AIT Technology Event

What makes buildings green and sustainable?

Brahmanand Mohanty

AIT
Asian Institute of Technology

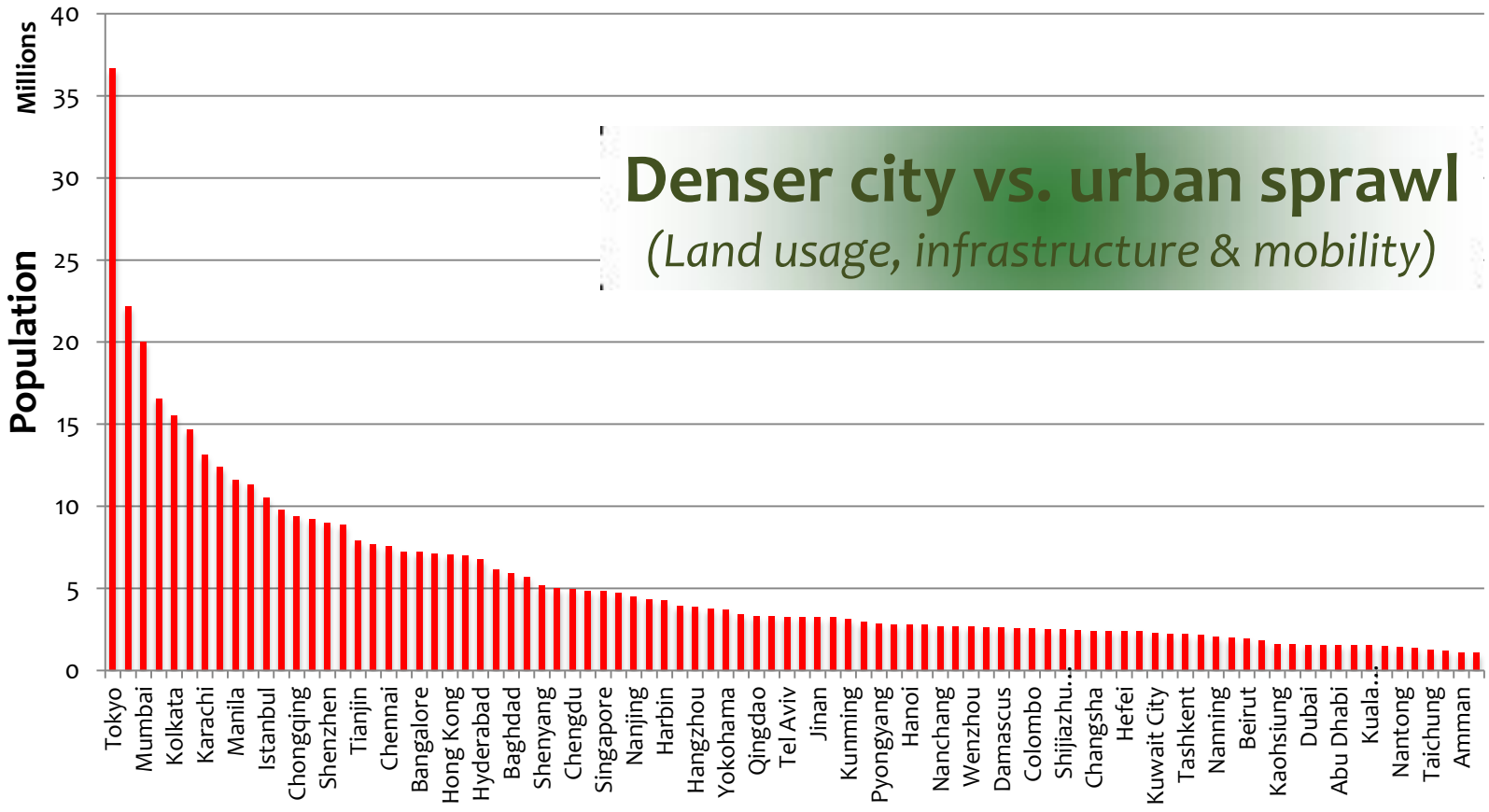
Flashback…

- Zero-energy building

- “Net positive” energy building

Population growth and urbanization

- **Asian cities with population above 1 million**



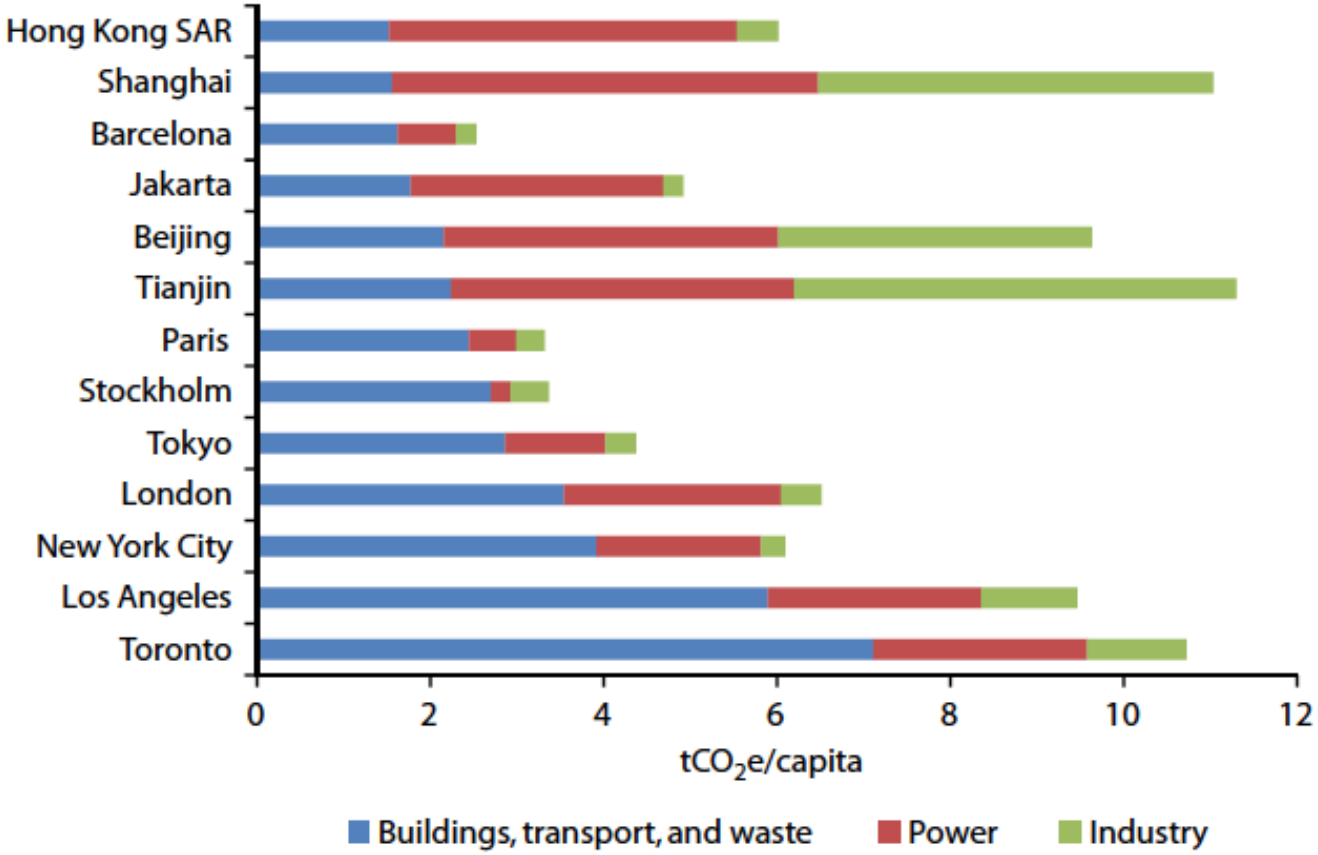
Denser city vs. urban sprawl

(Land usage, infrastructure & mobility)

(source: U.N. World Urbanization Prospects, 2010)

Cities to combat climate change

- **Cities are on a high carbon-emission growth path**



Per capita carbon emission of selected cities (source: World Bank, 2010)

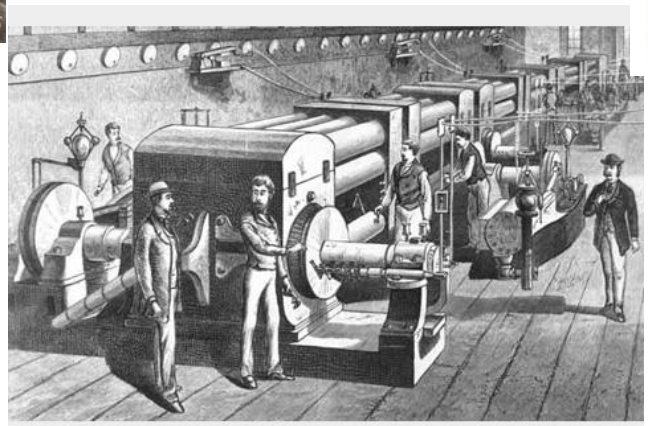
Tall buildings improve urban density

- **Energy benefits from tall buildings**
  - Density versus horizontal spread
  - Less materials per unit of usable floor space
  - Smaller surface area of envelope per floor area
  - Natural energy share occurring between floors
  - Potential for harvesting solar and wind energy at height

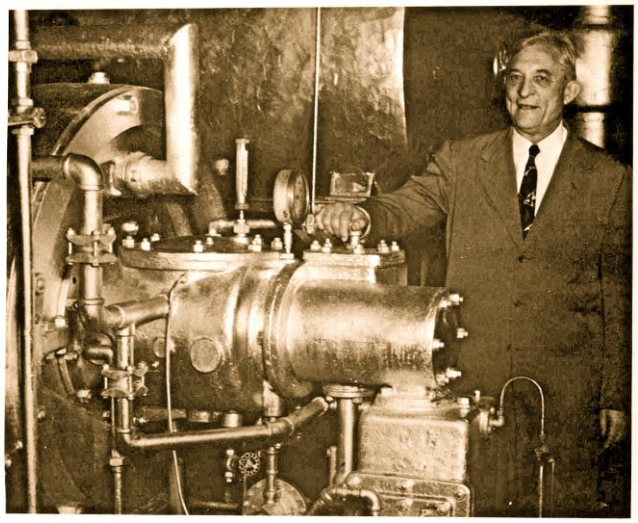
- **Disadvantages of tall buildings**
  - Limited contact between occupier and envelope
  - Materials at heights need greater sizing and performance

Genesis of tall buildings

Otis Elevator (1850s)



Edison's electricity (1880s)

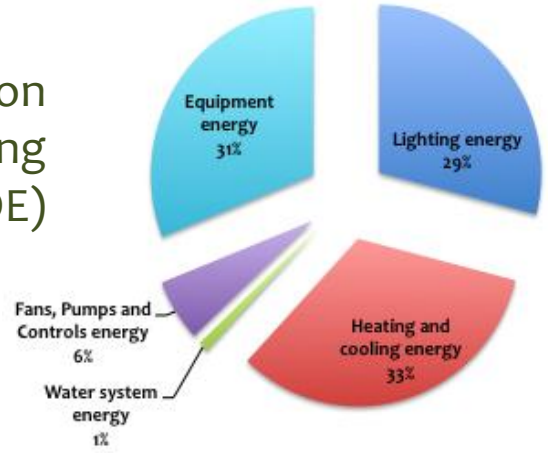


Dr. Willis H. Carrier with centrifugal refrigeration machine installed at Onondaga Pottery Co. in 1923

Carrier's air conditioner (1920s)

Zero-energy to high-energy building

Average energy consumption of a typical office building (Source: US DOE)



Elevators (1854)

Electric Lighting (1890)

HVAC Systems (19[illegible]4)

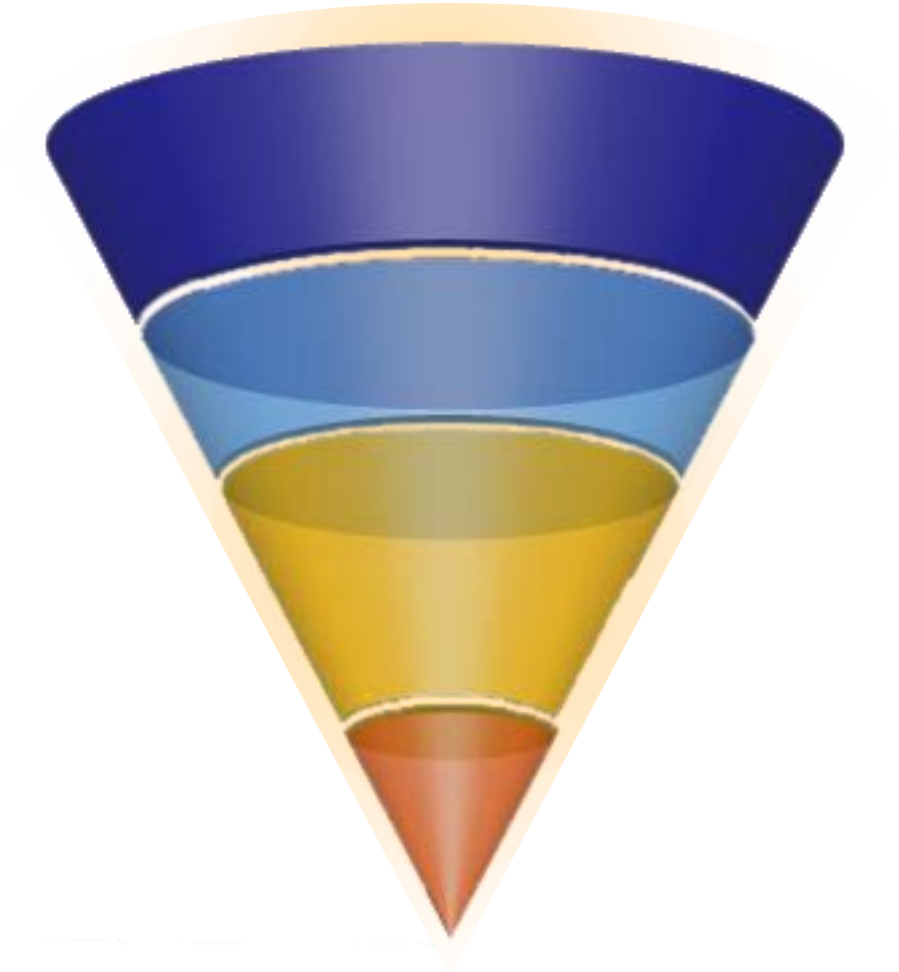
Zero-Energy Building

High-Energy Building

All-glass box style architecture era

- Heavyweight stones or brick-clad skyscrapers replaced by light, fully glazed office buildings
- High heating and cooling loads due to light structure and lack of solar shading

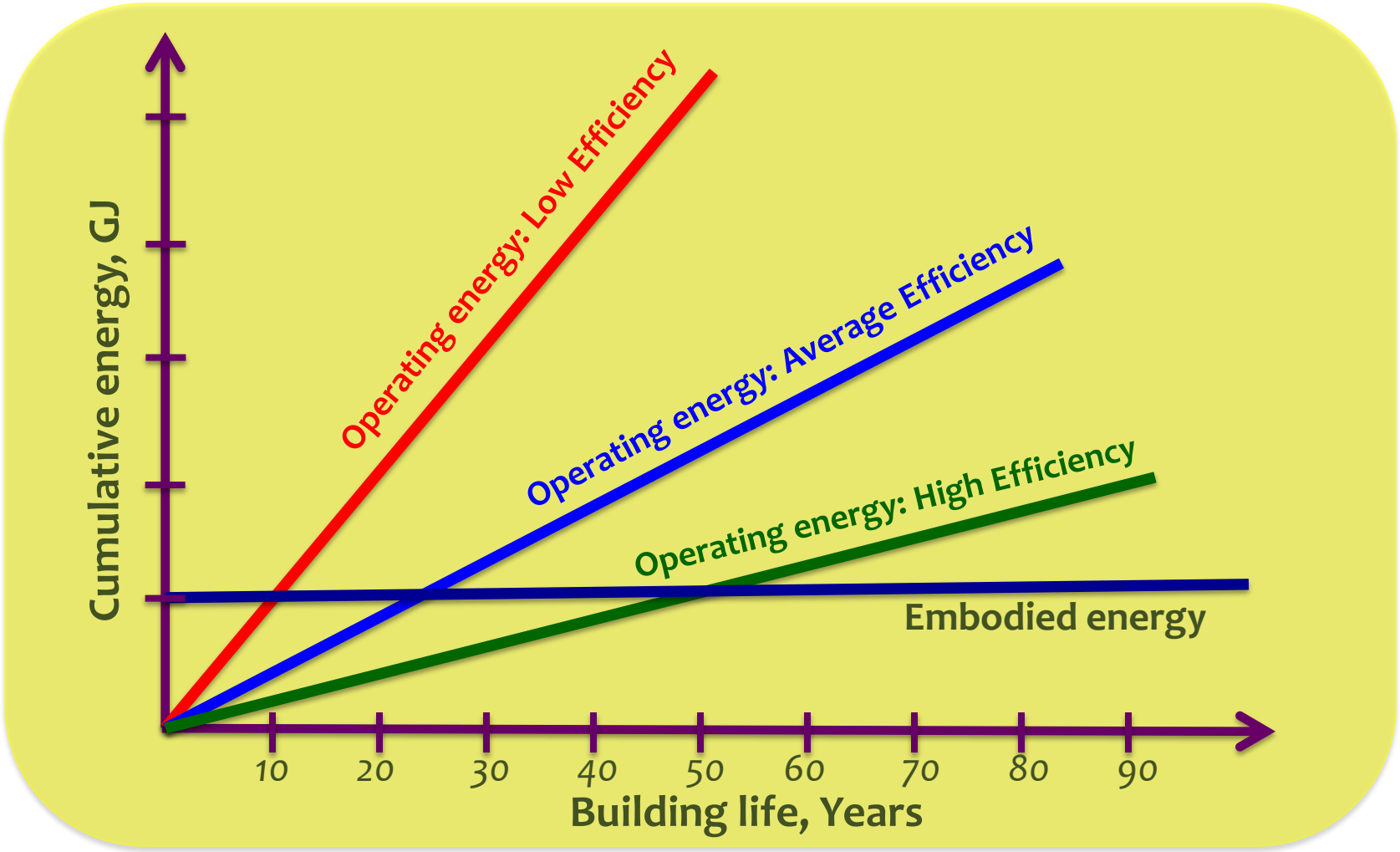
Energy use in office buildings



250kWh/m².year

Reversing the trend:
From high-energy to low/zero-energy building

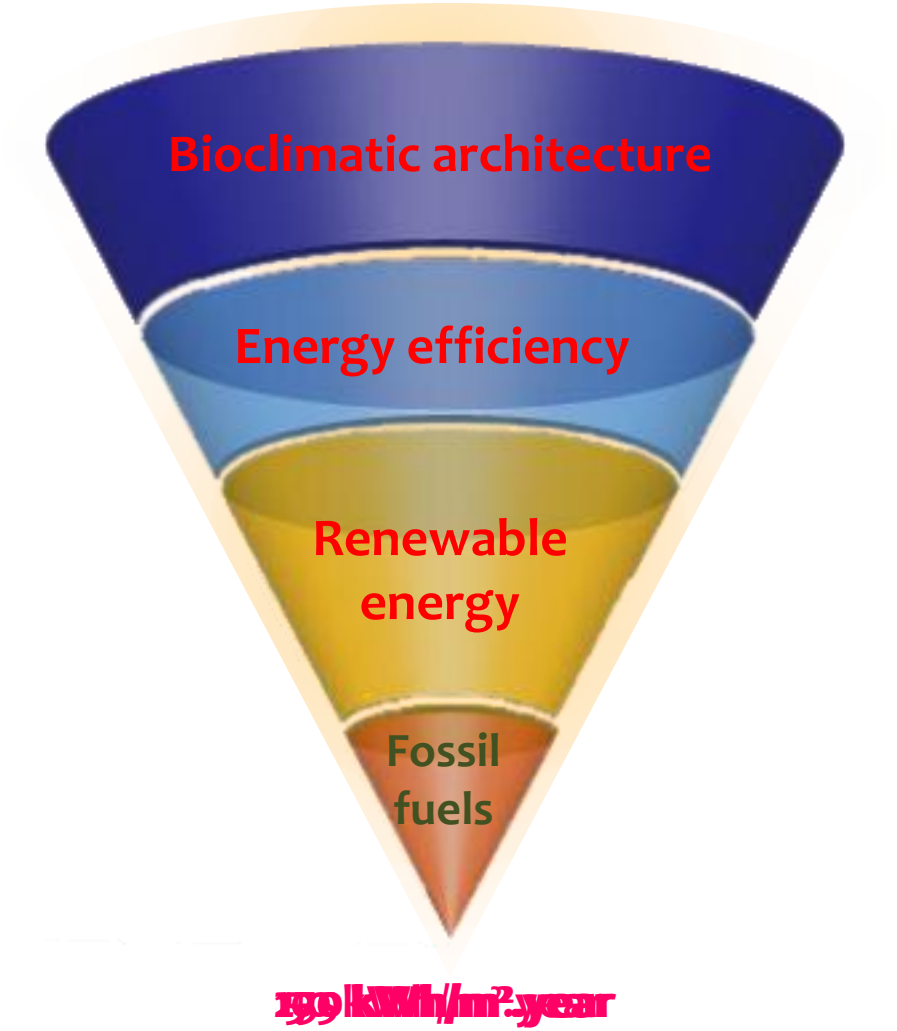
Operating versus embodied energy



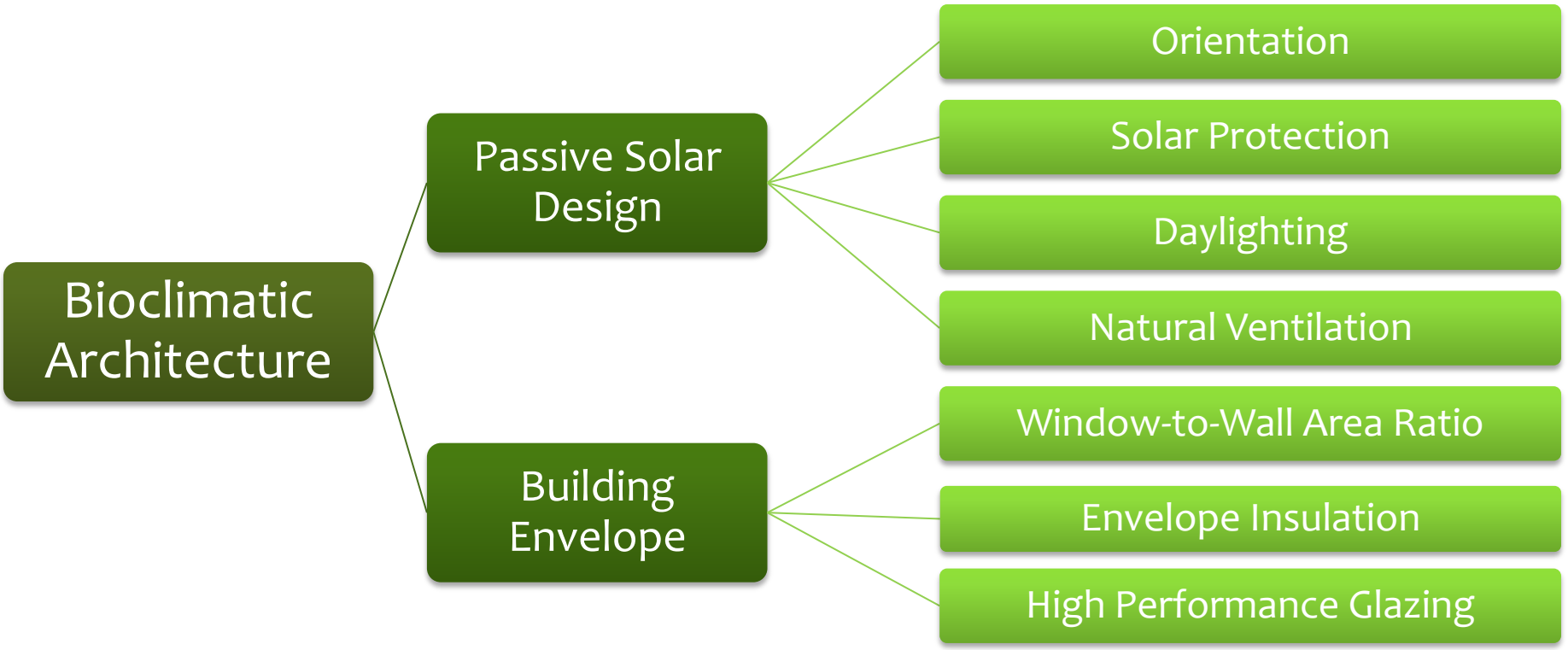
Emerging trends in tall building design

- **Making the entire building sustainable by reducing in every component and system of the building**
  - **Operating energy**
    - *Demand side measures*
      - *Bioclimatic and passive design*
      - *Energy Efficiency and management (and energy recovery)*
    - *Supply side measures*
      - *Energy generation (Renewables and on-site generation)*
  - **Embodied energy**
    - *Innovative structural systems*
    - *Reduction of embodied energy in materials*
    - *Smart, Nano and Green technologies*

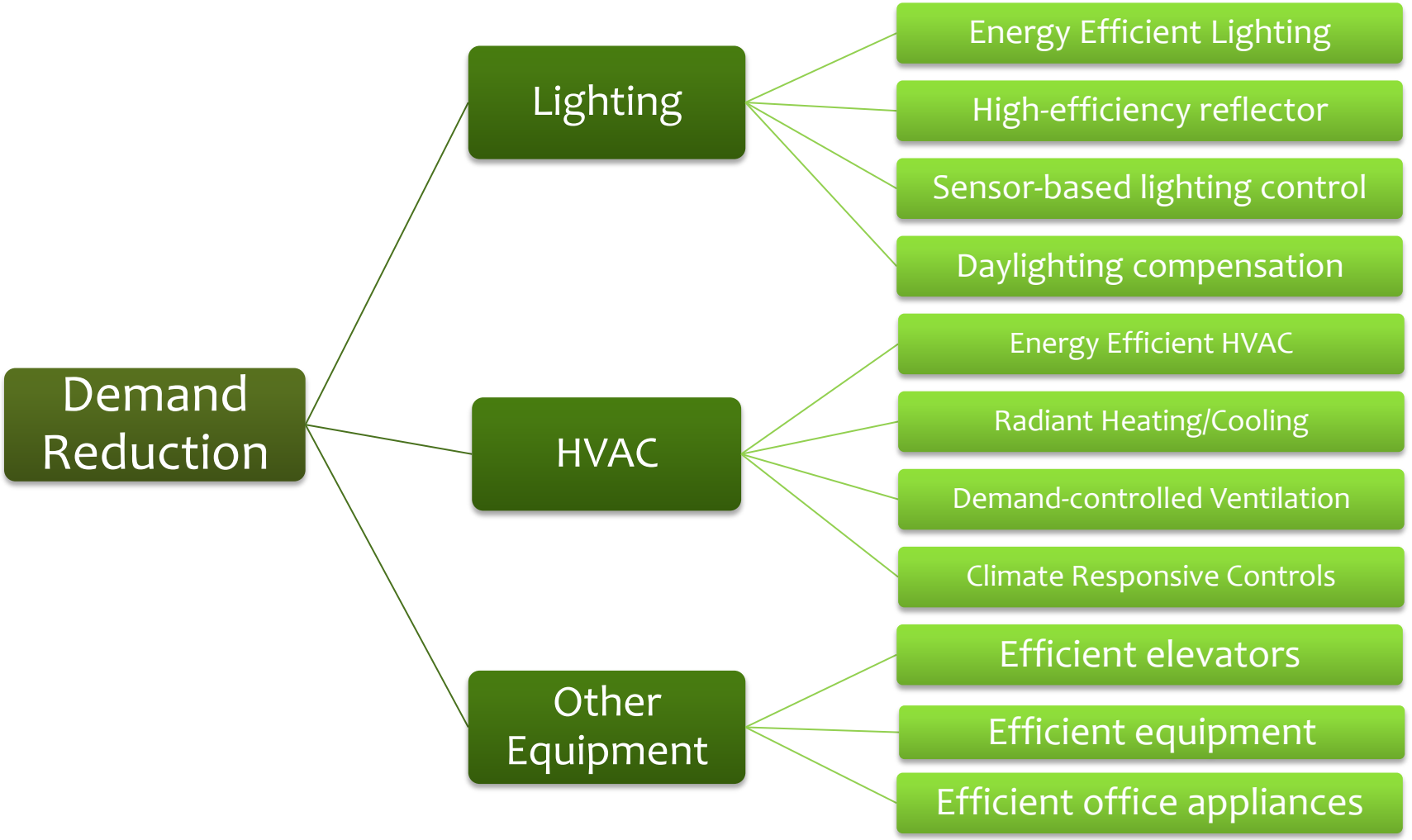
Sustainable energy strategy



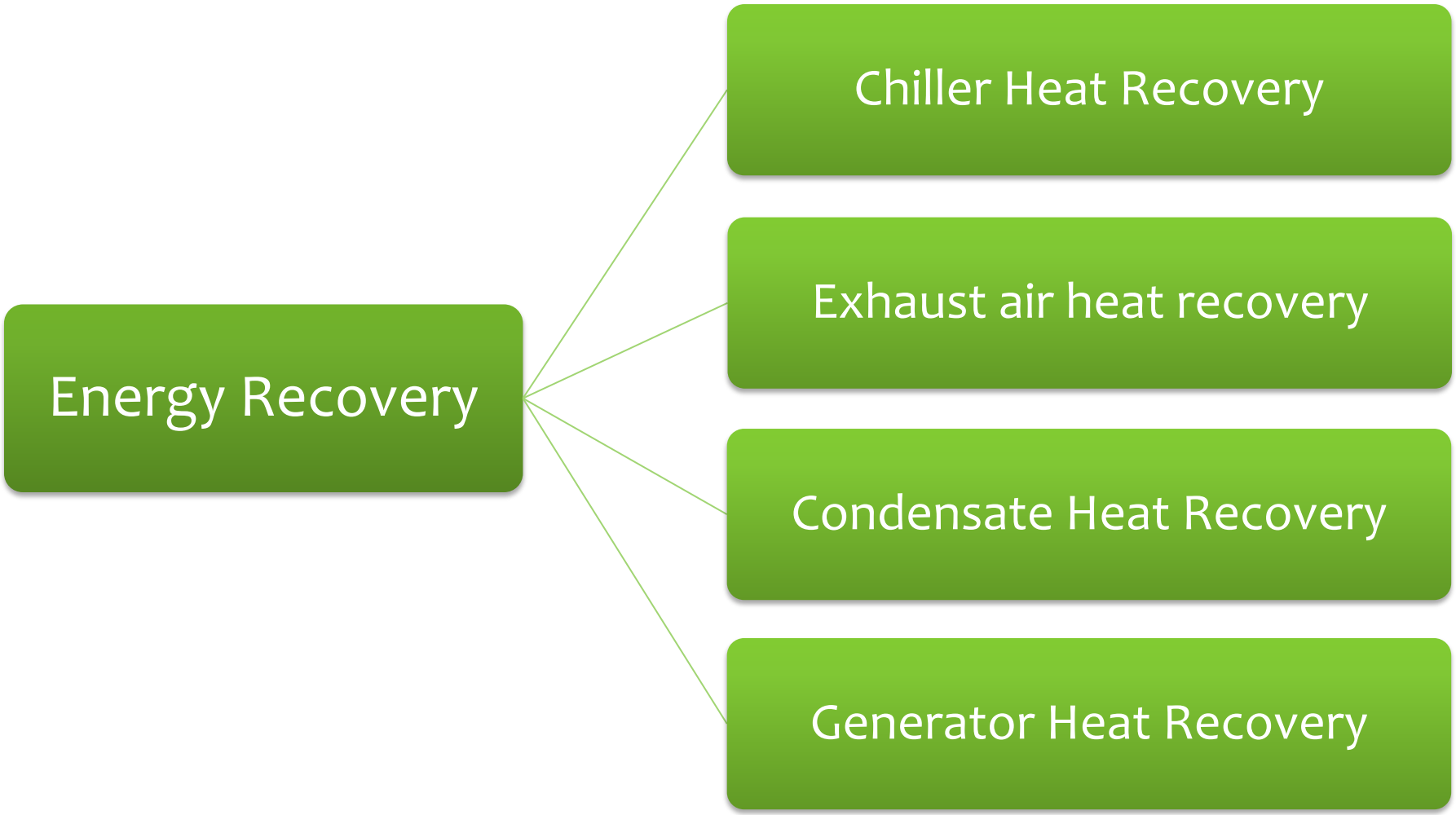
Bioclimatic architecture



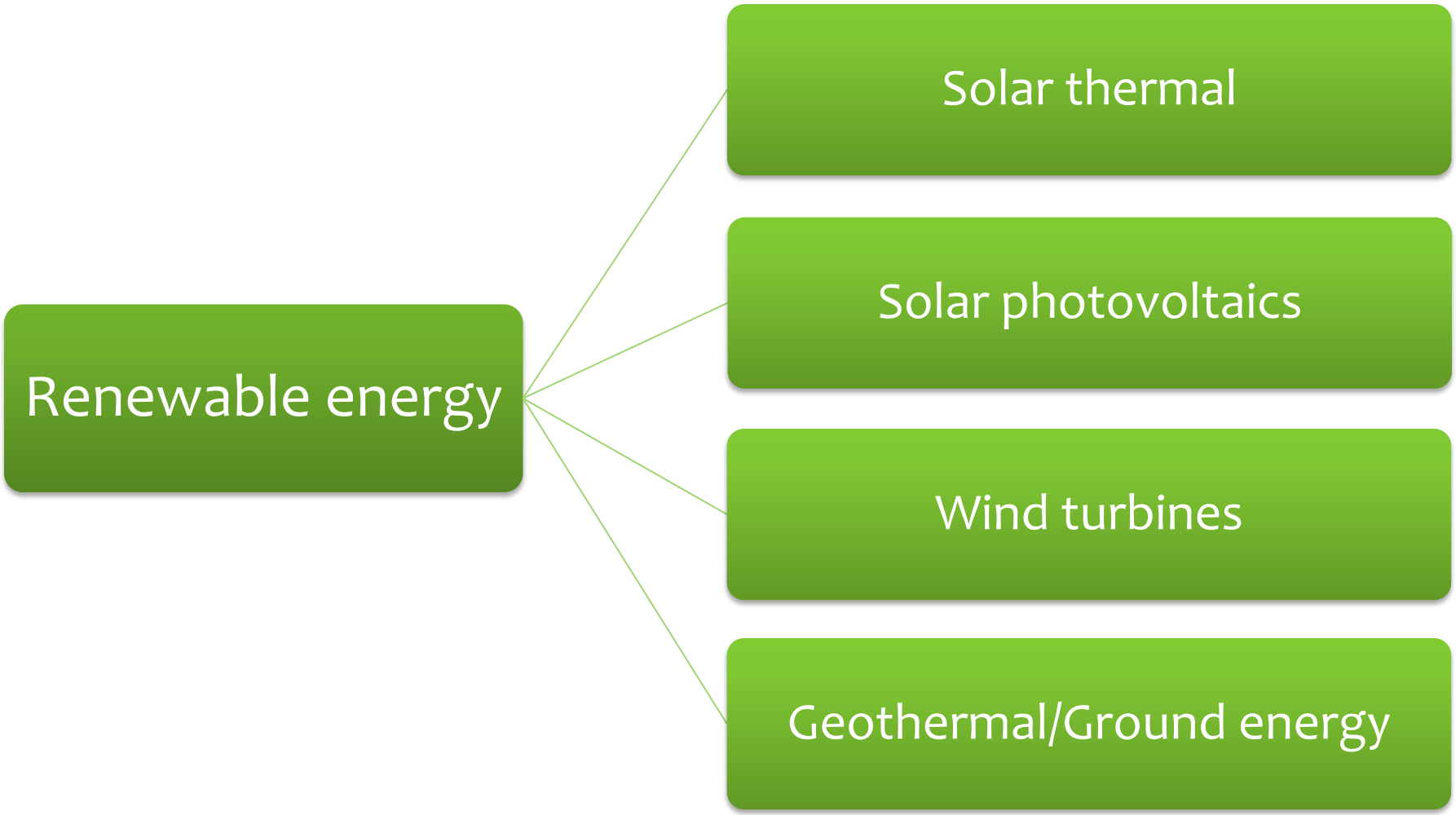
Energy efficiency



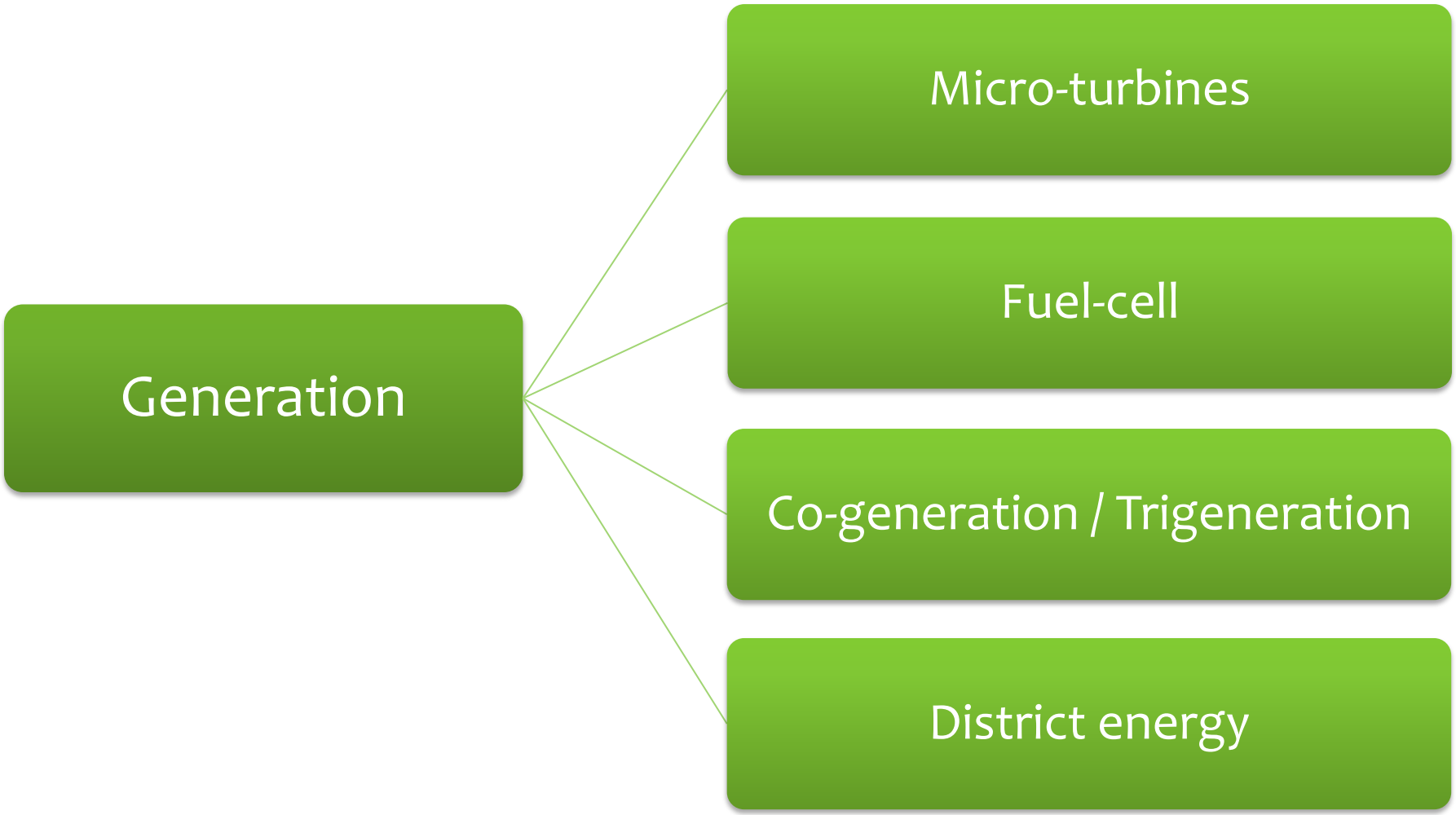
Energy efficiency



Renewable energy



Fossil fuels



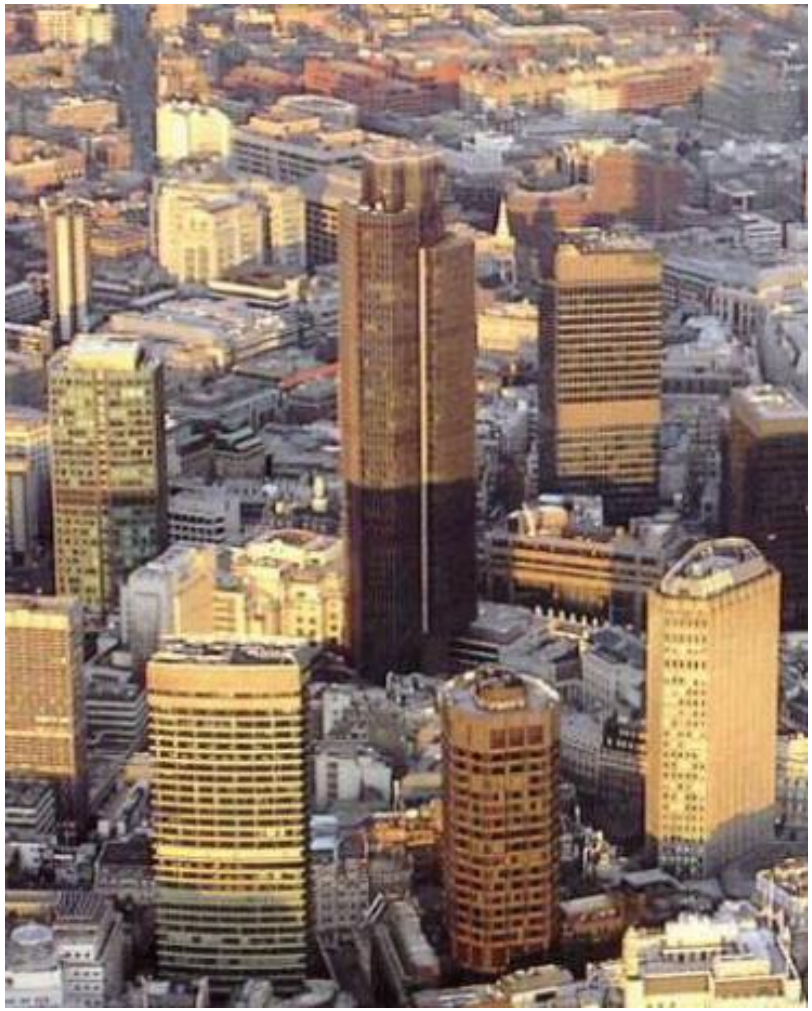
Passive design features

- Reducing heating / cooling load through solar shading
  - Horizontal louvers on western and eastern facades
  - Angle automatically controlled by solar detection equipment to increase / decrease solar shading
  - Reduced air infiltration by sealing the building

Lloyds Register of Shipping Building

Passive design features

- Daylighting and passive solar gains
  - Tall buildings are less constrained by the shape of land plots and street layout
  - More of street level area can be for public amenities and recreational space
  - Thermal and visual performance improvement by orienting building in relation to the seasonal path of the sun across the sky



Passive design features

- **Double screen facades**
  - **Act as buffer zones between internal & external conditions**
  - **Eliminate potential security and safety problems (opening windows and wind pressure differentials)**
  - **Passive thermal effect through ventilation between the two facades**
    - **Natural ventilation through opened windows in the inner façade**
    - **Stack effect of thermal air currents**

Ventilated double-screen facades of HSBC Headquarters

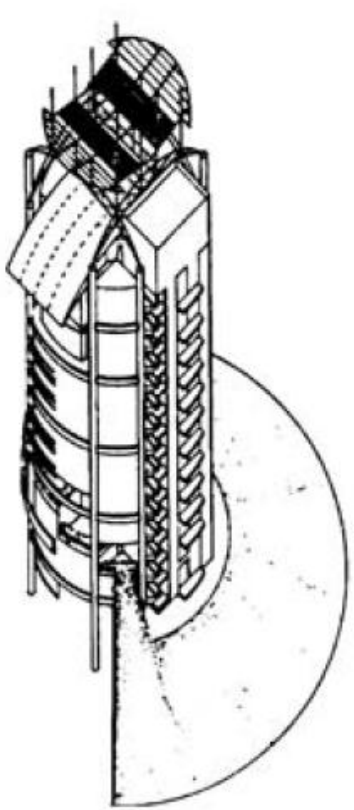
Bioclimatic design

- **Bioclimatic skyscraper**
  - **Responds to the ambient climate of its location**
  - **Uses passive low energy techniques**
  - **Performs with high quality and comfort levels**
  - **Recreates the conditions of the ground on the building**
    - **Ramps of vegetation around the building and sky garden built into internal spaces**

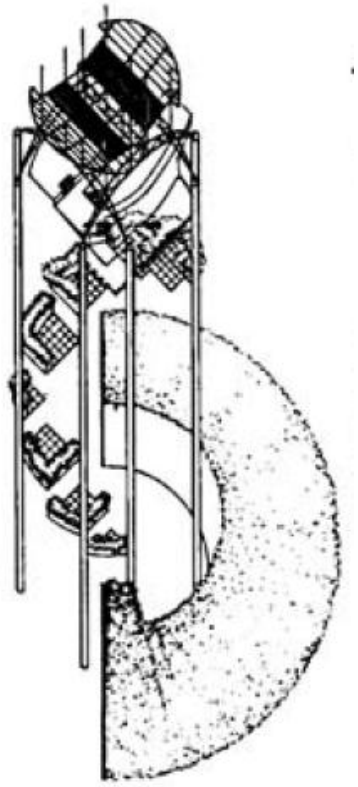
Flower Tower in Sutton by Bill Dunster

Bioclimatic design (Kuala Lumpur)

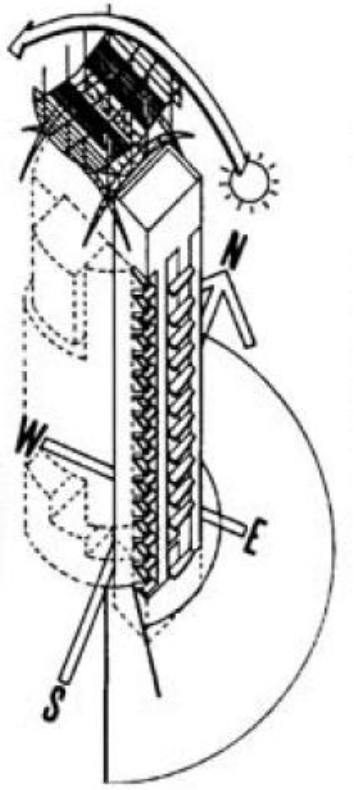
- **Architect's bioclimatic principles (Menara Mesiniaga)**



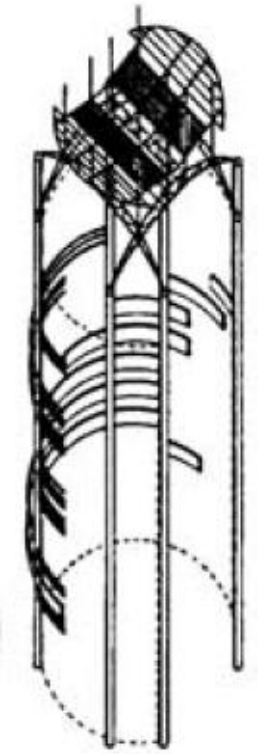
Built Form



Planting and Terraces



Orientation



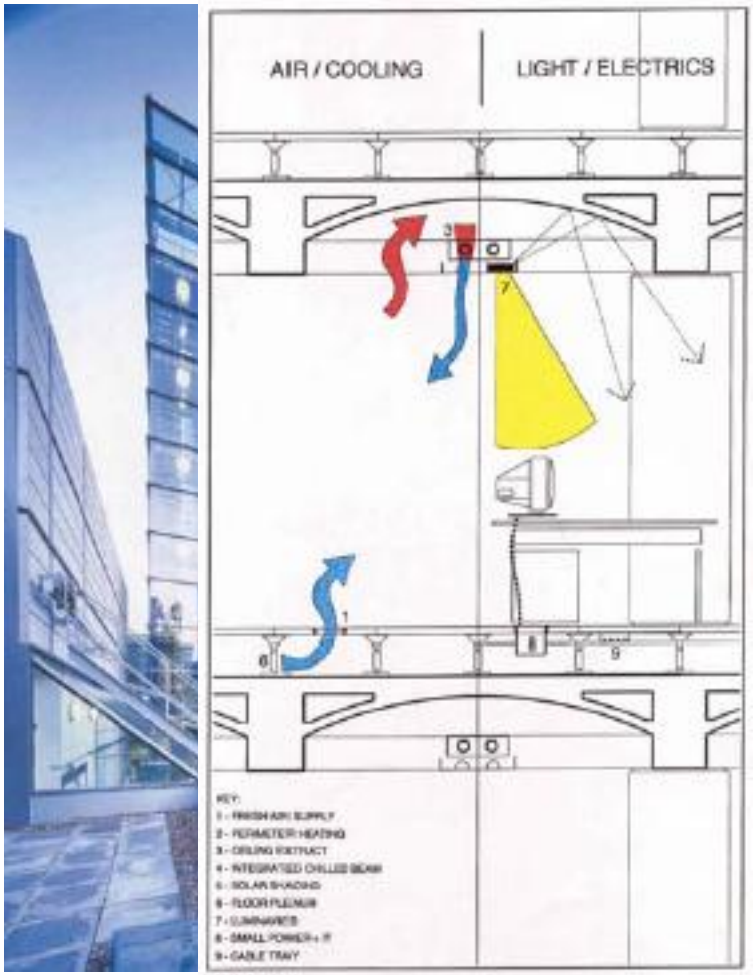
Glazing and Shading

Bioclimatic design (Kuala Lumpur)

- **Menara Mesiniaga (IBM Tower)**
  - Control of fresh air and air movement
  - Access to operable windows (potential for natural ventilation)
  - Provision of interior and exterior areas for relaxation
  - Recreation of ground condition in the sky through elevated gardens
  - Interaction with nature and sunlight
  - Very good lighting and HVAC control
  - Trussed steel and aluminium sunroof incorporates solar PV panels

Integrated lighting and cooling

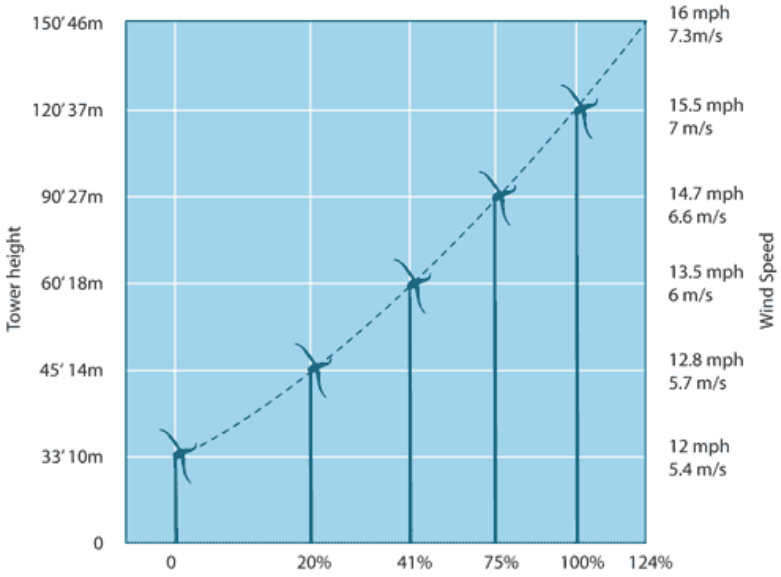
- **Integrated lighting and cooling strategy**
  - **Slender floor plate (width) of the upper storeys assures maximum daylight**
  - **Artificial lighting as supplement to daylighting**
  - **Chilled beams and low velocity air using displacement ventilation near floor level**
  - **Contaminated warm air exhausted via driven fan ducts**

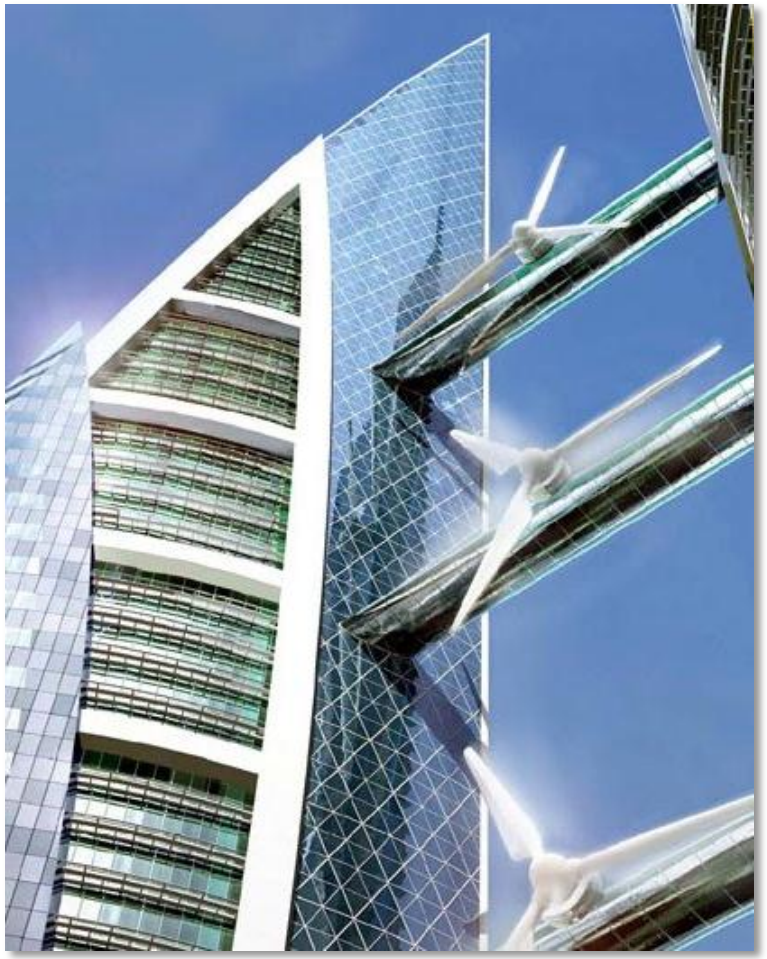


Lloyds Register of Shipping Building

Renewable energy

- **Harnessing wind power**
  - **Wind speed increases with height**
  - **Optimum wind generating capacity by funneling effects from the profile and orientation**

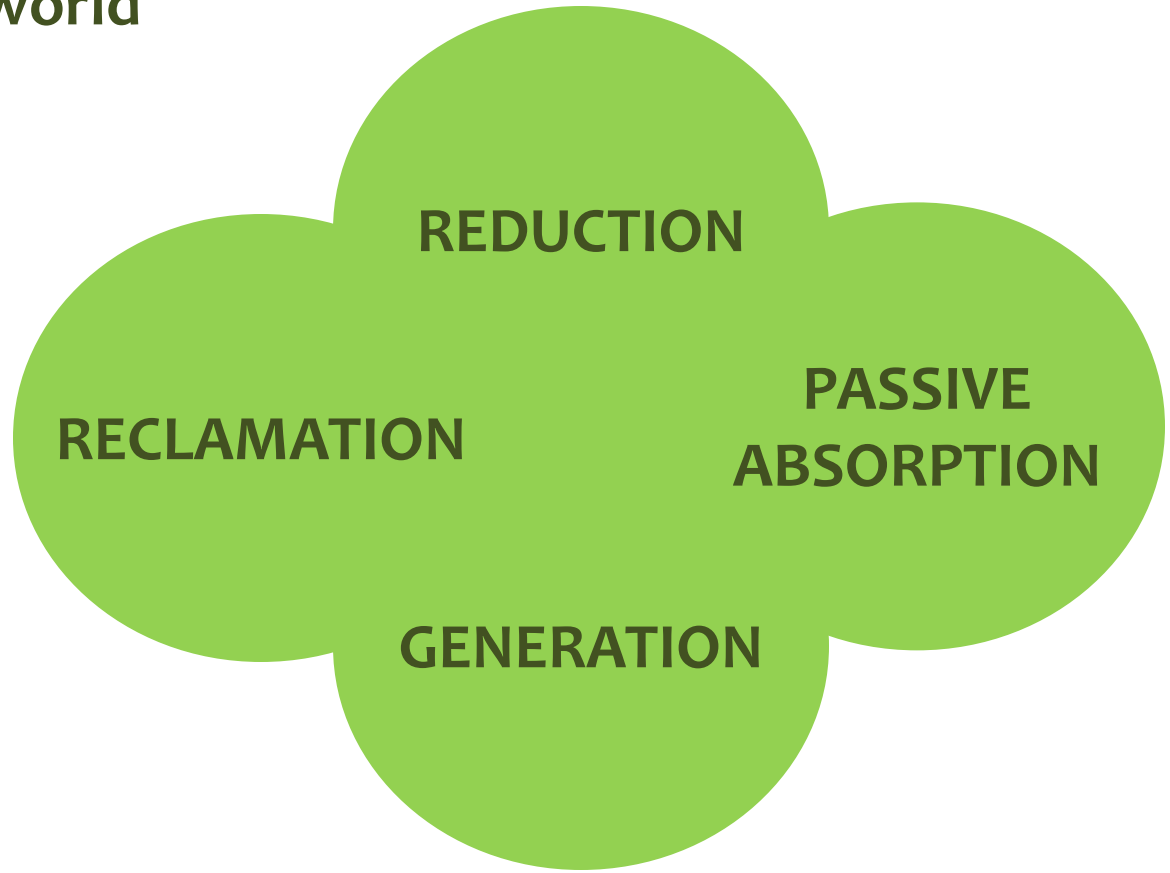




Bahrain World Trade Center

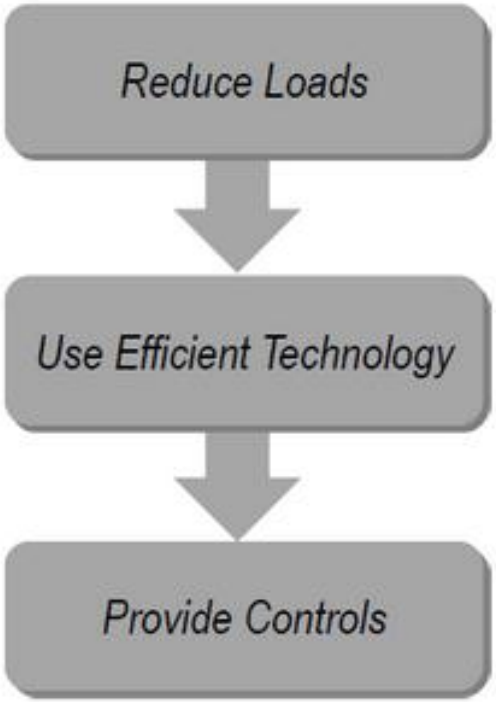
Pearl River Tower (Guangzhou)

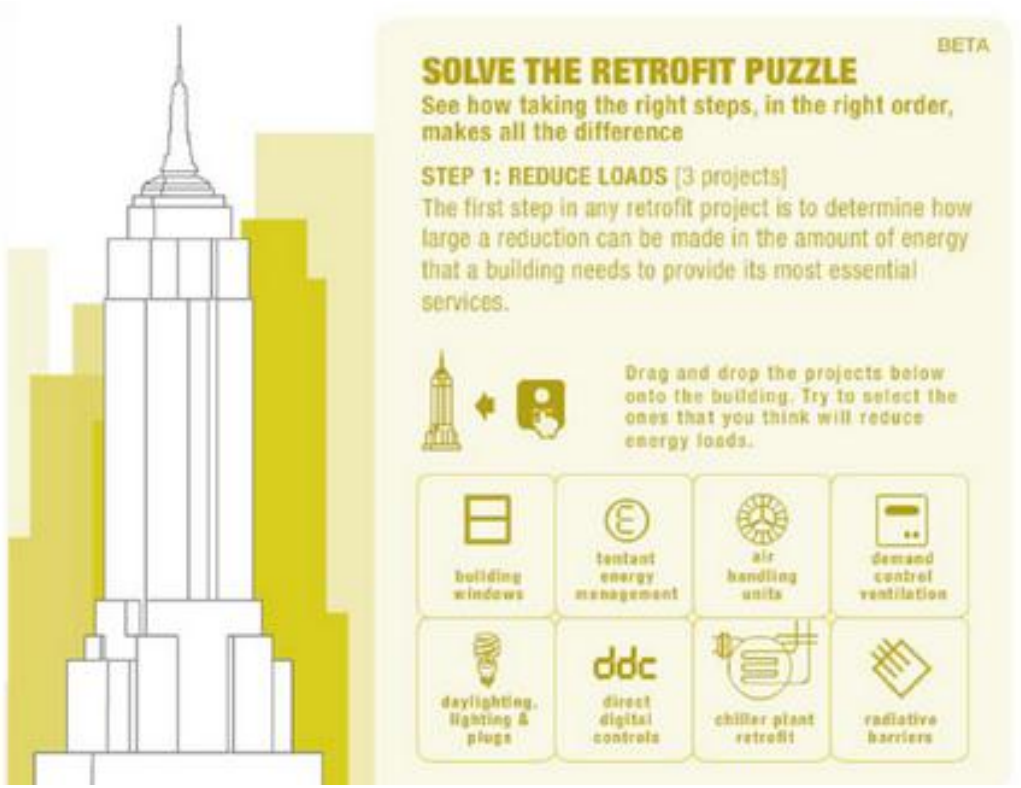
- **Most energy-efficient tall building in the world**



Retrofitting of the Empire State Building

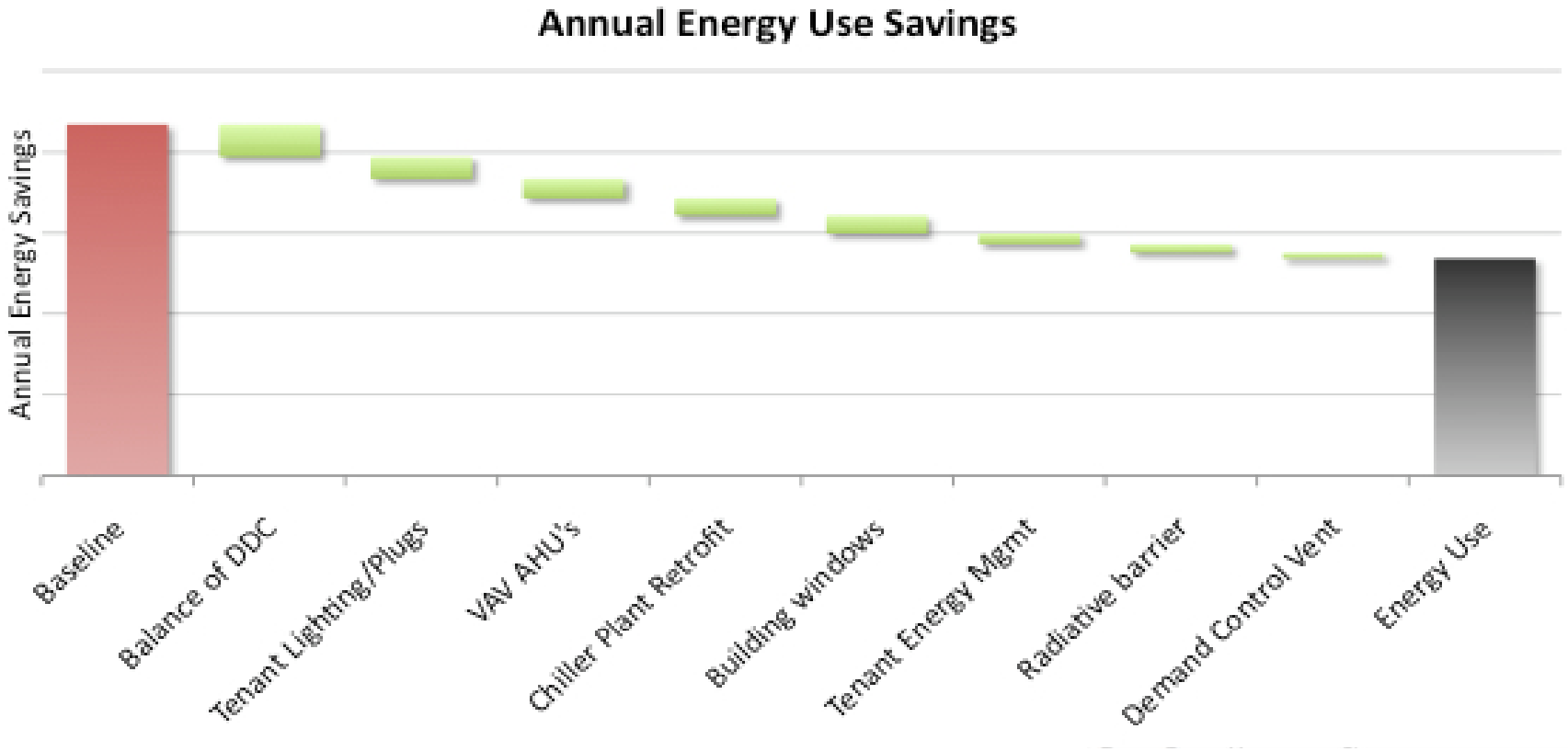
- **Take the right steps in the right order to minimize loads prior to investigating expensive new equipment or controls**





Source: Anthony Malkin, Empire State Building Company

Retrofitting of the Empire State Building



- Reduction of energy bill by 38%, or 4.4 million USD/year
- Capital investment to be paid back in 3-5 years

Government leading the way

- **ST Diamond Building for the Malaysian Energy Commission**

Exterior view of the building

ST Diamond Building, Malaysia

Thank You

AIT
Asian Institute of Technology

Brahmanand Mohanty, Ph.D.
Visiting Faculty, Asian Institute of Technology
Regional Adviser for Asia, French Environment and Energy Management Agency
E-mail: mohanty@ait.asia; mohantyb@gmail.com