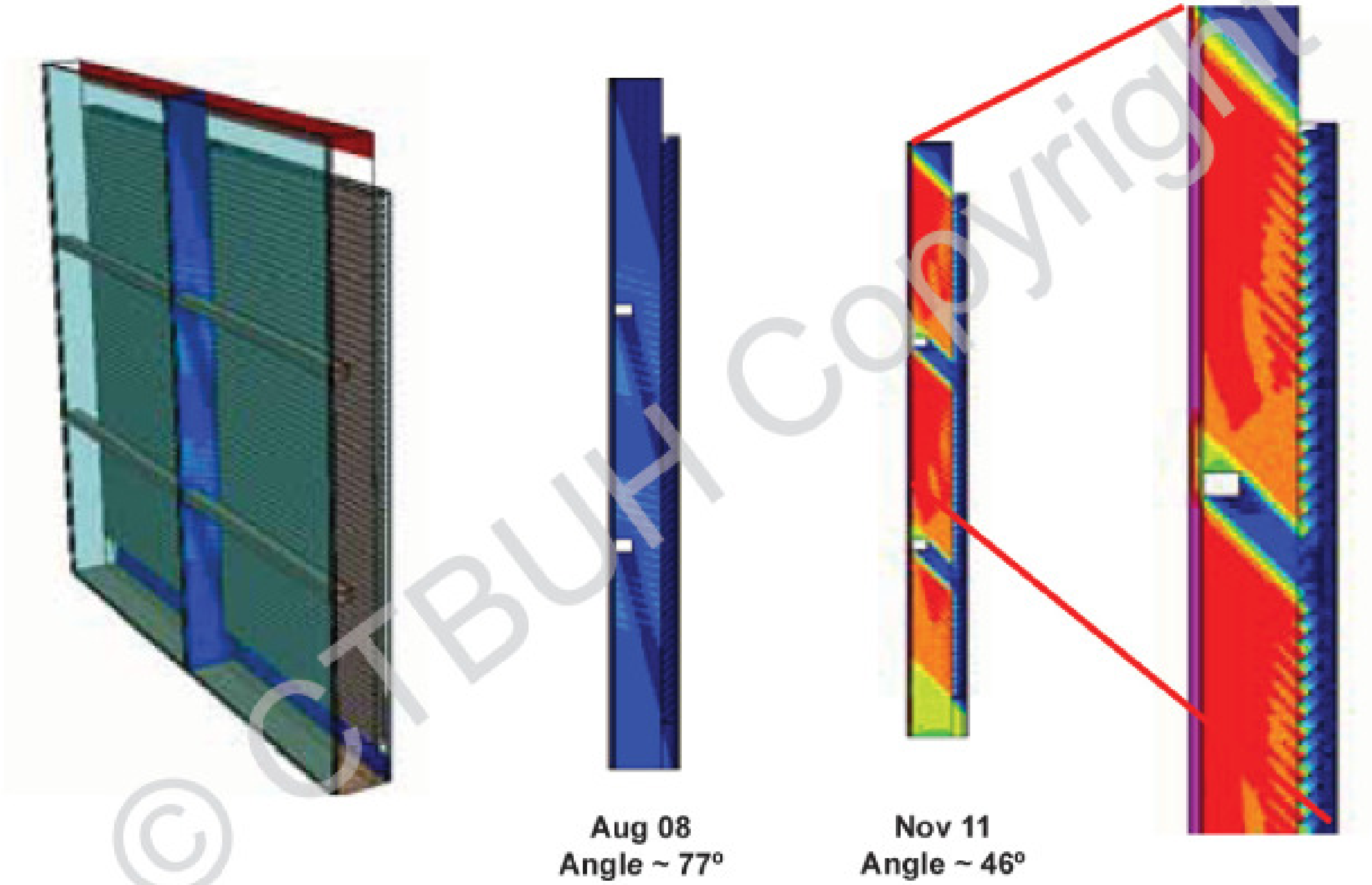
high efficacy lighting

▪Low-energy, high-efficiency lighting system using radiant panel geometry to assist in distribution of light.

high efficient office equipment

▪Water Conservation – Ultra Low Flow Toilets, low flow sinks and Waterless Urinals

PEARL RIVER TOWER, Guangzhou, China

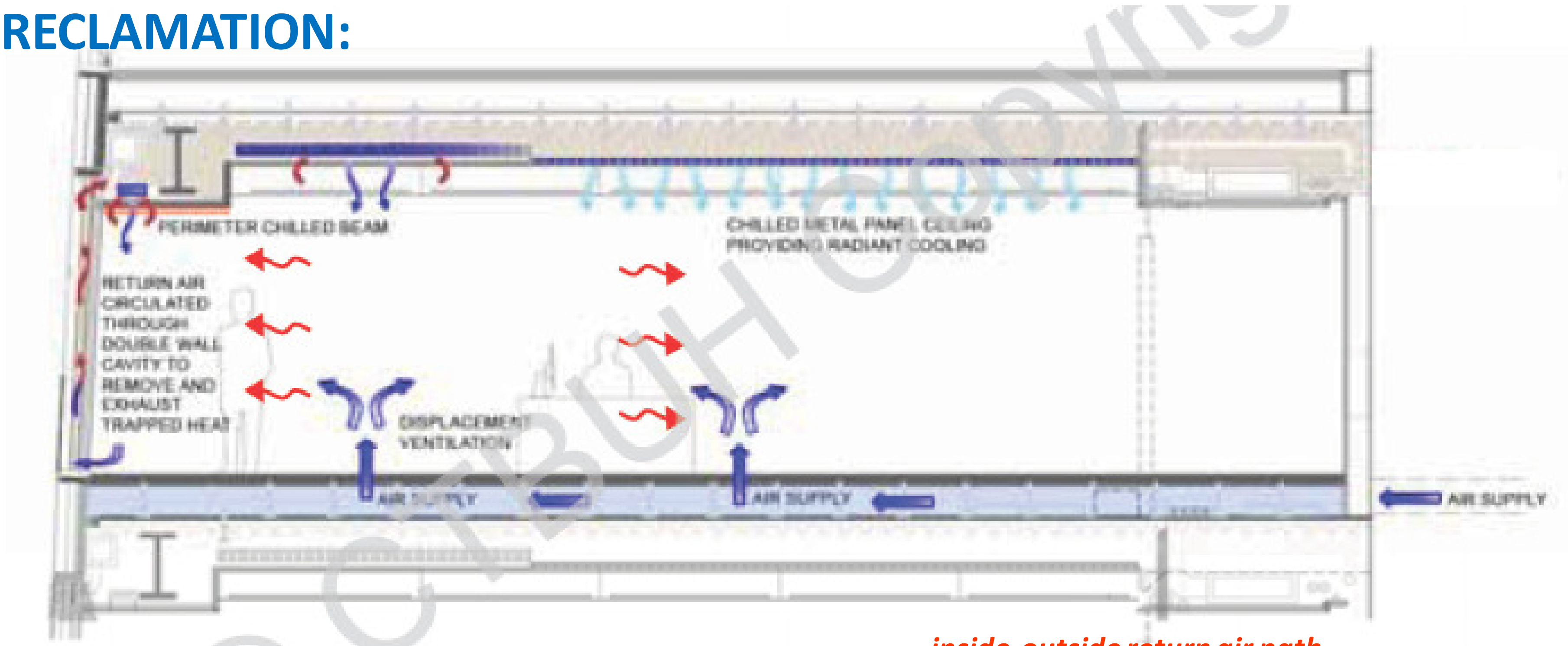


Solar Radiation through glazing (W/m2)

The façade features an internally ventilated double wall system that incorporates motorized venetian blind system controlled by PV cells that track the sun movement. The exterior glazing will take form of insulated, tempered glass with low-E coating, inner layer will be operable for maintenance

PEARL RIVER TOWER, Guangzhou, China

RECLAMATION:



inside-outside return air path

chiller heat recovery

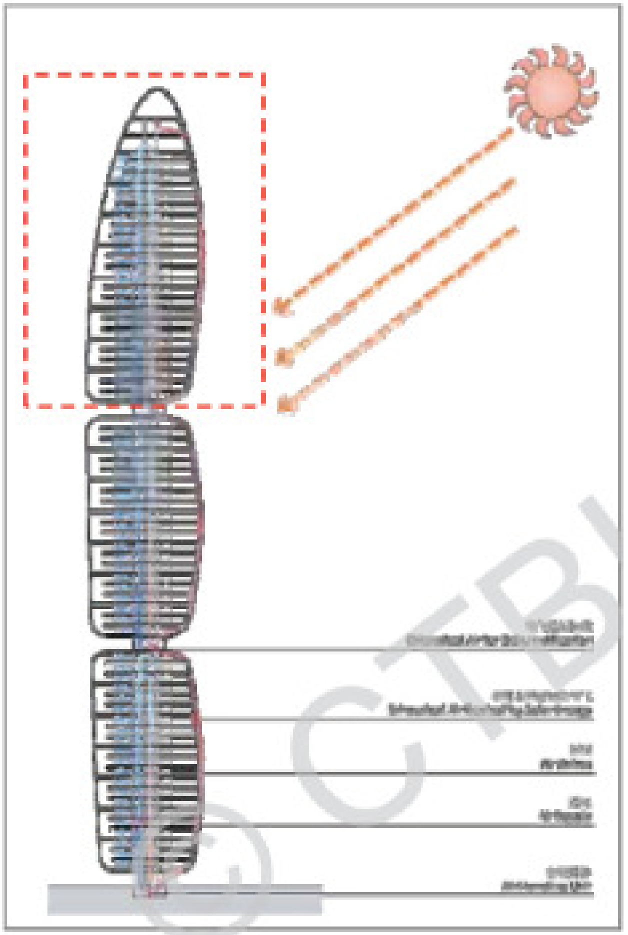
generator heat recovery

exhaust air heat recovery

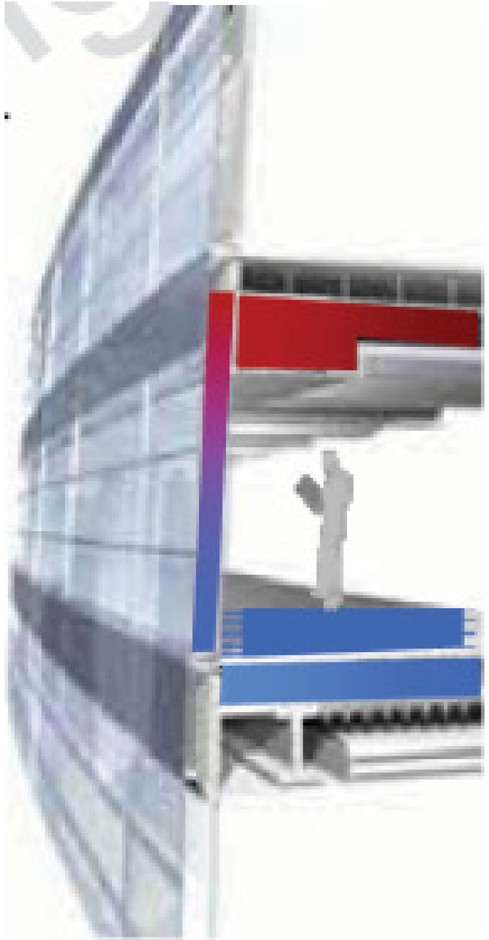
- Using ***double walls*** with mechanized blinds on the northern and southern facades, ***insulates** the interior and traps some heat* in the double walls
- this heat is used in the ***de-humidification*** system to tackle the humidity in the city.

- Hot air is vented to the north face and is drawn out through a *stack effect*.
- Cool air is brought in at night to cool the thermal mass of the building.
- *Condensate reclamation system*. Harvests water from chilled surfaces to control interior humidity. Water is filtered and used for interior plantings and toilet flushing.

PEARL RIVER TOWER, Guangzhou, China



Solar energy is collected within the double wall façade. The energy is transferred to the mechanical floors and is used as heating for the dehumidification system



Envelope as a thermal regulator

PEARL RIVER TOWER, Guangzhou, China

ABSORPTION:

▪advanced wind and solar technologies were incorporated into the design of this skyscraper in order to generate or **"absorb"** the natural energy from the building's surroundings.
▪Photovoltaic cells were incorporated into the mechanized shade system to capture the sun's energy in the eastern & western facades.
▪The blue areas of the picture show the location of the solar panels.
▪The automated blinds system are programmed to make the most of the natural lighting.
▪PV cells are incorporated only in certain locations on the building envelope and in an asymmetrical manner and at the roof level where the system also acts as a sunshade for the rest of the building.
▪The ***Building Integrated Photovoltaics (BIPV)*** are incorporated exclusively on the south façade.
▪As daylight hours are predictable & PV systems provide no benefit at night and limited benefit on overcast days. For this reason, SOM incorporated an intensive wind turbine system in the building.

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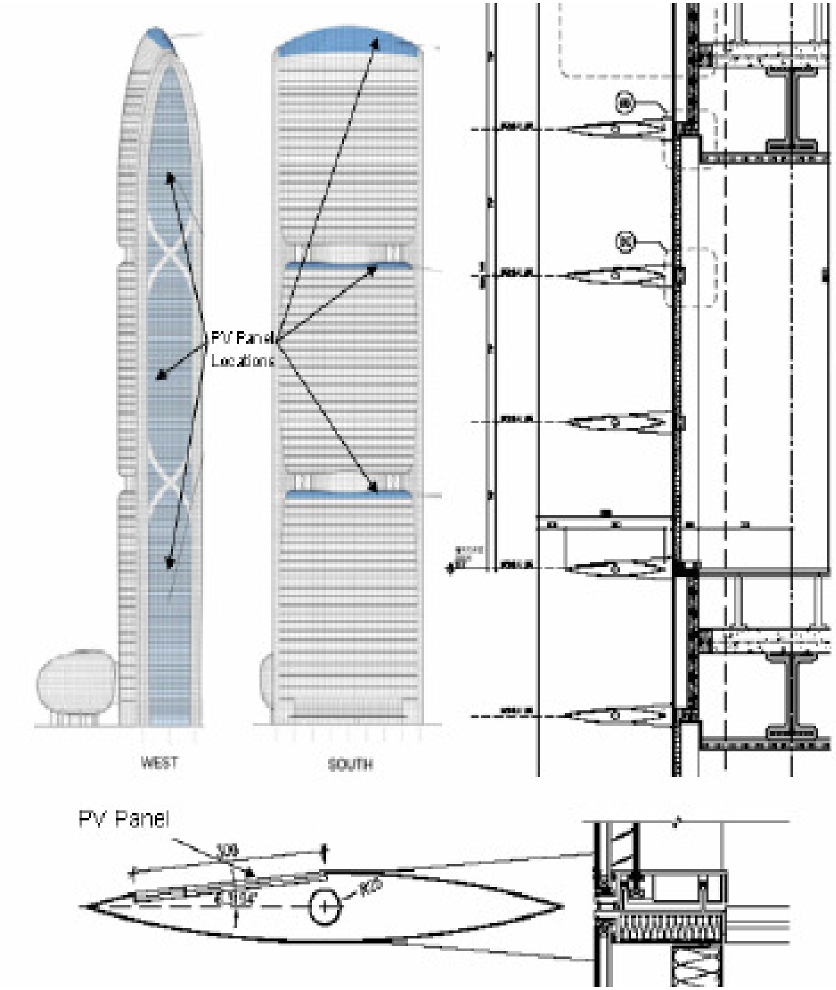
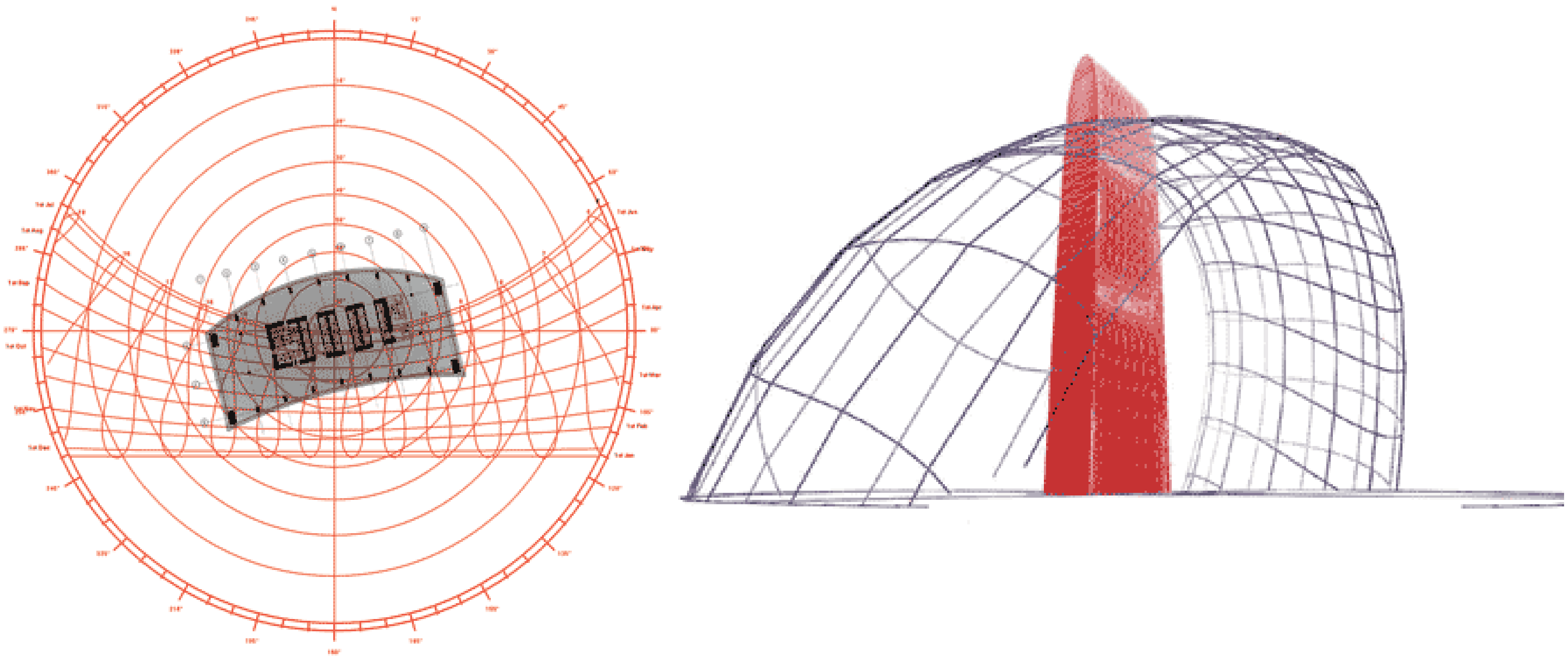
SOLAR TECHNOLOGY



pv panels integrated with the façade system

PEARL RIVER TOWER, Guangzhou, China

SOLAR TECHNOLOGY

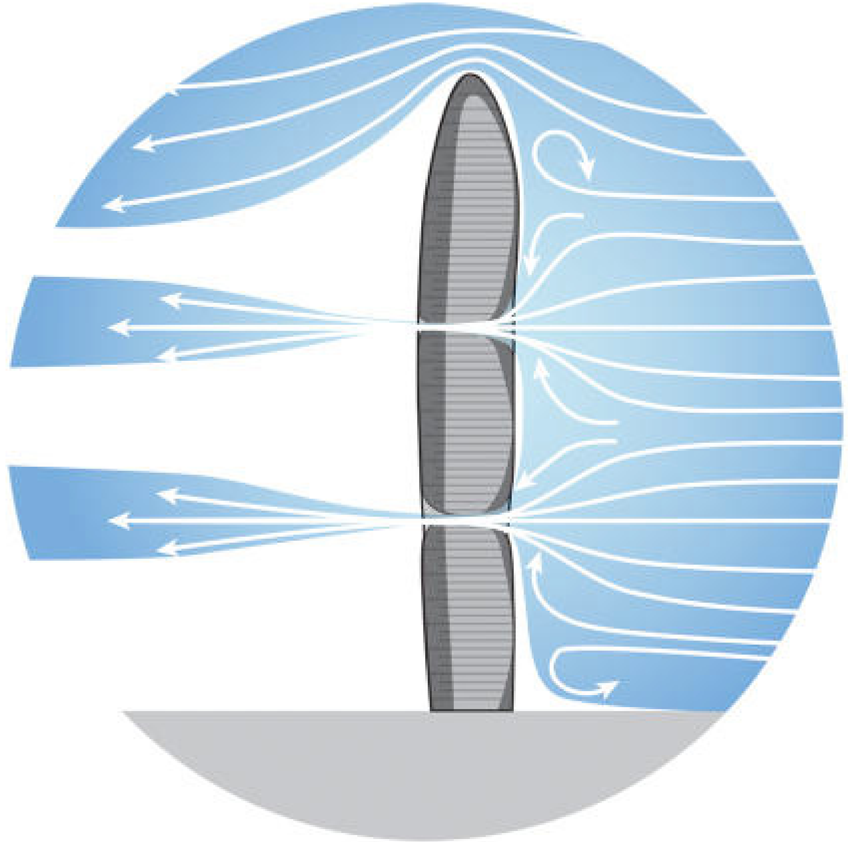


SUN PATH DIAGRAMS GENERATED TO STUDY LOCATION OF PV PANELS ON THE BUILDING FAÇADE

PEARL RIVER TOWER, Guangzhou, China

- An innovative aspect of the building's design was the use of vertical-axis wind turbines to generate electricity.
- exterior of the building has four large openings, 6 by 6.8 meters wide, on either side of the core at the mechanical levels.
- The room for these openings was made available due to the lack of ventilation shafts and fans in this building.
- These openings run through the building and are funnel shaped to increase the air speed as it rushes through the building.

WIND TECHNOLOGY



Wind builds positive pressure on the windward side of the building - through vortex shedding around the sides and over the top of the building – creates large pockets of negative pressure on the leeward side. But if the air is allowed to pass through the building the differential pressure is reduced from front to the back, as are forces on the building

wind turbine concept

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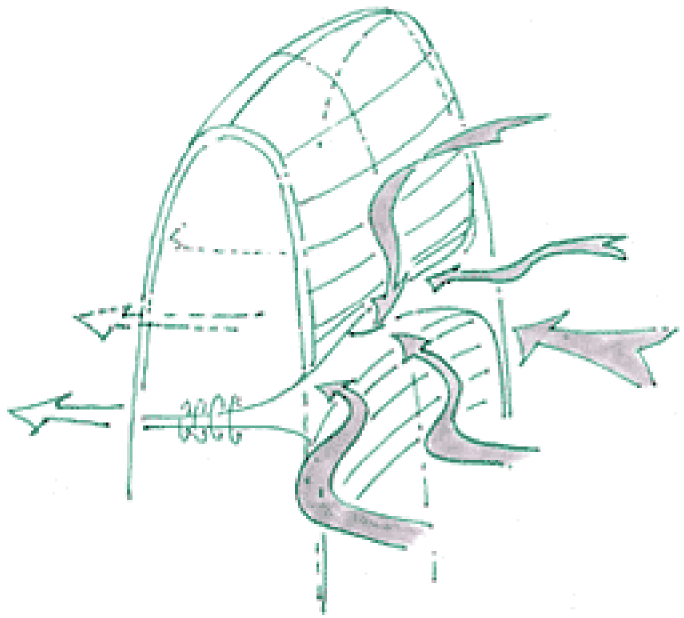
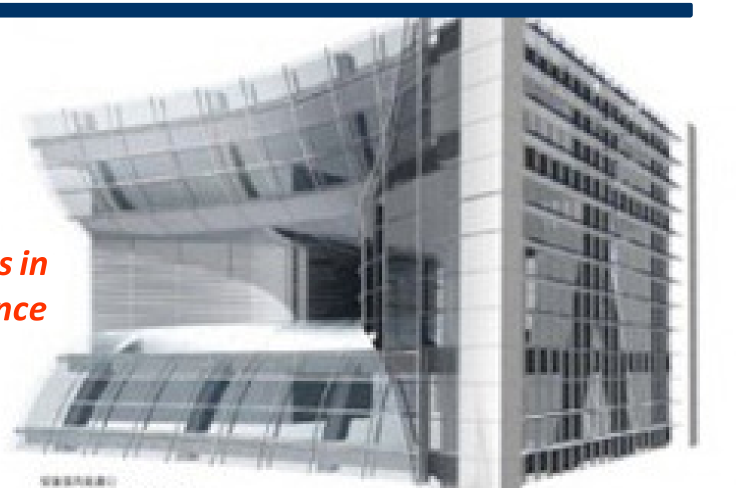
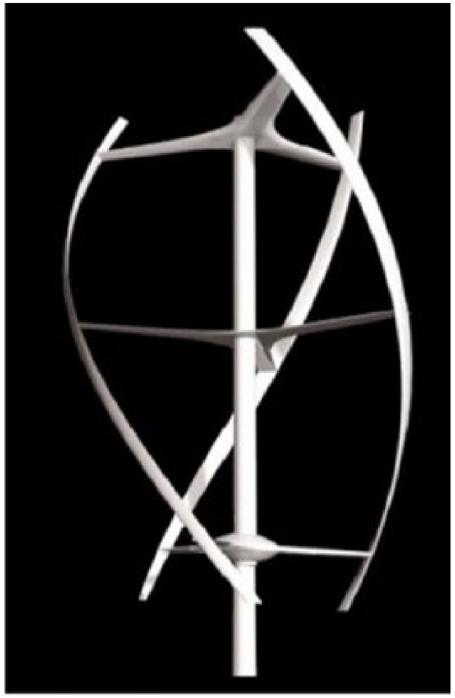


PEARL RIVER TOWER, Guangzhou, China

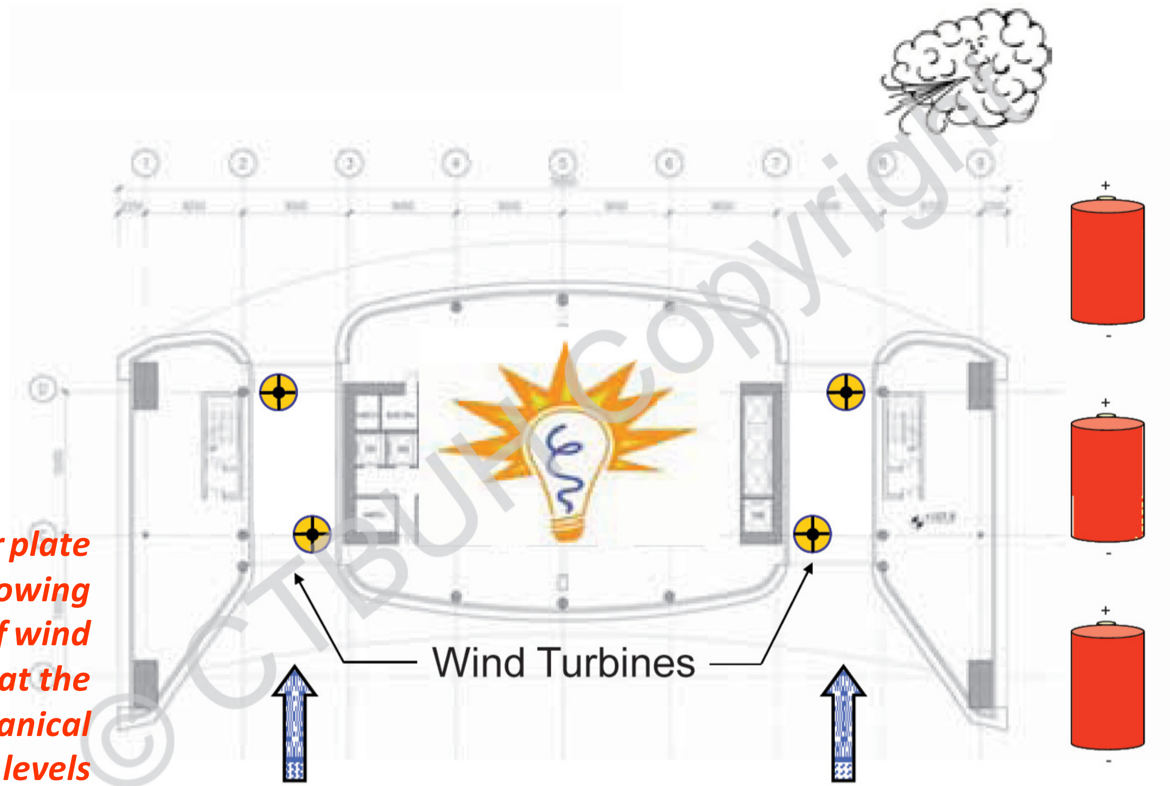
- The Tower is positioned so that the broadest side of the building faces directly into prevailing winds.
- This is to the advantage of the wind turbines though it does greatly increase the building's wind load.
- the openings and the curvature serve to reduce the wind load

Funnel shaped areas in the façade to enhance wind speeds





vertical wind turbine



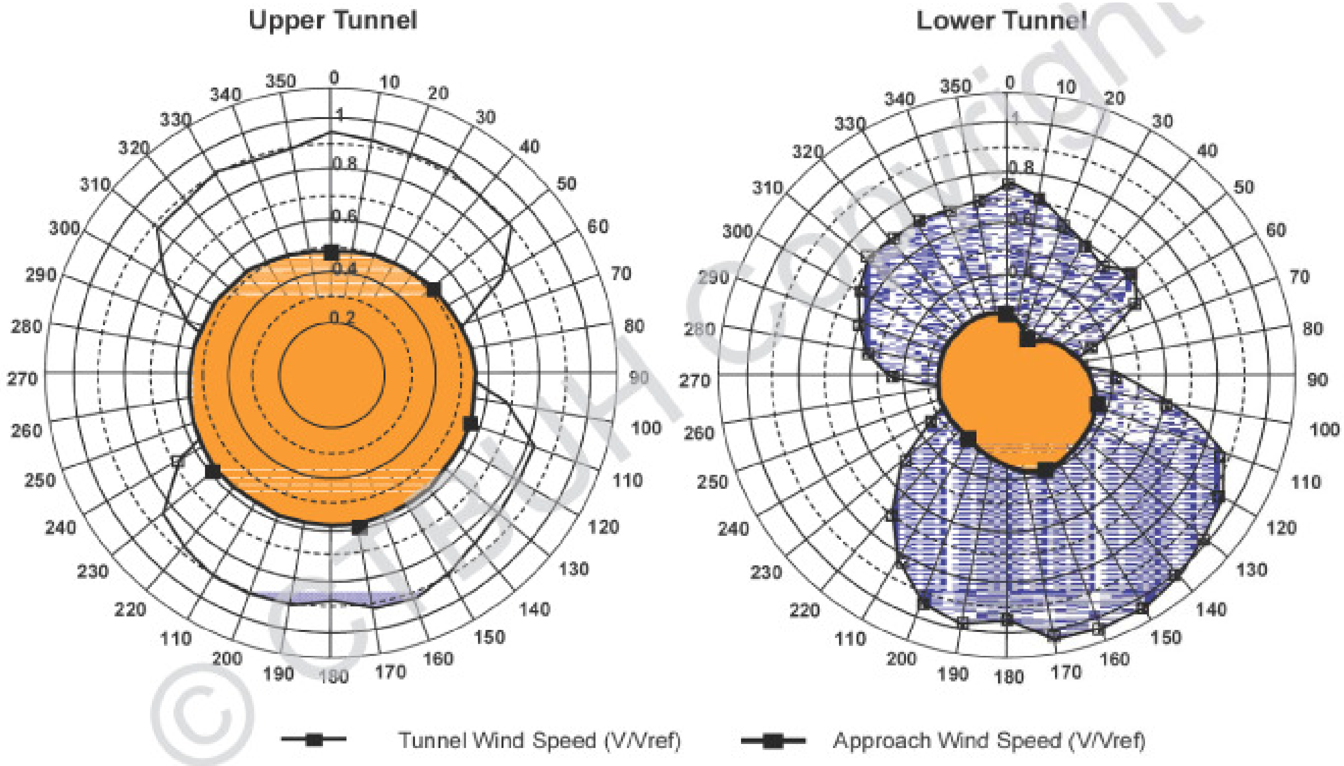
floor plate showing location of wind turbines at the mechanical levels

PEARL RIVER TOWER, Guangzhou, China

- The effect of the wind travelling through the four openings studied in a wind *tunnel testing rig* that featured a scaled model of the Pearl River Tower.
- This testing took air-flow measurements of the wind speeds as the winds approached the building & also measured the corresponding air velocities within the four openings
- model was then rotated within the tunnel to simulate what would happen when the wind approached from all possible directions.
- The results indicate that as the *air passes through the openings the wind accelerates and the velocity increases*.
- If the wind strikes at a perpendicular angle to an opening the velocity drops. But from very other angle, the increase in the wind velocity exceeds ambient wind speeds

•placing one *vertical-axis wind turbine* within each of the four openings takes advantage of the increased power potential of the airstream and provides power year round.

•The addition of the four opening also results in *structure-related cost savings*.



PEARL RIVER TOWER, Guangzhou, China

Hydrogen Fuel Cells

▪hydrogen fuel cells to store excess generated energy.
▪they are actually similar to batteries than to a fuel such as oil.
▪Hydrogen fuel cells such as these are also only 30-50% efficient (fuel cell vehicles are 22% energy efficient) at storing energy whereas a lead-acid battery is 90% efficient as an energy storage system, leading to some debate as to whether hydrogen fuel cells are truly the way to go.

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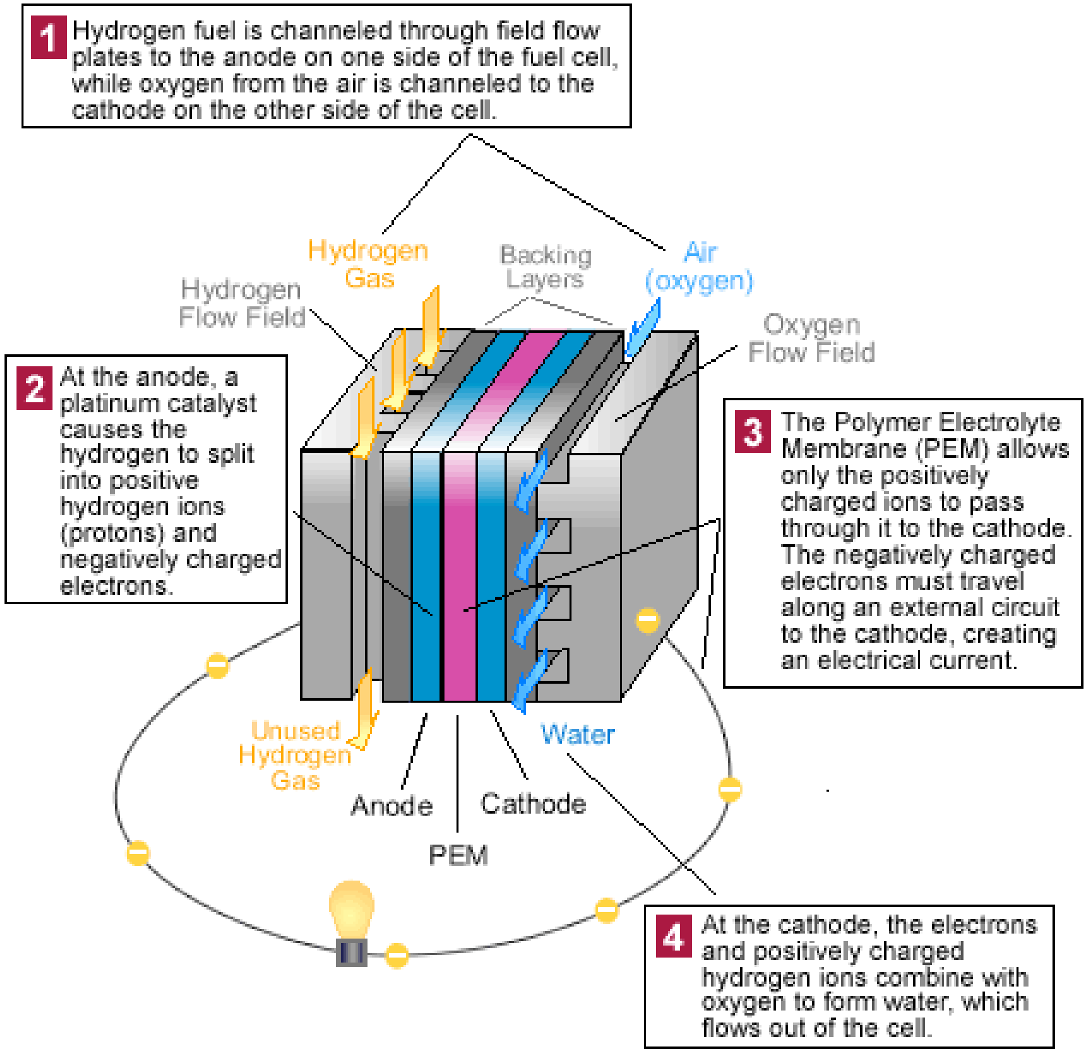
ENERGY STORAGE SYSTEM



PEARL RIVER TOWER, Guangzhou, China

GENERATION:

▪In order to achieve it's goal of becoming a *net-zero building*, the Pearl River Tower needed to use a system of *linked micro-turbines*.

▪These small, highly efficient turbines would run off of anything from *biodiesel to natural gas*.

▪With these micro-turbines in place the ***excess electricity*** being generated would have been *sold back to the grid* making the Pearl River Tower a mini power plant.

▪ However, as mentioned before Guangzhou authorities did not warm up to the idea. Their reluctance coupled with the faulty electrical grid led to these micro-turbines being put on hold.

▪There is however room for these micro-turbines in the final design should the local grid be upgraded and everything approved.

▪ If these micro-turbines were added, the Pearl River Tower would become the net-zero tower it was designed to be.

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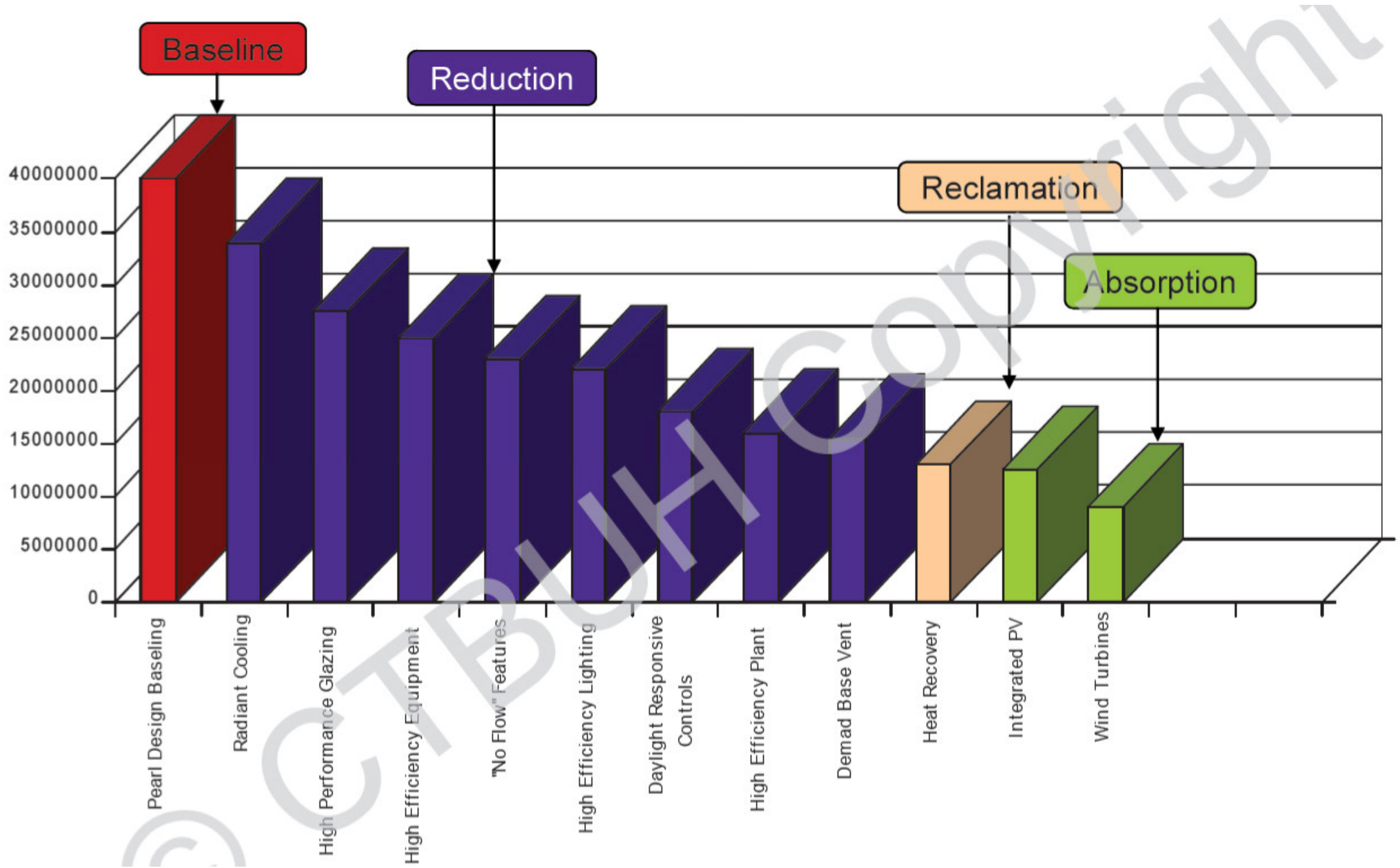
micro-turbines for generation of power

PEARL RIVER TOWER, Guangzhou, China

NET ZERO ENERGY STRATEGY:



CENTRE OF SUSTAINABLE TECHNOLOGIES,
Ningbo, China

Architect : **Mario Cucinella Architects**
Location : **Ningbo**
Client : **University of Nottingham**
Area o f bldg : **1,300 sqm**

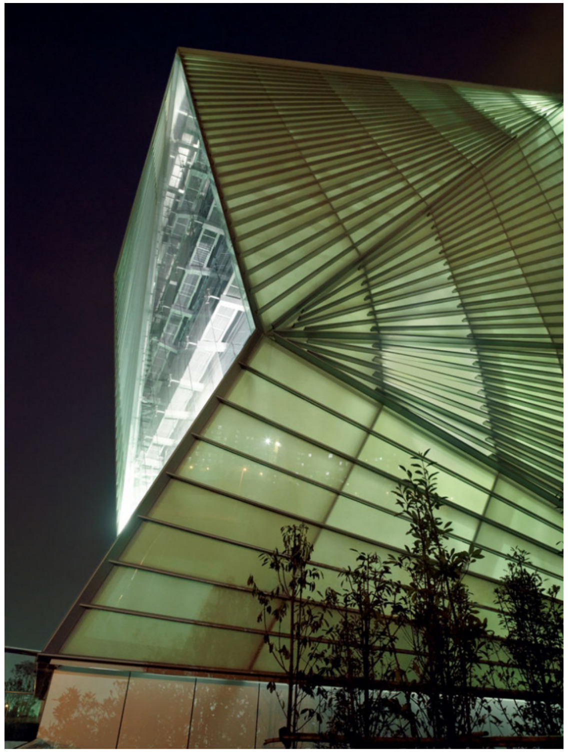
Climate of Ningbo:
- **monsoon-influenced humid sub-tropical**
- **featuring temperate and humid weather**

The Centre for Sustainable Energy Technologies (CSET) will focus on the diffusion of sustainable technologies such as solar power, photovoltaic energy, wind power and so forth. The building accommodates a visitors centre, research laboratories and classrooms for masters courses. The pavilion stands in a large meadow alongside a stream that runs through the campus. It’s design is inspired by Chinese lanterns and traditional wooden screens.

LOW CARBON DESIGN – ENVIRONMENTAL STRATEGIES:

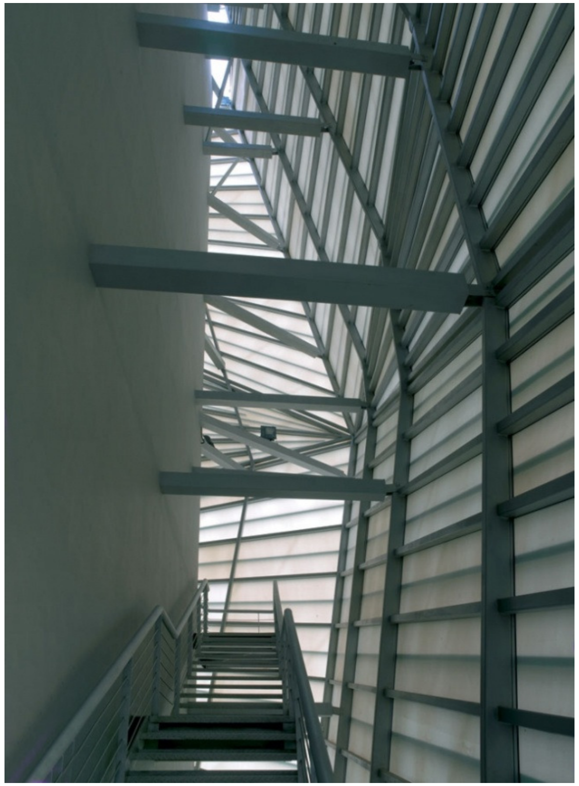
The building is designed to respond to diurnal and seasonal variations in ambient conditions by means of a **‘5’ point** environmental design strategy:

- **High Performance Envelope**
- **Exposed Thermal Mass**
- **Daylight & Solar control**
- **Natural Ventilation to Tower**
- **Piped Ventilation to Laboratory & Workshop**



CENTRE OF SUSTAINABLE TECHNOLOGIES,
Ningbo, China




CENTRE OF SUSTAINABLE TECHNOLOGIES,

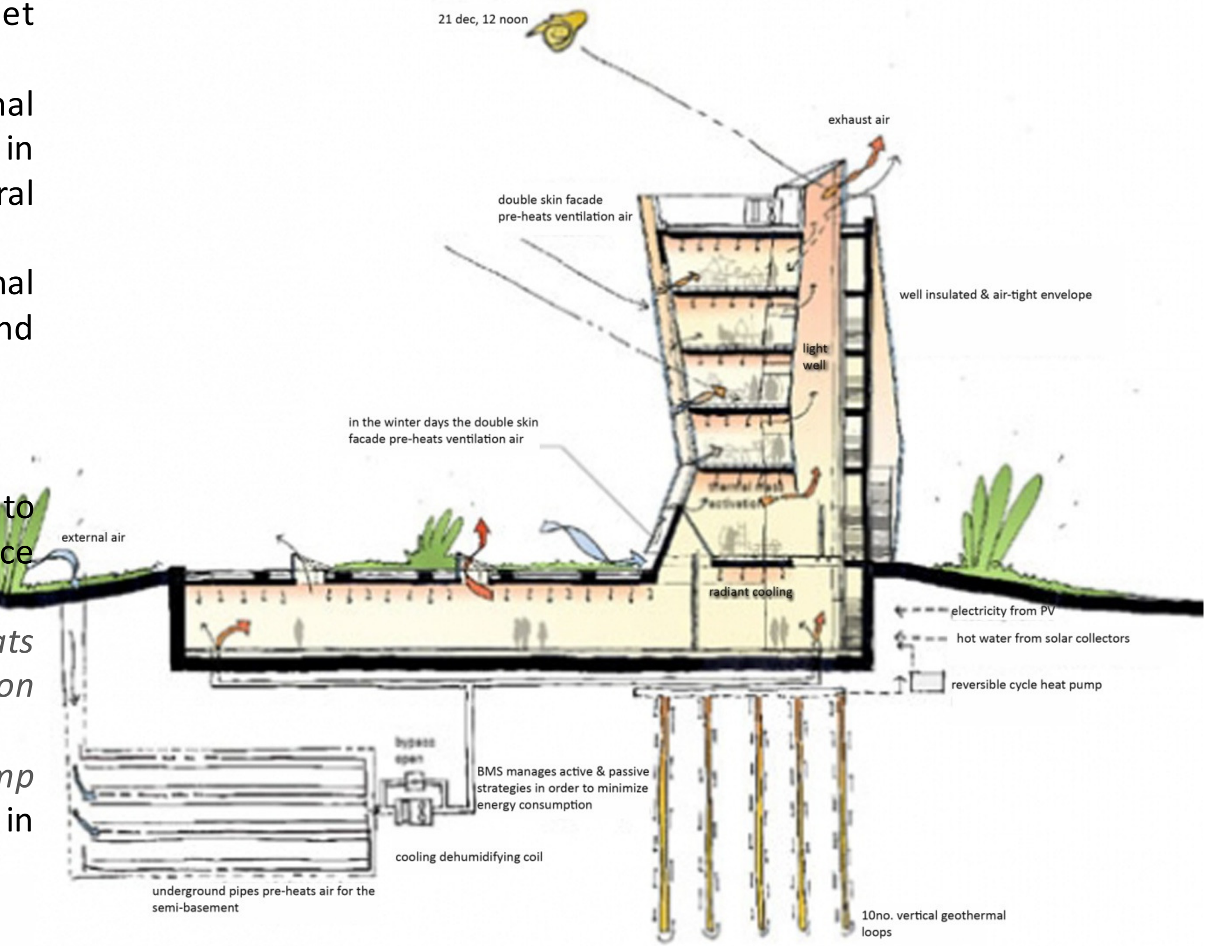
Ningbo, China

ENVIRONMENTAL & ENERGY PERFORMANCE:

- *building does not require conventional heating system*
- residual energy requirement is met through renewable energy sources
- building responds to diurnal & seasonal variation in climate, to minimize heating in winter, cooling in summer & promote natural ventilation in spring and autumn
- building is well insulated with high thermal capacitance internal floors & walls and ventilated, glazed south façade

HEATING

- COLD PERIOD – additional heat required to pre-heat ventilation air and to raise surface temperatures
- SOUTH FAÇADE - *passively pre-heats ventilation air supplied by natural convection* to teaching room, offices & meeting rooms
- using a *reversible ground source heat pump* 'top-up' heating through coils embedded in the soffit of the concrete floor is provided



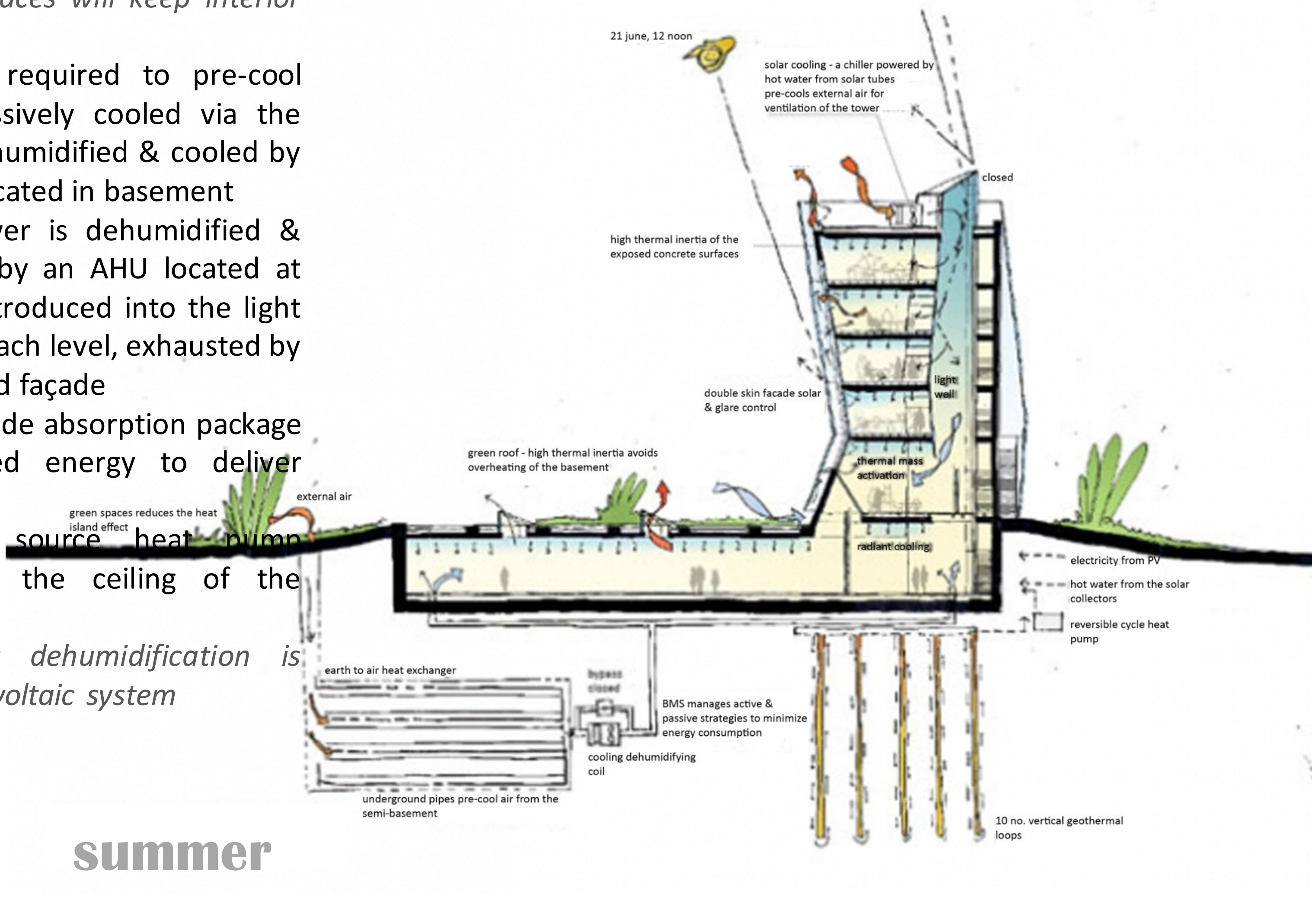
winter

CENTRE OF SUSTAINABLE TECHNOLOGIES,

Ningbo, China

COOLING

- IN SUMMER – *high performance envelope & thermal capacitance of the exposed internal concrete surfaces will keep interior cool*
- Additional cooling required to pre-cool ventilation air is passively cooled via the ground tubes and dehumidified & cooled by an air handling unit located in basement
- air supplied to tower is dehumidified & mechanically cooled by an AHU located at the roof top, then introduced into the light well, falling down to each level, exhausted by the naturally ventilated façade
- solar collectors provide absorption package chillers with required energy to deliver cooling to the AHUs.
- reversible ground source heat pump provides cooling to the ceiling of the concrete floor
- *electric power for dehumidification is provided by the photovoltaic system*



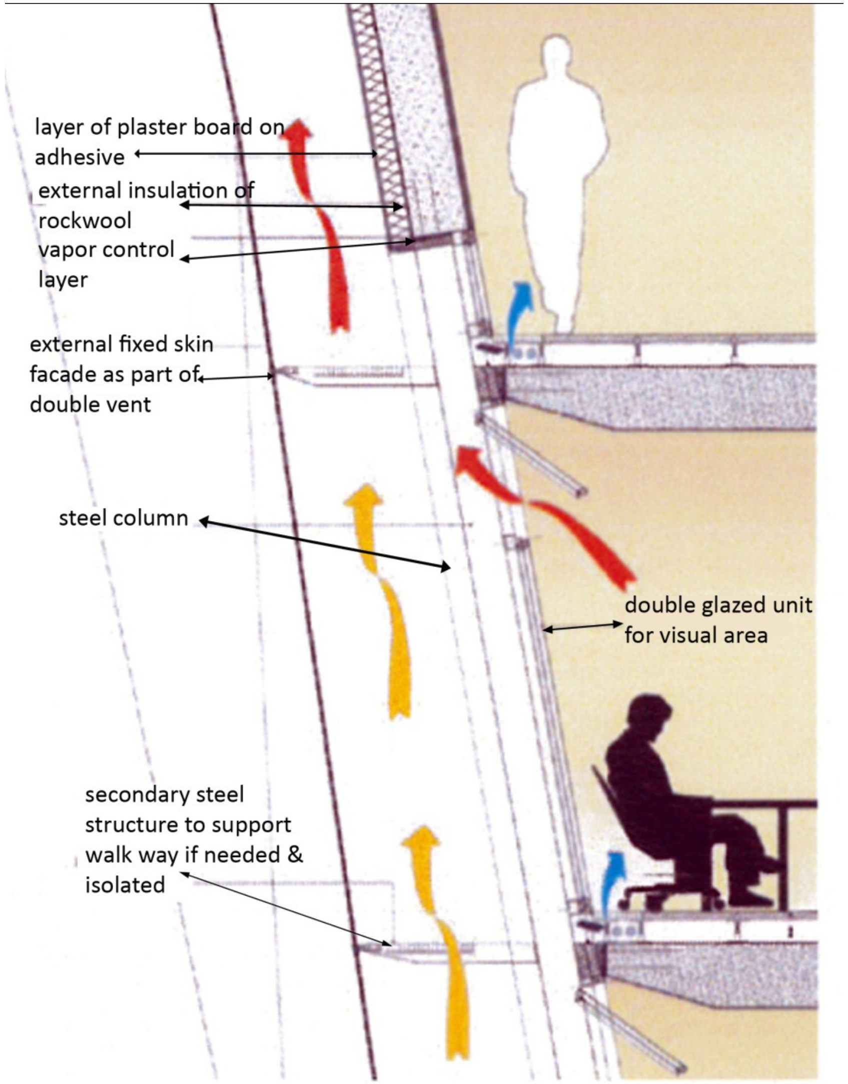
CENTRE OF SUSTAINABLE TECHNOLOGIES,
Ningbo, China

VENTILATION

- SPRING & AUTUMN – *natural ventilation promoted*
- controlled automatically by means of *vent opening gear within the perimeter glazing*

LIGHTING

- building designed to exploit daylight, while avoiding glare and solar heat gain
- this reduces the amount of time for which artificial light is required
- *photovoltaic system used to provide artificial lighting & small power* for office equipment such as computers, fax machines etc.
- during peak periods of sunshine enough power shall be produced from the PV system to run other equipment such as lift, mechanical ventilation & chilled water systems
- incase *extra power* is not utilized, it shall be *stored in batteries or transferred* to the nearby sports centre



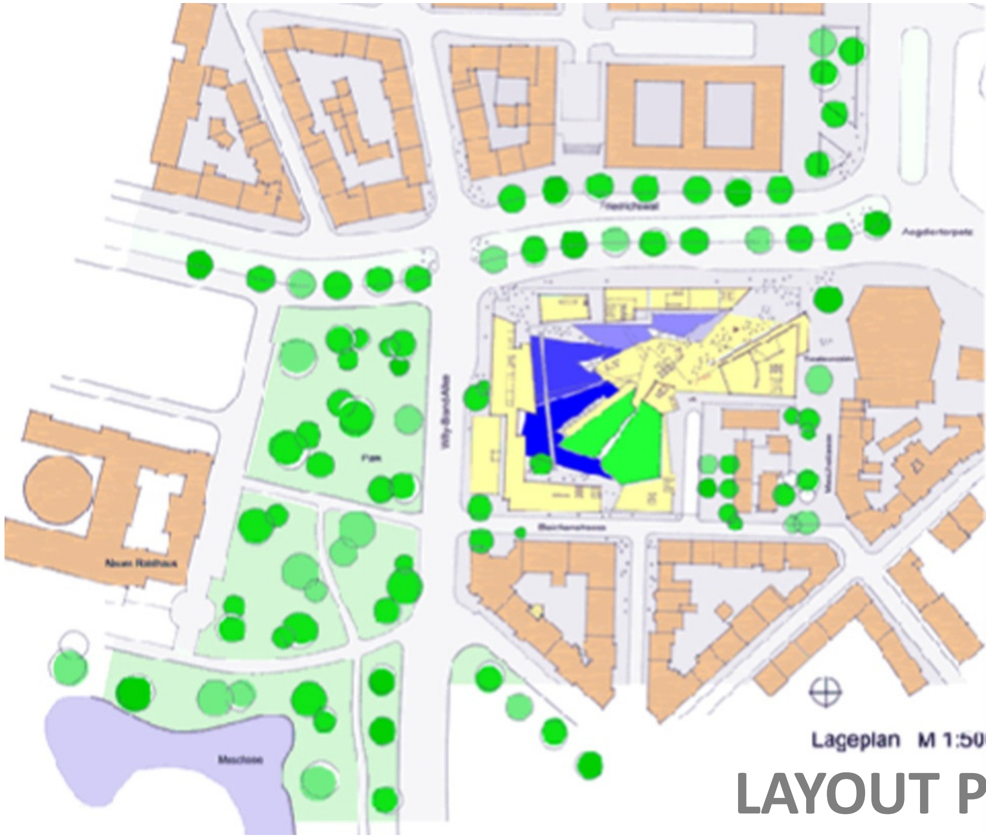
NORDDEUTSCHE LANDESBANK, Hannover, Germany

Architect : **Behnisch, Behnisch & Partners**
Location : **Hannover**
Client : **Norddeutsche Landesbank, Hannover**
Area o f bldg : **75,000 sqm**
Height of bldg: **70m**

Climate of Hannover:

- **warm summer continental climate**

Behnisch, Behnisch & Partner's strategy for the perimeter block and central tower was to create a building that is energy efficient, ensures worker comfort, and responds to and engages the urban context. To improve the buildings efficiency to surpass the 1997 German insulation regulations by 10%, and then to create environmentally sensitive measures at reasonable cost. The energy consumption for winter heating is comparatively low, attention was focussed on the reduction of costlier environmental necessities – ventilation, cooling and lighting.



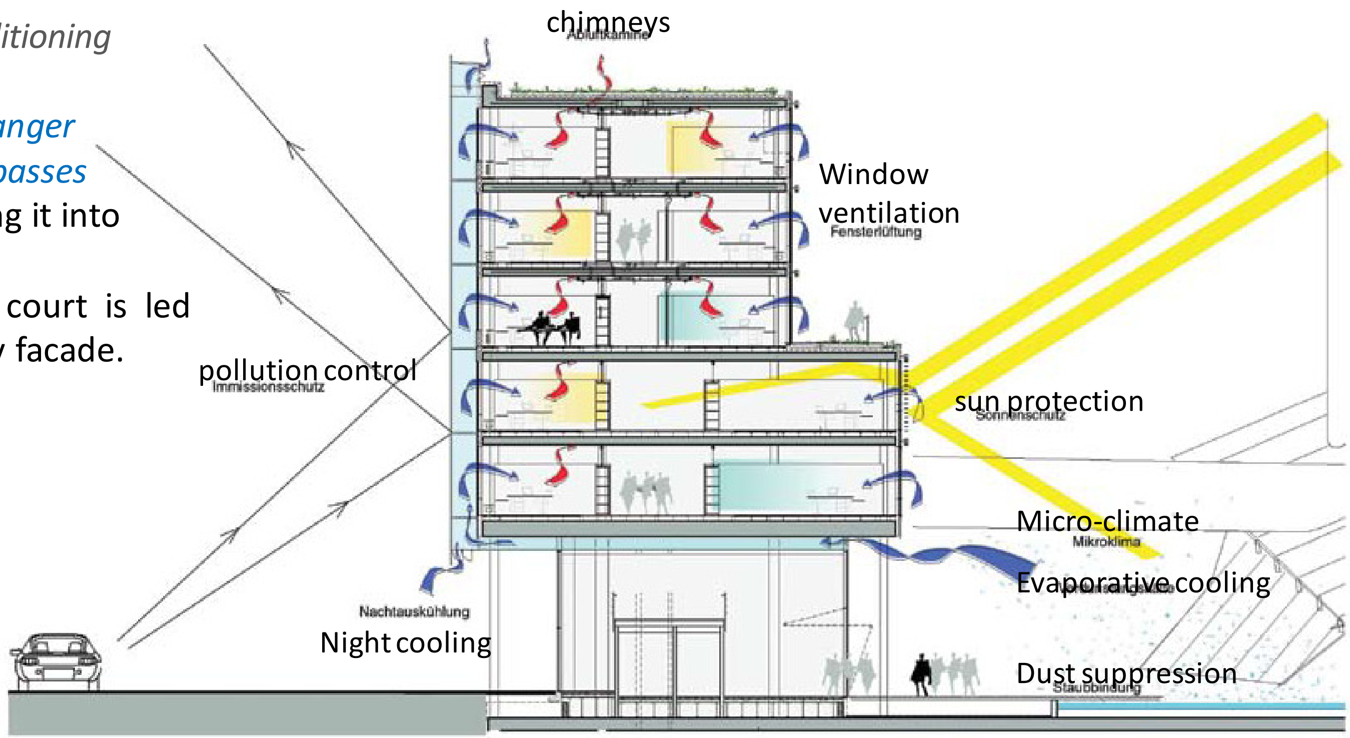
LAYOUT PLAN

NORDDEUTSCHE LANDESBANK, Hannover, Germany

LOW CARBON DESIGN – ENVIRONMENTAL STRATEGIES:

- The ground floor is forms a major part of the building's energy concept. The ***landscaped courtyard & water elements contribute to improving the micro climate*** of the interior. This '***good***' air, is introduced into the space between the double façade is also be used to *ventilate the building*, cooling it down at night.
- *offices do not have any air-conditioning*
- Due to the earth's capability to store cool air, *a soil-heat-exchanger located beneath the foundation passes this air to the floor slabs*, releasing it into the building.
- The fresh air from the inner court is led under the building into the cavity facade.

Roof gardens & landscaped court created to alter the micro-climate

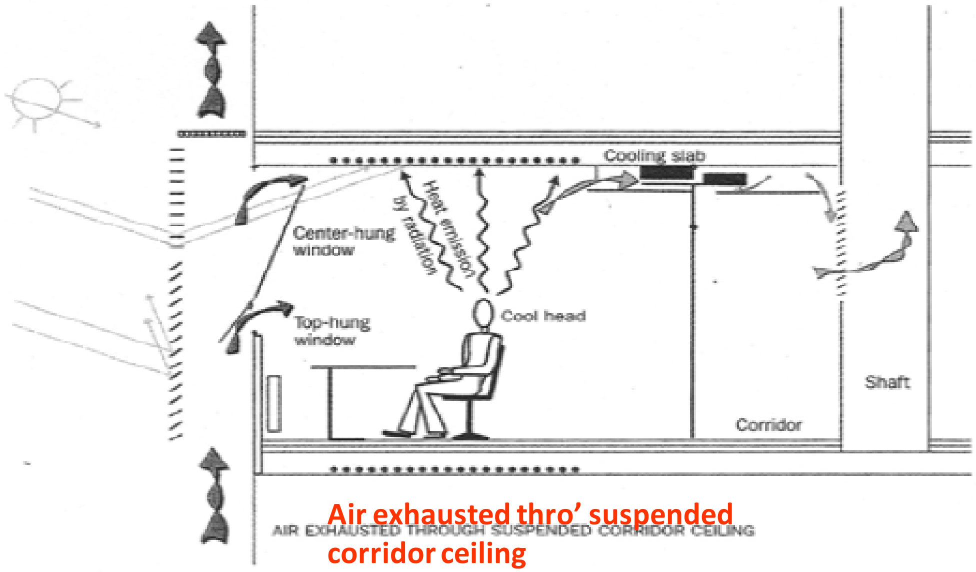


Ventilation system

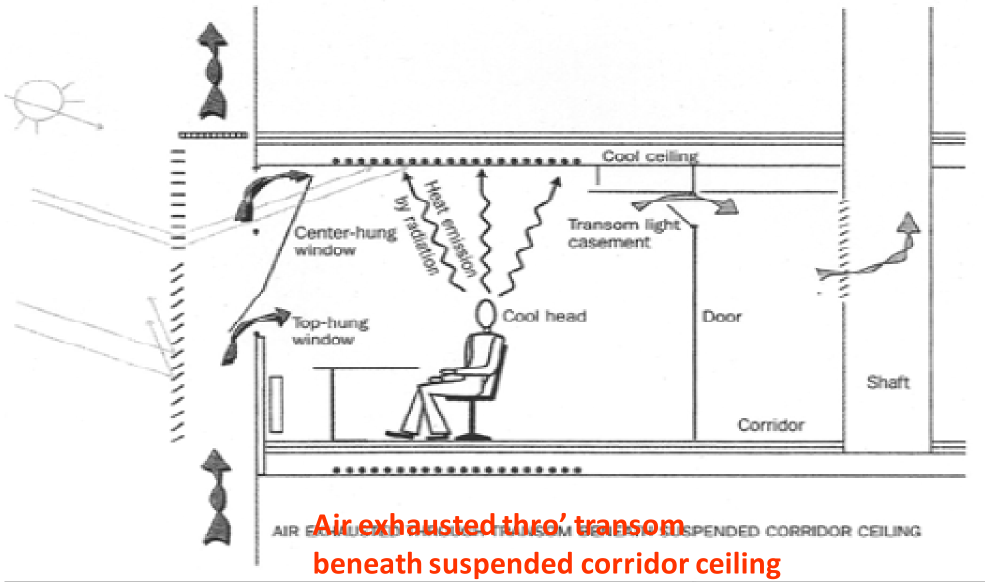
NORDDEUTSCHE LANDESBANK, Hannover, Germany

VENTILATION

- The Nord/LB uses an almost entirely *passive ventilation system*. Fresh air is supplied by shutter that open onto the courtyard
- This *microclimate provides the building with air* that is perhaps even cleaner and more refreshing that outside air, or the air that would be provided using a conventional mechanical system.
- *Air is vented* from the offices and similar rooms through a *suspended ceiling system* to the corridor, and from there to the large *passive vents or chimneys* that *exhaust air* to the roof. Room occupants are able to control the air flow with transom casement windows.
- As the hot stale air rises out of the building, more cool fresh air is drawn in from the courtyard below.



Air exhausted thro' suspended corridor ceiling



Air exhausted thro' transom beneath suspended corridor ceiling

NORDDEUTSCHE LANDESBANK, Hannover, Germany

COOLING

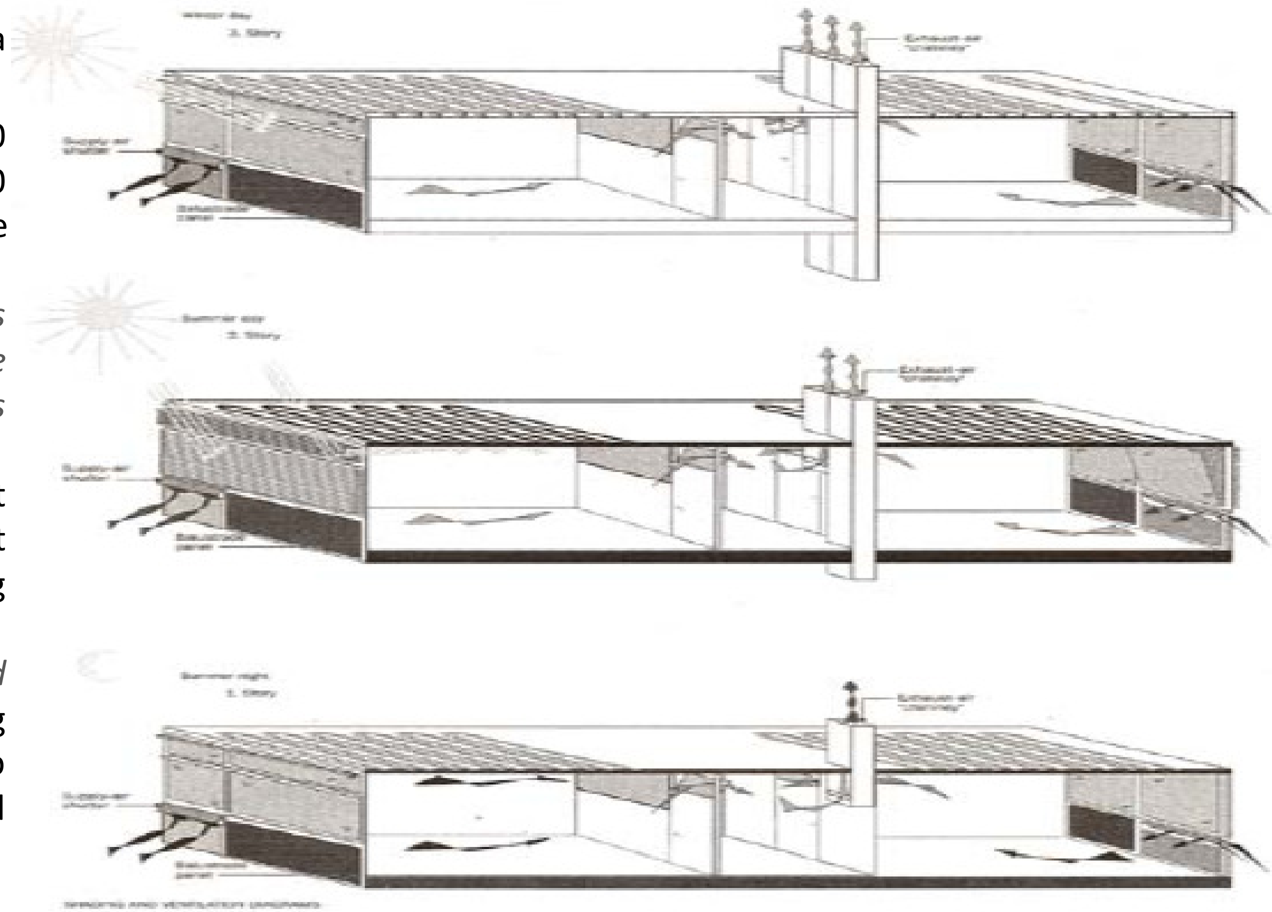
• Cooling is achieved with a *radiant slab cooling system* and a *geothermal heat exchanger*.

•The *concrete foundation piles* (120 of them) are sunk approximately 30 metres below ground and have *water pipes embedded* in them.

•*Water is pumped through the piles* to the building's *exposed concrete ceilings that have polyethylene pipes cast* into them.

• lighting combined with ambient and computer equipment heat sources heat the ceiling slabs during the summer days.

• *Cold water* (about 17/C) is *pumped* through the pipes *at night*, adsorbing the heat accumulated in the slab over the course of the day, and cooling for the day ahead.



embedded cooling pipes cool fresh air that is taken in through shutters on the building face and exhausted through chimneys

NORDDEUTSCHE LANDESBANK, Hannover, Germany

OTHER CONSIDERATIONS

•glazing systems used on the different faces of the Nord/LB are differently conceived

• A system of *operable thermal glazed windows and external louvers* is used

•The *north and west* facades next to *noisy roads*, have an *additional layer of glass* to protect from fumes and noise

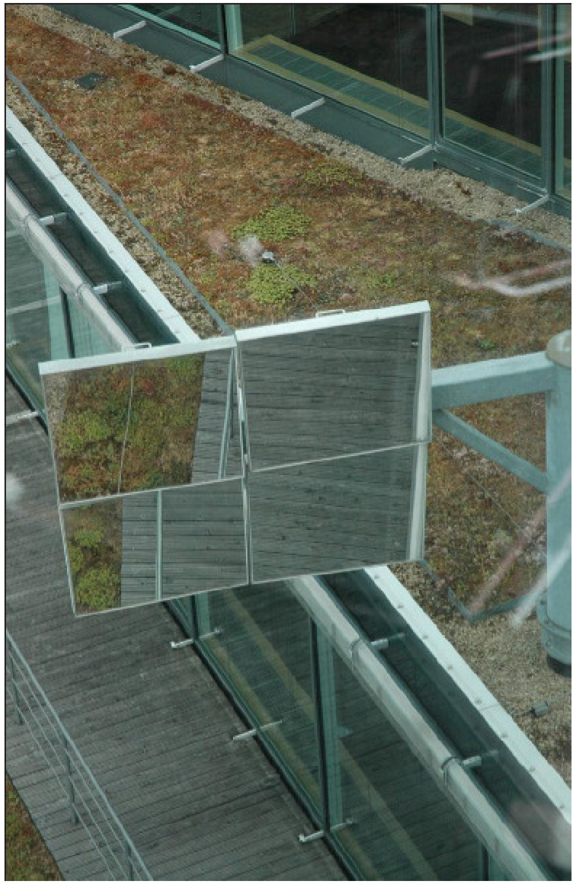
• *sunshades are controlled* both centrally by computer and by controls within each room.

•The *upper slats function like a series of light shelves that reflect light* up and on to the ceiling to provide ambient lighting (and passive heating in the winter).

•The *lower slats reflect light away* from the building, to *reduce solar gain and glare*, while still allowing the occupant to see outside.

• The louvers are set off away from the building line to allow a layer of air to flow behind them and up the building face.

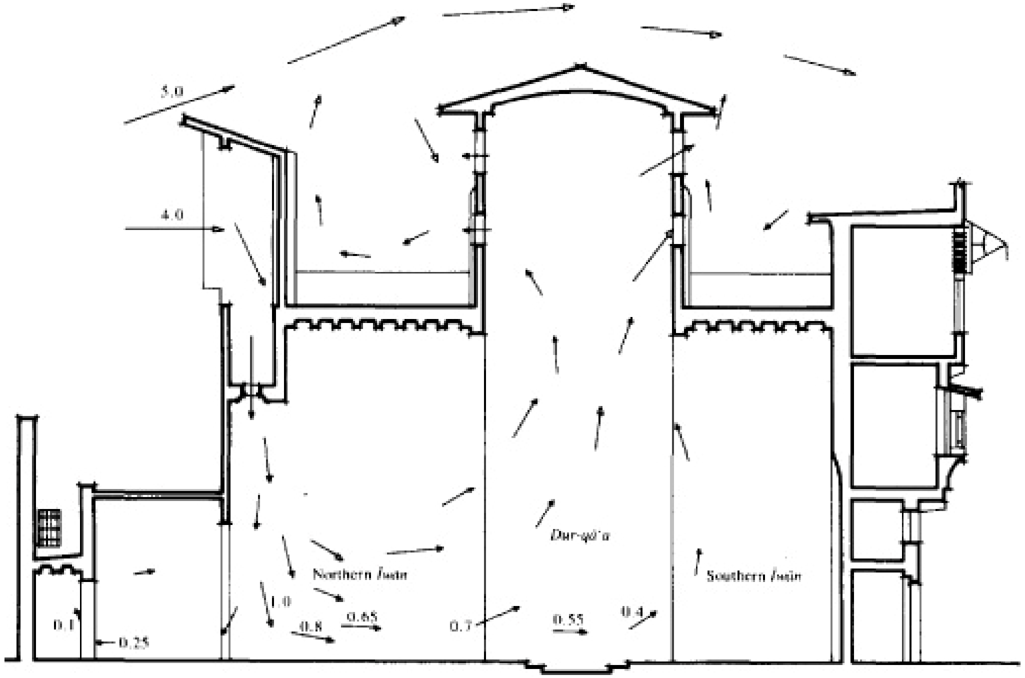
Façade glazing system



WINDCATCHERS & their adaptation into modern buildings

TRADITIONAL WINDCATCHERS

▪ found in Middle East, Pakistan & India
▪2 types of unidirectional & multidirectional



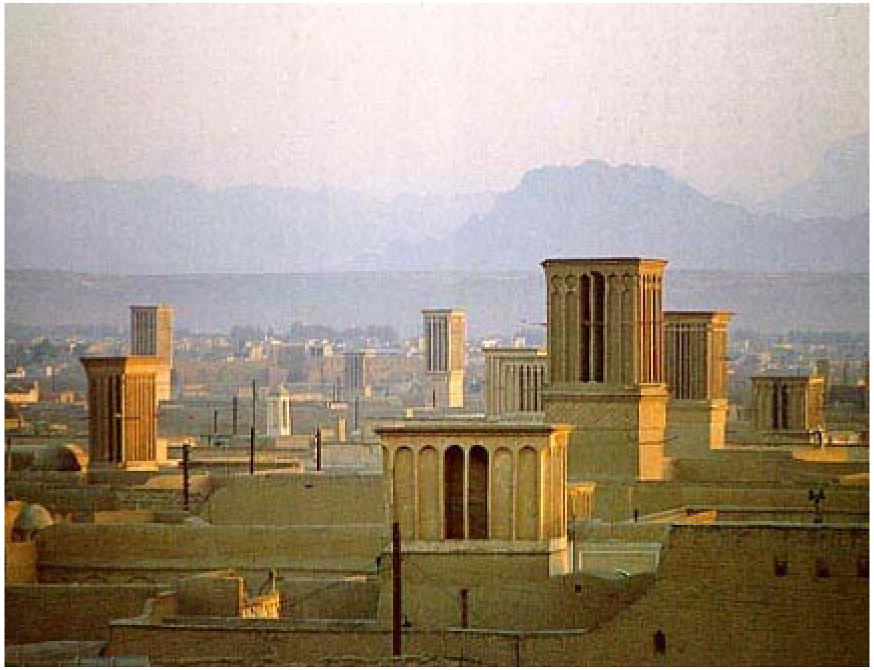
UNI-DIRECTIONAL WIND CATCHERS

▪**Shaft** rising high above the building with an opening *facing the prevailing wind* and constructed on the north
▪ It ***traps the cool air*** and channels it down into the interior of the building
▪ The size of the shaft *is determined by the* external air temperature.
If the air temperature is high, a smaller size is required and if it is low, a larger size is preferred
▪To increase the humidity a marble plate with wavy patterns was provided with a source of water

WINDCATCHERS & their adaptation into modern buildings

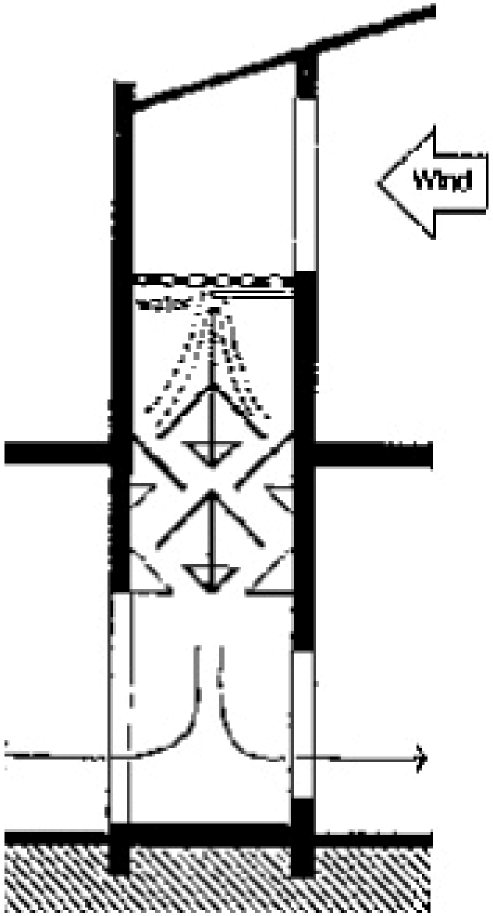
MULTI-DIRECTIONAL WIND CATCHERS

- **Shaft** has four openings at the top to *catch* the *breezes from any direction*.
- Air circulation coming from the shaft *can be adjusted by* opening or closing one or more of the scoops.
- Placing a *clay porous pot*, help *humidify* and *cool* the *air* coming from the shaft
- These *can also be used in pairs or four at a time to* cool underground water tanks

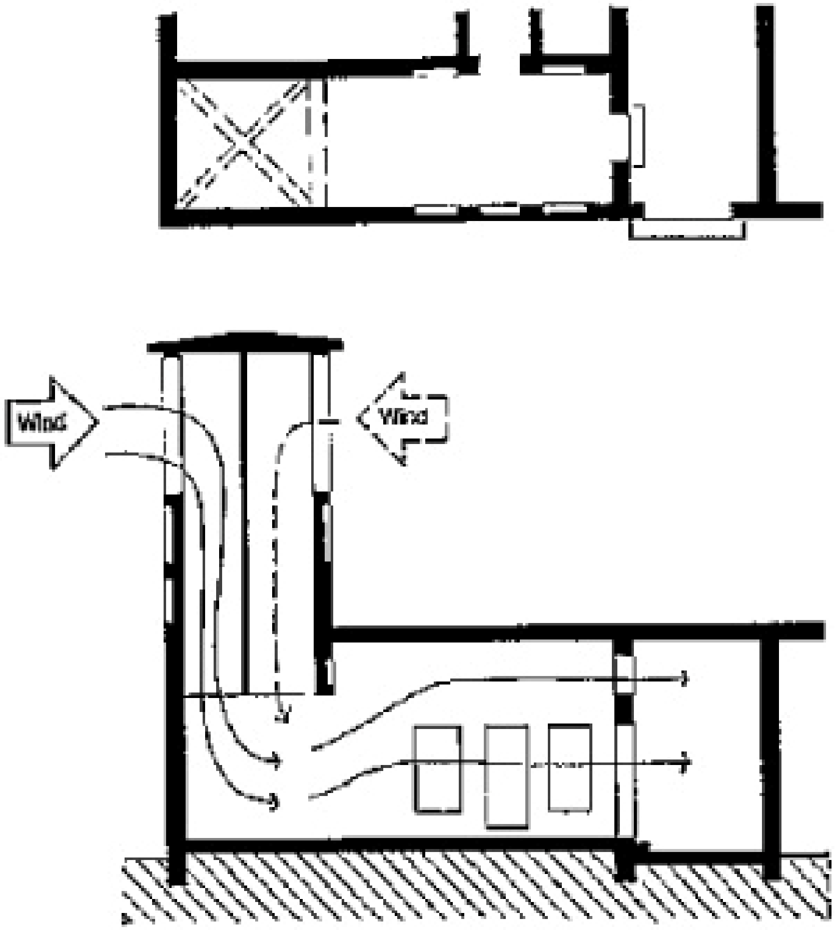


WINDCATCHERS & their adaptation into modern buildings

MULTI-DIRECTIONAL WINDCATCHERS



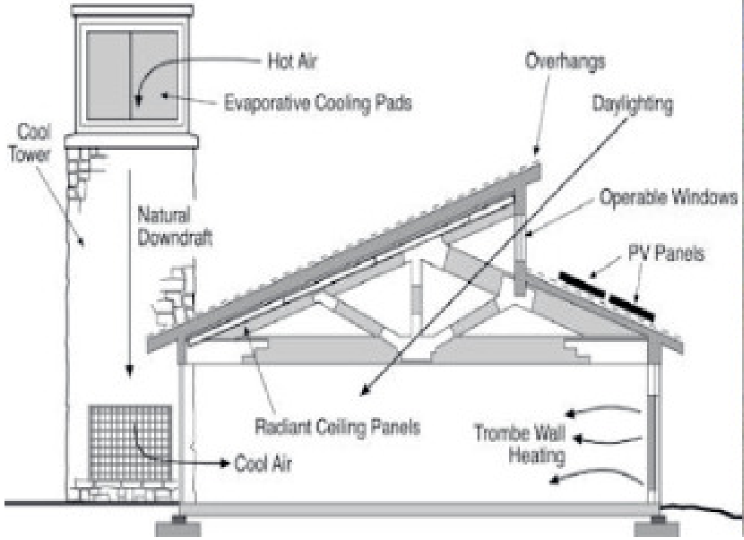
evaporative cooler

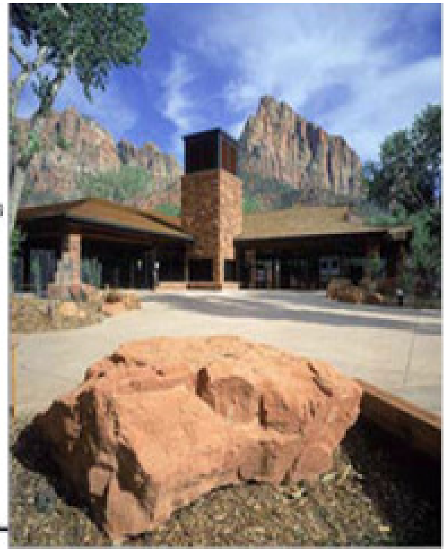


multi-directional wind catcher

WINDCATCHERS & their adaptation into modern buildings

MODERN INTEPRETATION OF WINDCATCHERS

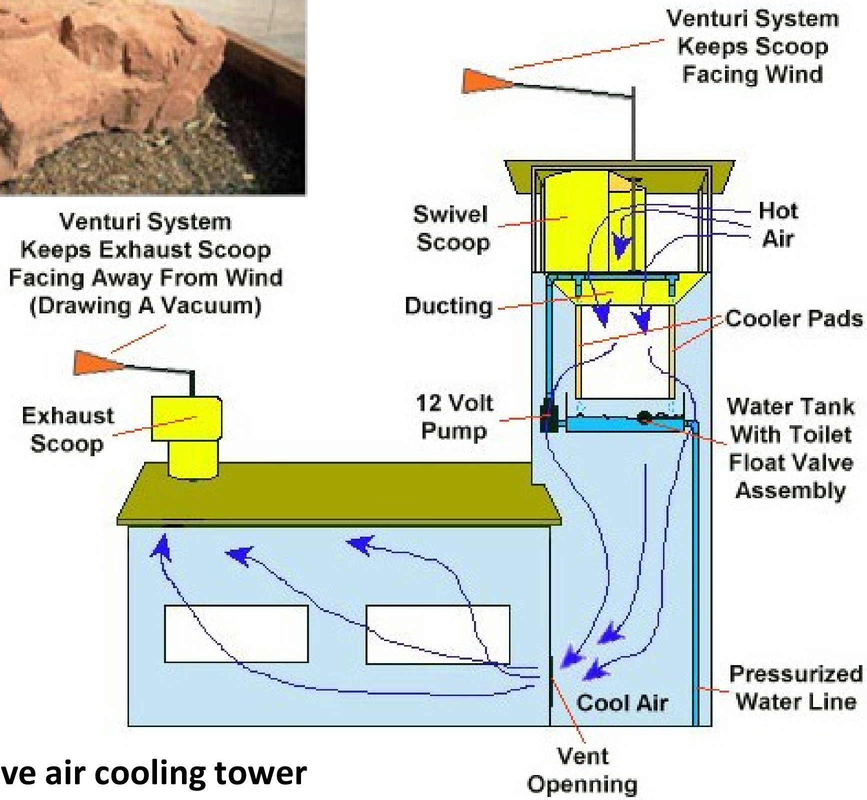




Visitor Centre at Zion National Park, US

PASSIVE AIR COOLING TOWER

- Combination of *wind catcher & modern devices*
- Large upswing swivel scoop to create larger air flows
- Exhaust swivels to keep away from air flow
- *Wind can blow from any direction*
- *Water* tank & pump provided to circulate & evaporate water *to cool the air*

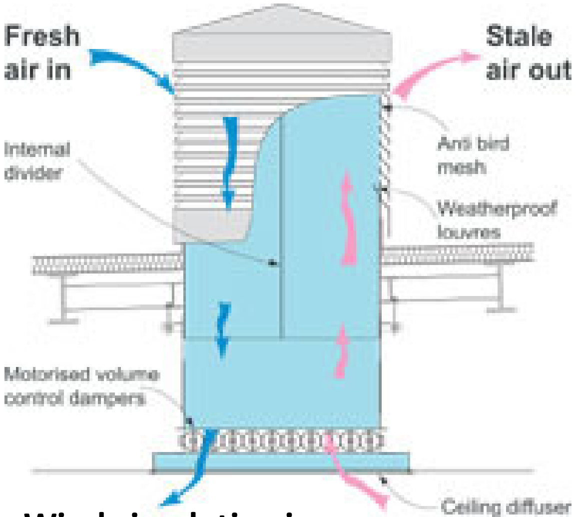


Passive air cooling tower

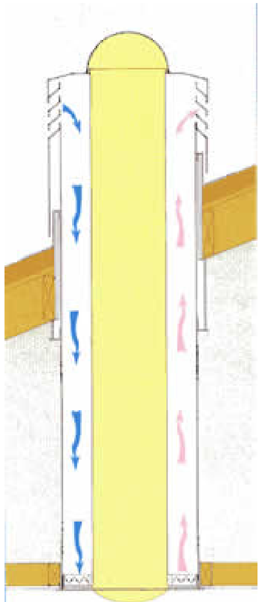
WINDCATCHERS & their adaptation into modern buildings

MODERN INTEPRETATION OF WINDCATCHERS

Metropole, Zenith, Foster & Partners



Wind circulation in mono-draught



Air ventilation & lighting

MONODRAUGHT

- Provides *light & ventilation*
- Fully automatic with dampers, sensors, adjustable ceiling ventilators
- *temperature sensors* are normally set to start opening at 16°C during the summer months and open 20 % for every one deg C in internal room temperature.
- *CO2 sensors* distributing fresh air throughout a building when the carbon dioxide levels become too high and ensure the hot air is removed.
- in winter unit is closed and only allows fresh air to enter

Wind catchers