MECH 1905 Buildings for Contemporary Living

Green Buildings

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Hong Kong University of Science and Technology

Kyoto Face House, 1998

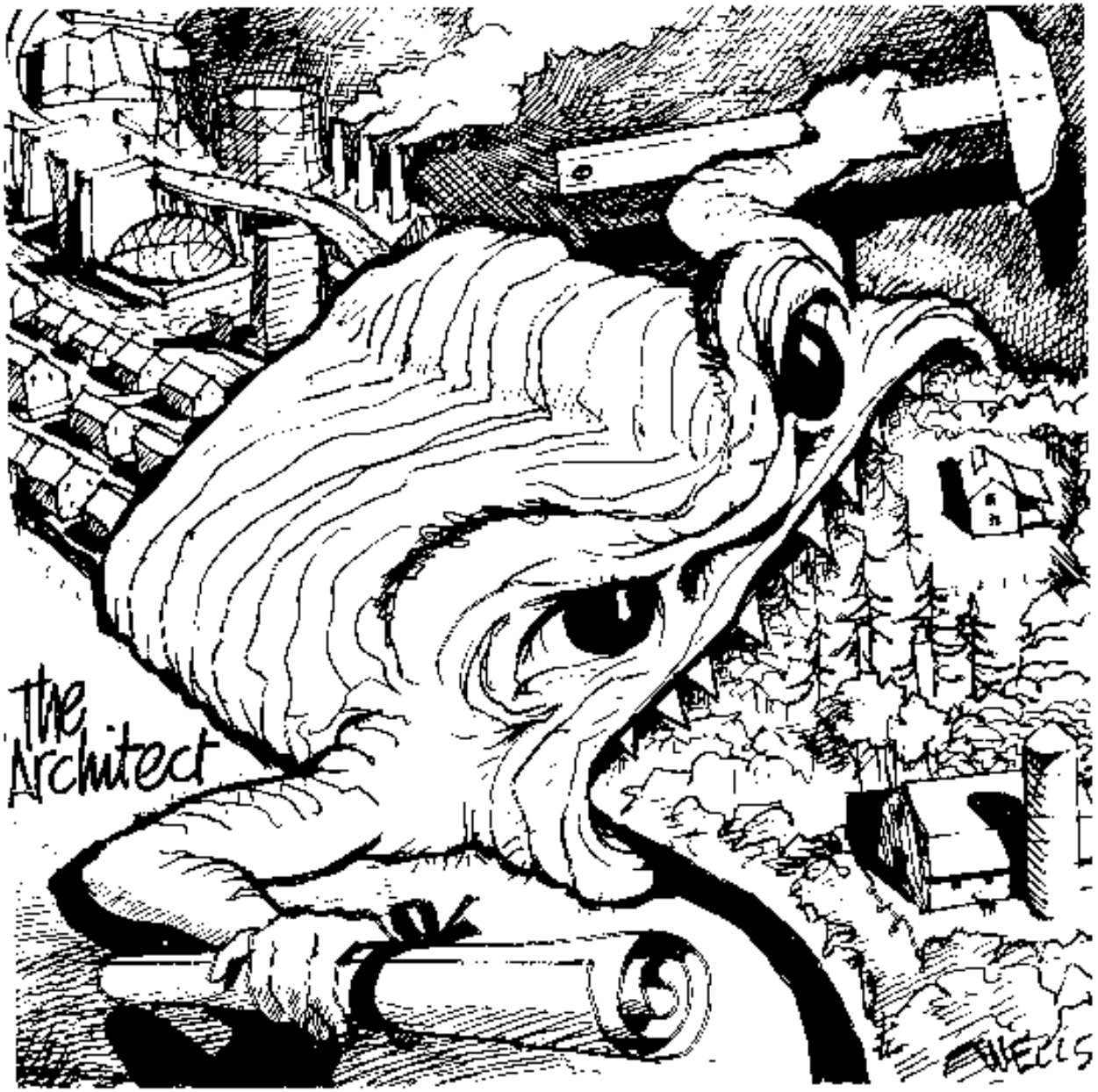
“What is a green building?”

Cologne

Building
+
Green

Toronto

Green building is NOT just adding a green outlook



Drawing by the American architect Malcolm Wells

Contents

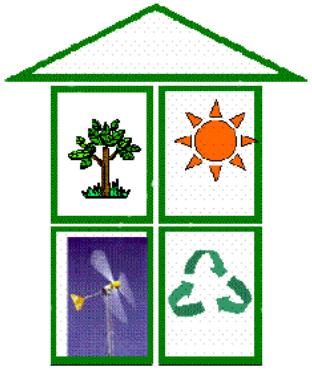
- What is a Green Building?
- Why Going Green?
- Basic Principles
- Certification Systems
- Green Building Elements
  - Sustainable sites
  - Water efficiency
  - Energy and atmosphere
  - Materials and resources
  - Indoor environmental quality
- Summary

What is a Green Building?

- A loosely defined collection of land-use, building design, and construction strategies that reduces the environmental impacts
- The term "green" is extremely wide ranging, encompassing many viewpoints and open to broad interpretation
  - Debate around green building/architecture
  - Complexity of environmental issues

What is a Green Building?

- Lasts a long time
- Uses less energy/water and other scarce resources in its operation (including siting close to public transportation).
- Is made with products that
  - Require less energy to manufacture
  - Can be recycled
  - Can be disposed of in an ecological way
  - Protects occupant health and improves employee productivity



What is a Green Building?

- It involves a *holistic* approach to the design and operation of buildings. It considers:
  1. *Economy and efficiency of resources*
  2. *Life cycle design*
  3. *Human well-being*
- Main objectives
  - Be environmentally friendly and responsible
  - Improve the quality of built environment

What is a Green Building?

- Green buildings are
  - Energy and resource efficient
  - Non-wasteful and non-polluting
    - Sustainable design that helps minimizing broad environmental impacts
  - Highly flexible and adaptable for long-term functionality
  - Easy to operate and maintain (lower running costs)
  - Supportive of the productivity and well-being of the occupants

What is a Green Building?

- **Principles of Sustainable Design**
  - Understanding place
  - Connecting with nature
  - Understanding natural processes
  - Understanding environmental impact
  - Embracing co-creative design processes
  - Understanding people

Why Going Green?

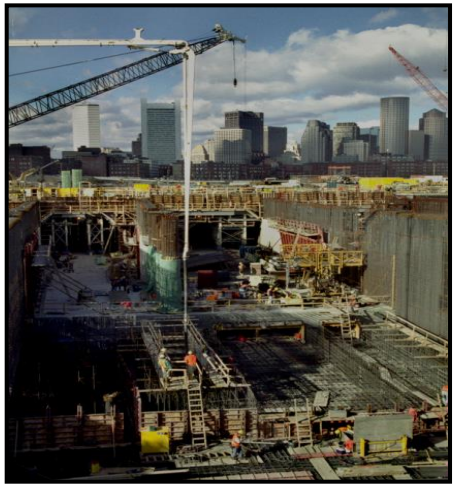
- Survival of our planet: environmental crisis
  - Air (destruction of Earth's atmosphere)
    - Global warming, climate change
  - Water (an undervalued resource)
    - Shortage and pollution
  - Fire (the problem of fuels)
    - Fossil fuel burning (coal, oil)
  - Earth (resources and materials)
    - Resources depletion

Why Going Green?

- Buildings consume significant resources
  - Consumption of energy and water
  - Use of building materials
  - Transport of materials and products
- Construction as the worst polluters
  - Operation on site and off site
  - Waste from construction/occupants
  - Pollutants from buildings

Why Going Green?

- Green buildings pay
  - Direct benefits (e.g. energy/cost savings)
  - Indirect benefits (e.g. healthier conditions)
  - Wider global benefits (e.g. reduced CO_2 emission)
- Life-cycle benefits
  - Total economic and environmental performance
  - Long-term "*sustainability*"



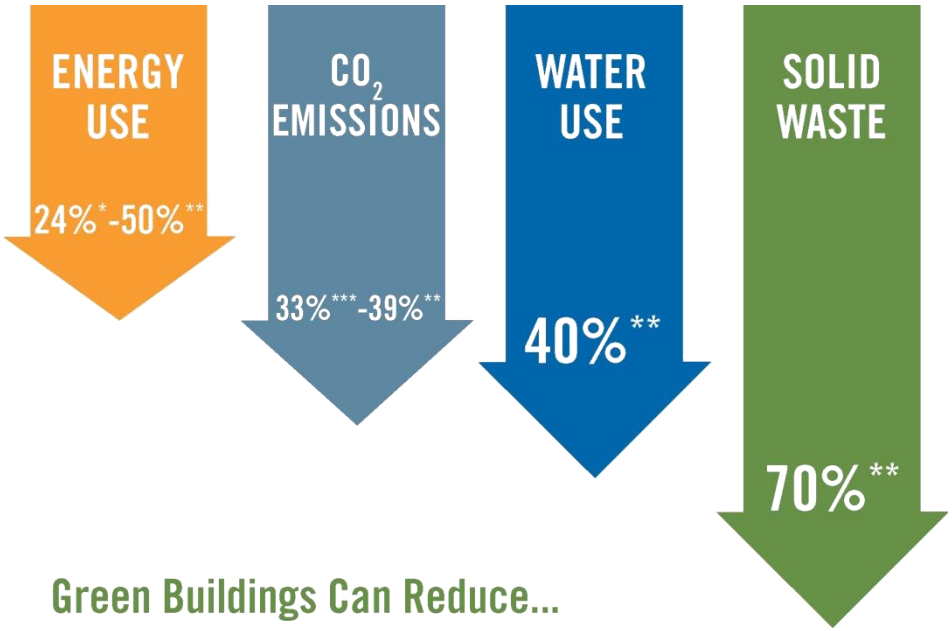
Environmental Impact of Buildings

- 65.2% of total U.S. electricity consumption
- > 36% of total U.S. primary energy use
- 30% of total U.S. greenhouse gas emissions
- 136 million tons of construction and demolition waste in the U.S. (approx. 1.3 kg/person/day)
- 12% of potable water in the U.S.
- 40% (3 billion tons annually) of raw materials use globally

Economics of Green Buildings

- Reduction in lighting energy requirements by at least 50 %
- Cut heating and cooling energy consumption by 60 %
- Reduced water consumption by up to 30 % or more
- Lower building operating expenses through reduced utility and waste disposal costs
- Lower on-going building maintenance costs, ranging from salaries to supplies
- Increase worker productivity by 6 to 16 %
- Higher property values and potentially lower lenders' credit risk
- Higher building net income
- New economic development opportunities

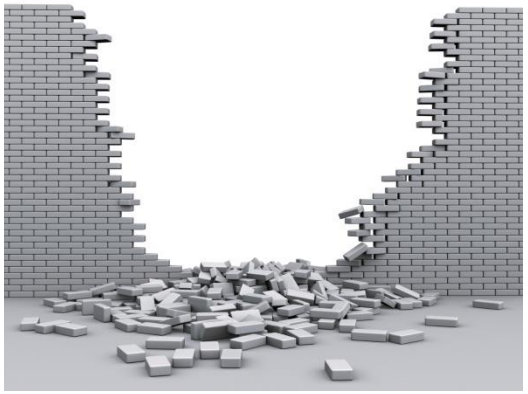
Green Building Benefits



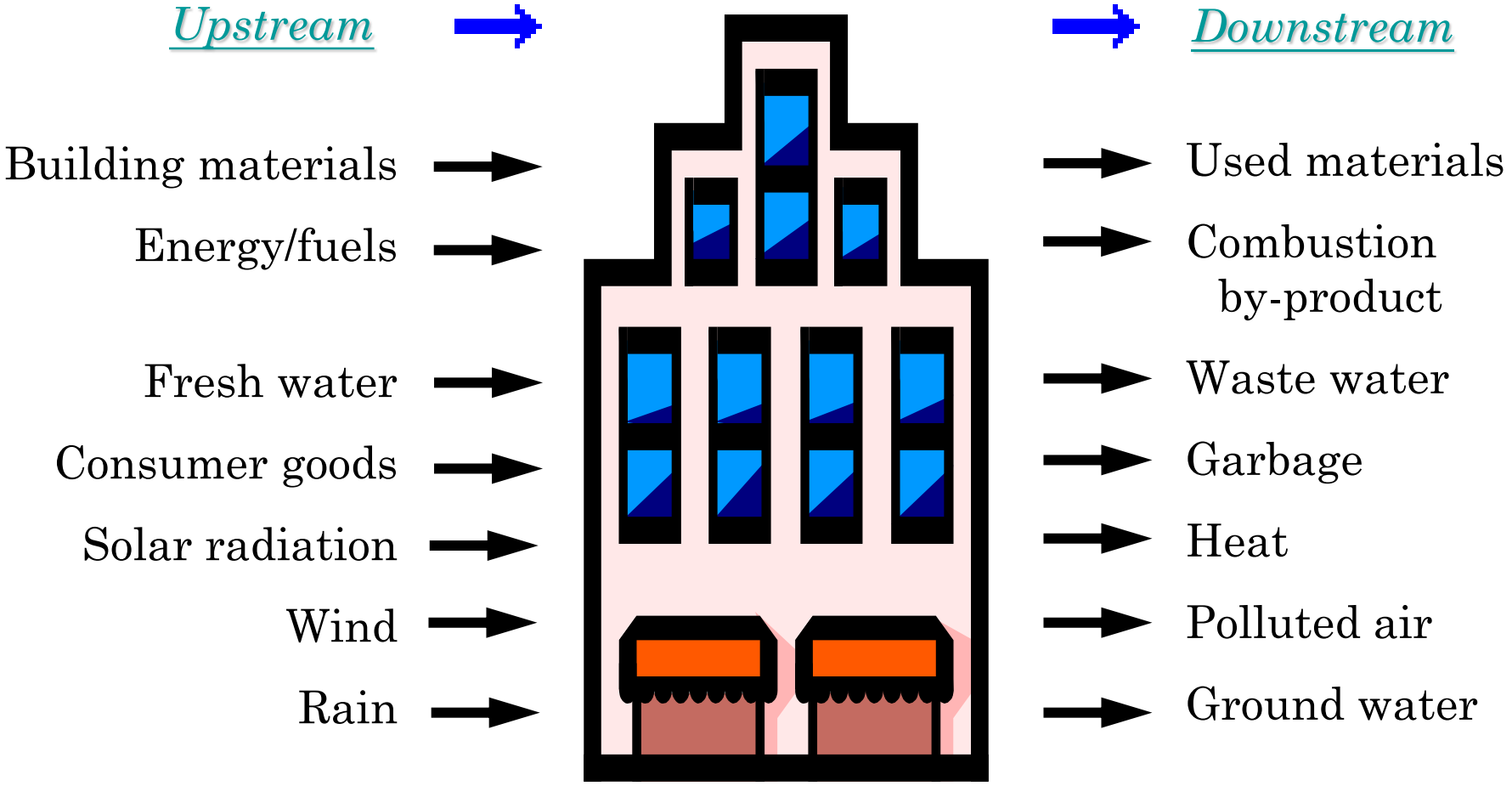
- 25 ~ 60% energy savings
- 30 ~ 50% water savings
- Certified Business Intelligence Professional (CBIP) financial incentive
- Improved worker productivity – due to improved lighting and thermal comfort
- Reduced sick time from allergies, asthma and respiratory illness
- Lower life-cycle costs

Barriers to Green Buildings

- Barrier 1: Builder Incentives
- Barrier 2: Product/Systems Information and Sourcing
- Barrier 3: Client Knowledge
- Barrier 4: Actual cost increase
- Barrier 5: Lack of knowledge: how to build green
- Barrier 6: Certification cost/paperwork
- Barrier 7: Lack of regulations / Building code



Basic Principles (1)



Resource and Material Flow in the Building Ecosystem

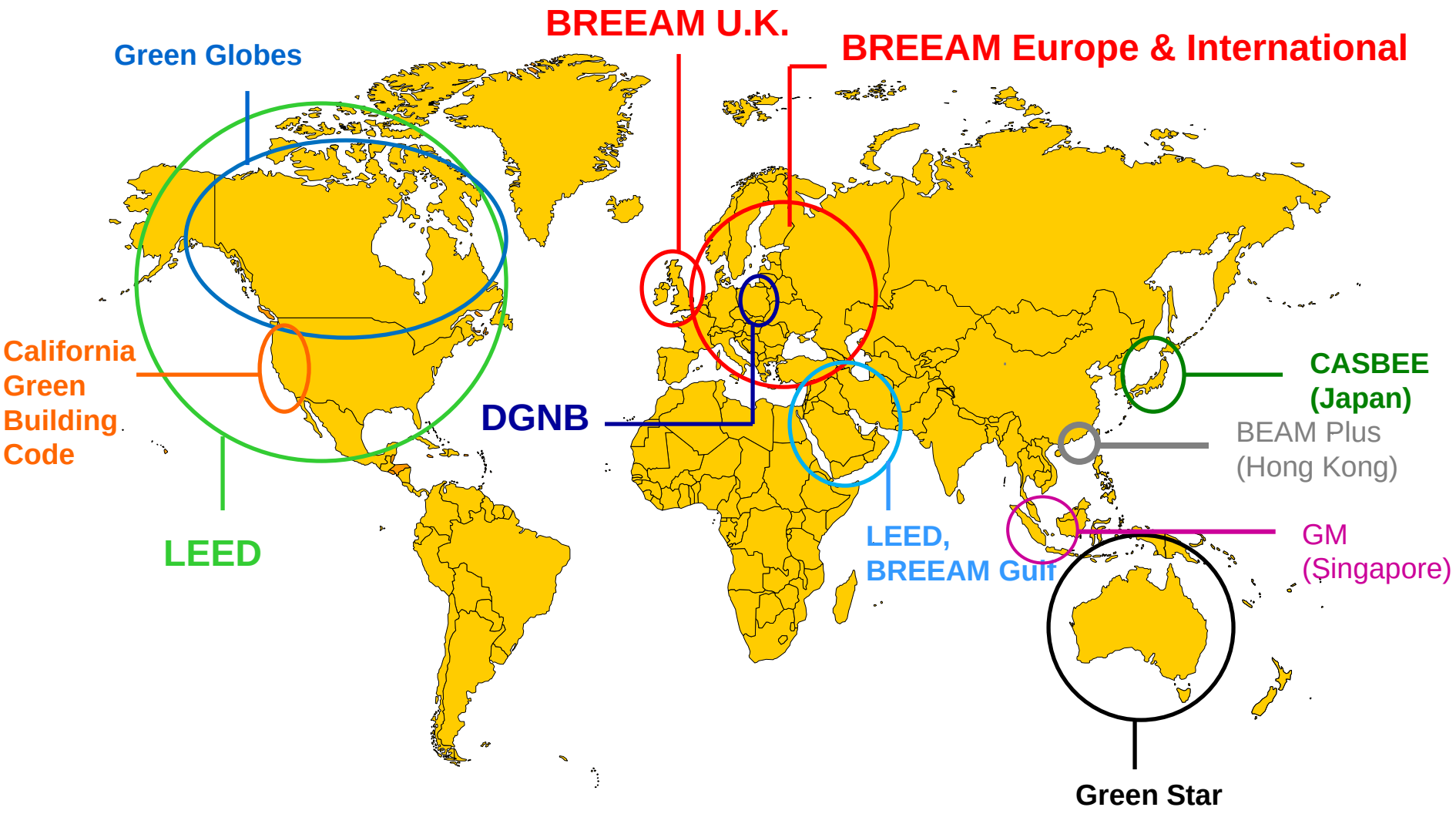
Basic Principles (2)

- Major concerns
  - Conserve non-renewable energy and scarce materials
  - Minimize life-cycle ecological impact
  - Use renewable energy and materials that are sustainably harvested
  - Protect and restore local air, water, soils, flora and fauna
  - Support pedestrians, bicycles and mass transit
  - Reduce human exposure to noxious materials

Basic Principles (3)

- Green building design strategies
  - Urban and site design
  - Energy efficiency
  - Renewable energy
  - Building materials
  - Water issues
  - Indoor environment
  - Integrated building design

Green Building Certification Systems



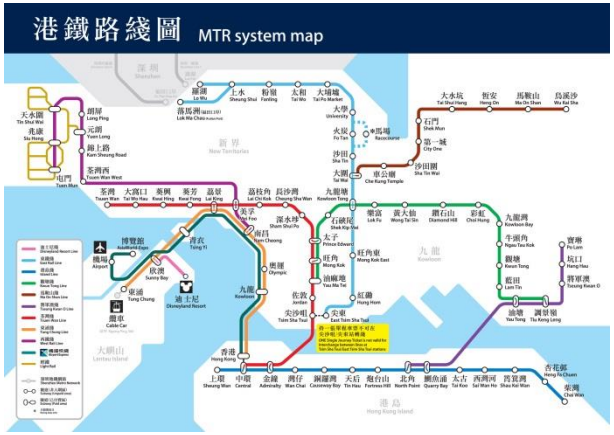
LEED Green Building Rating System

- Evaluates and recognizes performance in accepted green design categories, including:
  - Sustainable sites
  - Water efficiency
  - Energy and atmosphere
  - Materials and resources
  - Indoor environmental quality
  - Innovation credits
- Website: www.leedbuilding.org

Site Selection / Design (1)

Promote:

- Proximity and access to Transit
- Promote walking and biking
- Stormwater Management
- Maintenance of wildlife habitat



Site Selection / Design (2)

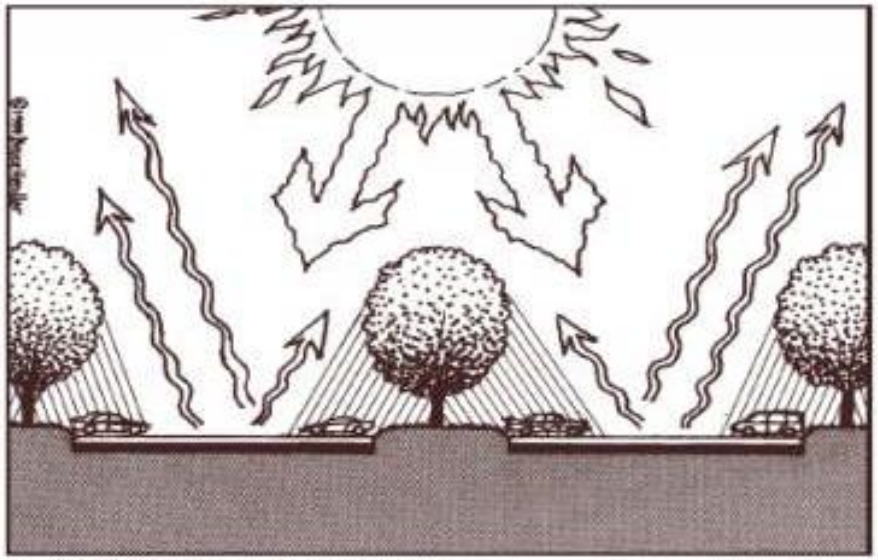
Avoid:

- Excessive grading/ site disturbance
- Soil erosion
- Excessive stormwater run off

Site Selection / Design (3)

Avoid:

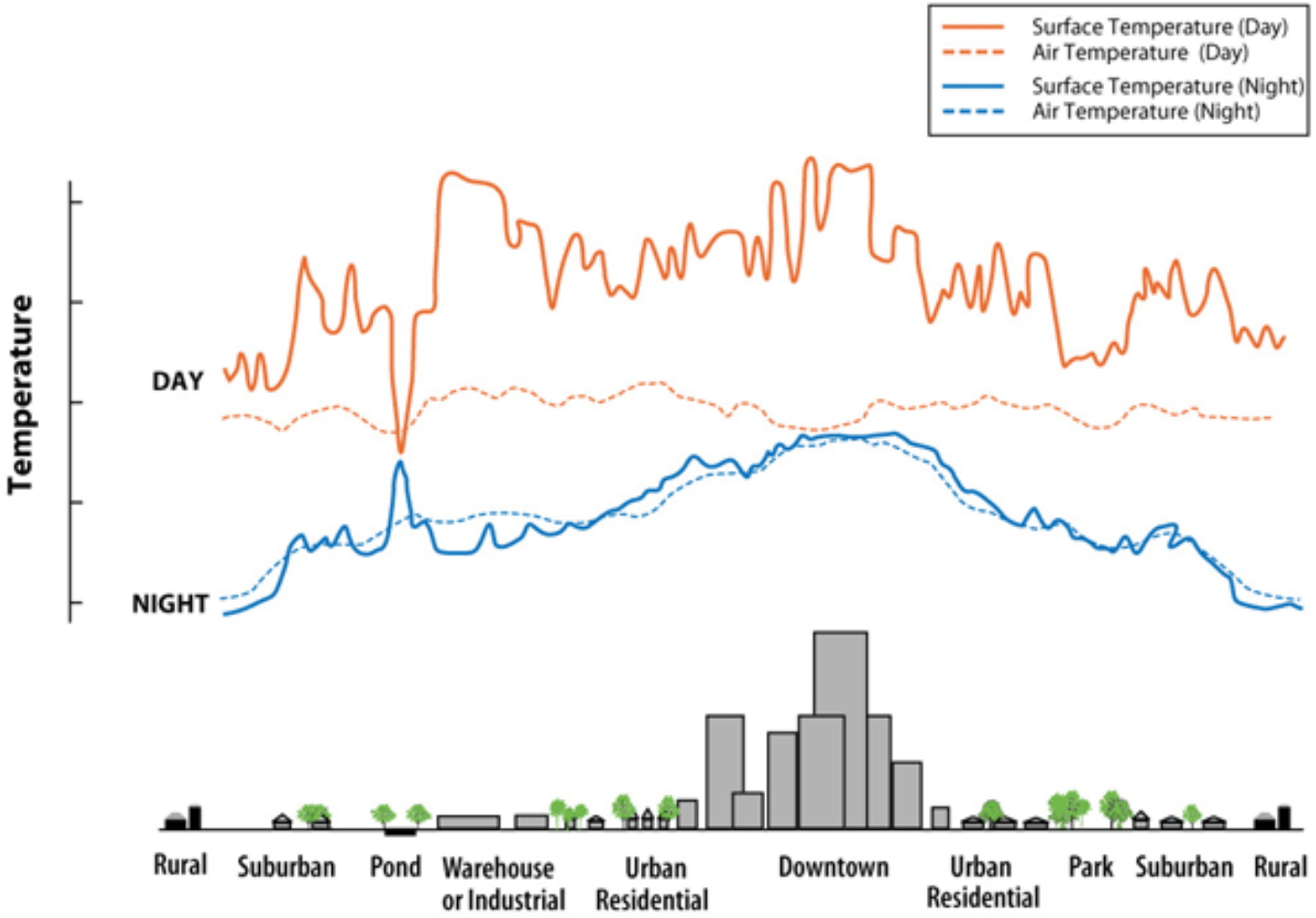
- Sensitive environmenta areas (farmland, floodplains, sensitive habitats)
- Heat Island Effect
- Light pollution



Mitigation of Urban Heat Island Effect

Illustration: Bruce Hendler

Urban Heat Island



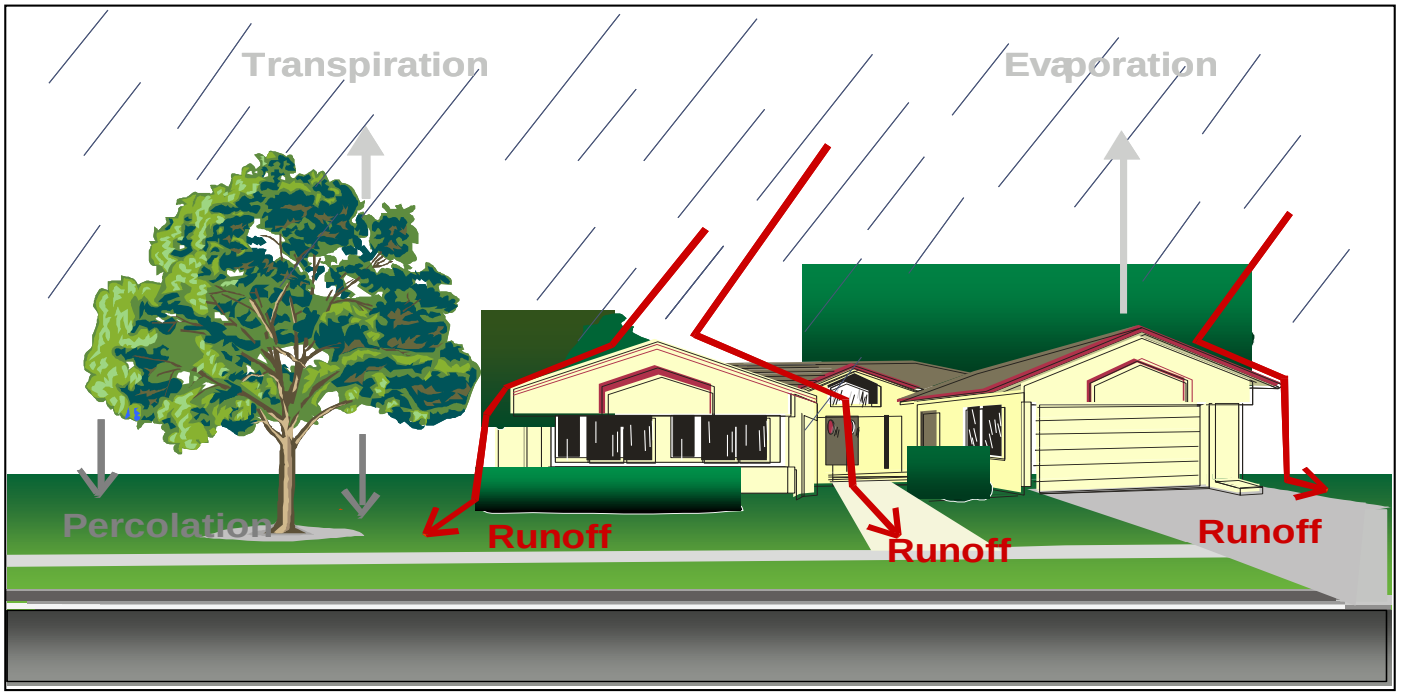
Strategies to Reduce the Heat Island Effects

- Increasing tree and vegetative cover;
- Creating green roofs (also called "rooftop gardens" or "eco-roofs");
- Installing cool — mainly reflective — roofs; and
- Using cool pavements

Public Transportation

- Public transportation releases fewer greenhouse gas emissions into the air per person than driving does.
- Taking a train or bus is much cheaper than owning a car, and you don't have to find a parking space once you get to your destination!

Stormwater Runoff



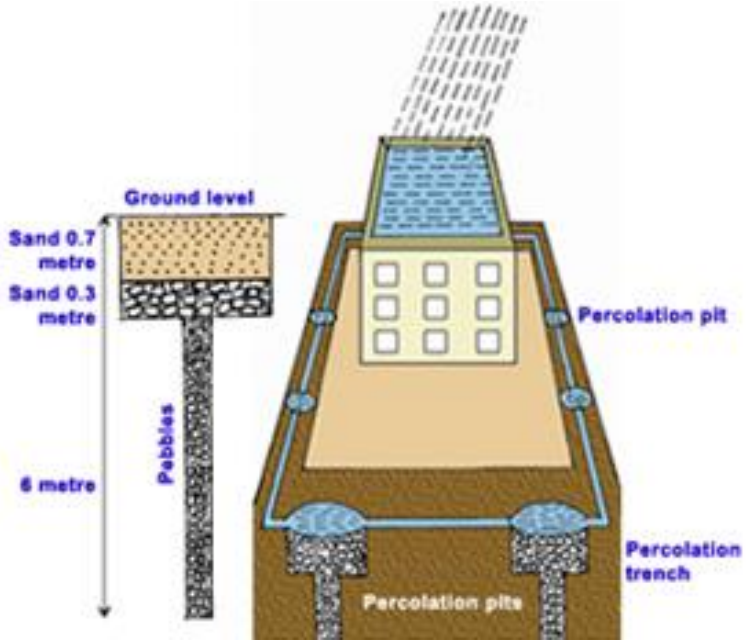
- Stormwater is…
  - Rain that hits the earth's surface
- Stormwater Runoff is…
  - Rain that runs off hardened surfaces

Water Erosion and Sedimentation

- Sediment is the #1 nonpoint source of water pollution
- Erosion causes additional problems
  - Loss of property
  - Degradation of streams

Sea Water for Flushing

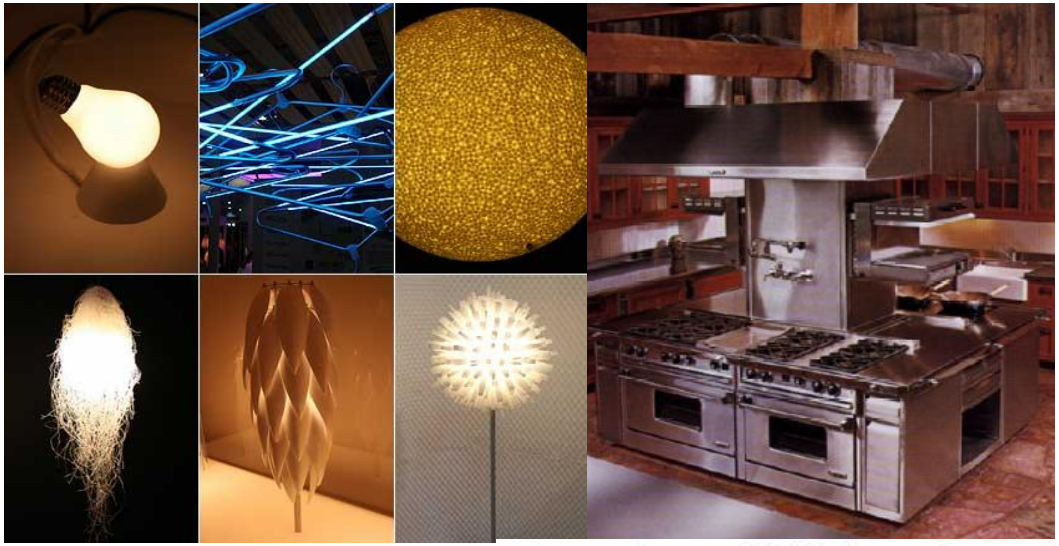
Rainwater Harvesting



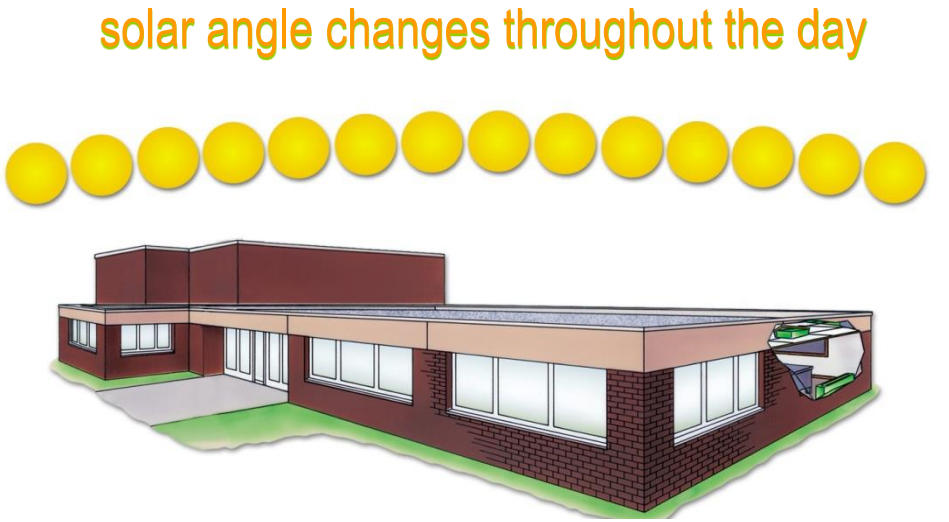
- Rainwater for non-potable uses:
  - floor cleaning
  - gardening
  - toilet flushing
  - fire fighting
  - etc.
- Need extra storage tanks and simple water treatment processes such as sedimentation and filtration.

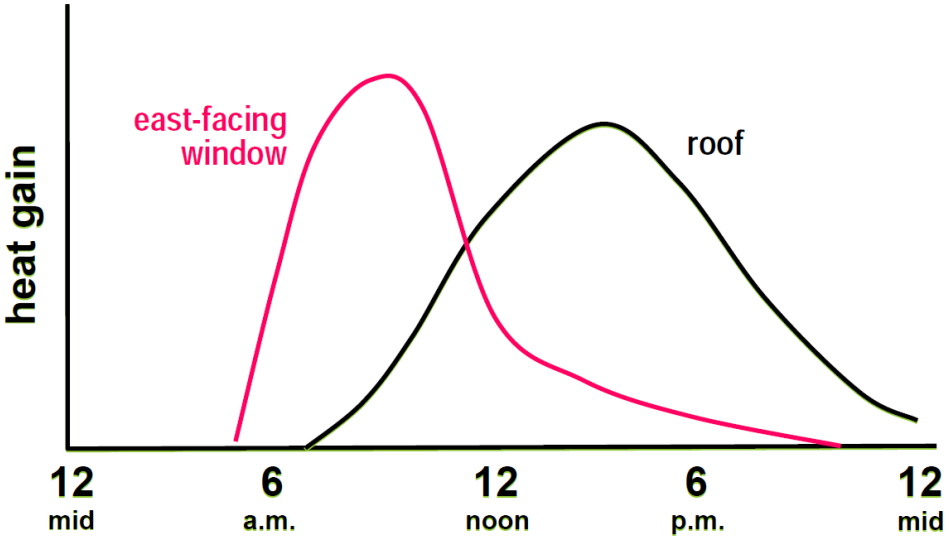
Energy Supplies for Buildings

- Fuels
  - Cooking
  - Hot water
  - Space heating
  - Gas engine heat pump
  - Power generation
  - Others
- Electricity
  - Lighting
  - Space air-conditioning
  - Space heating
  - Refrigeration
  - Cooking
  - Office equipments
  - Clothes washing
  - Others



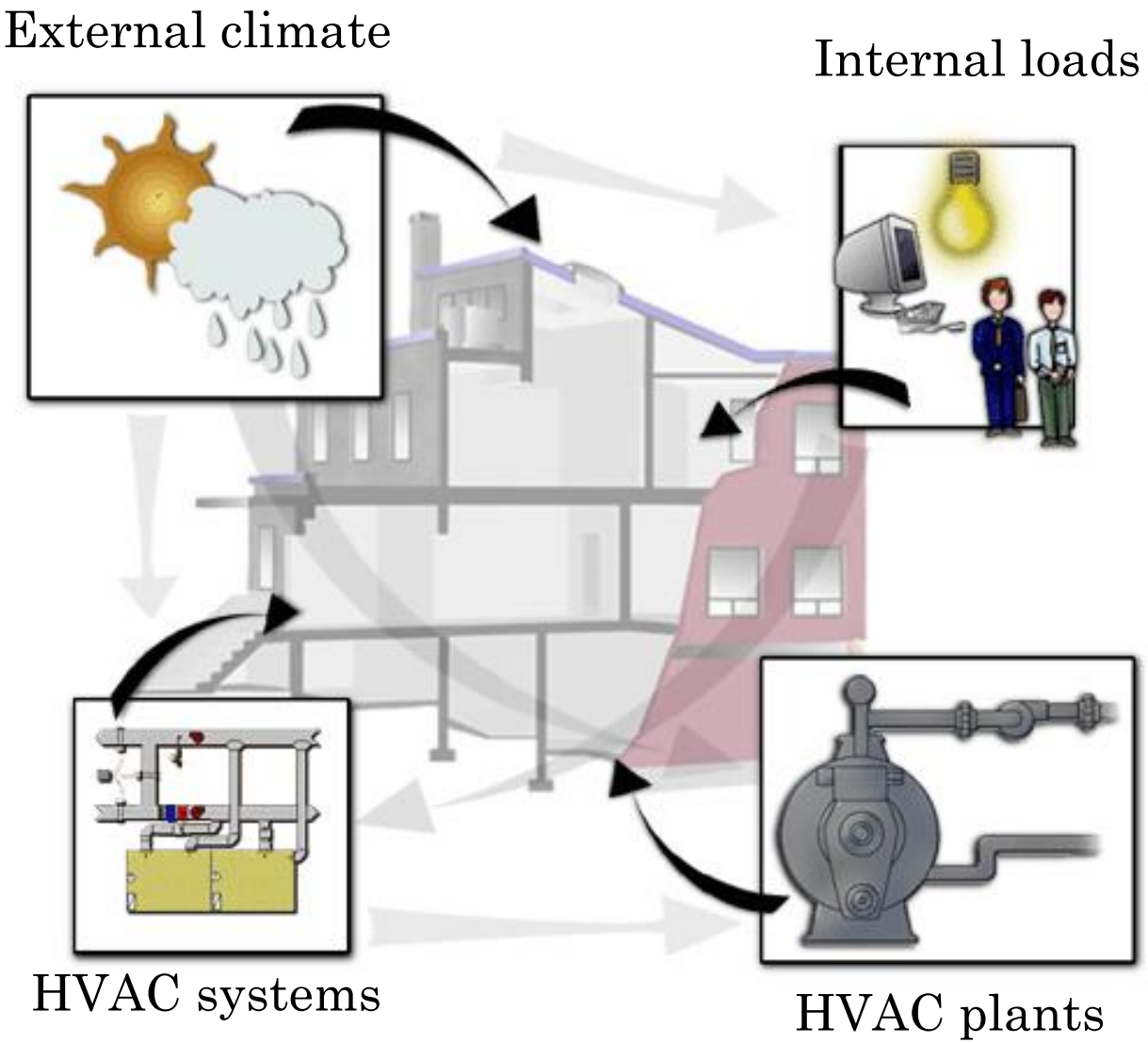
Solar Heat Gain Factors





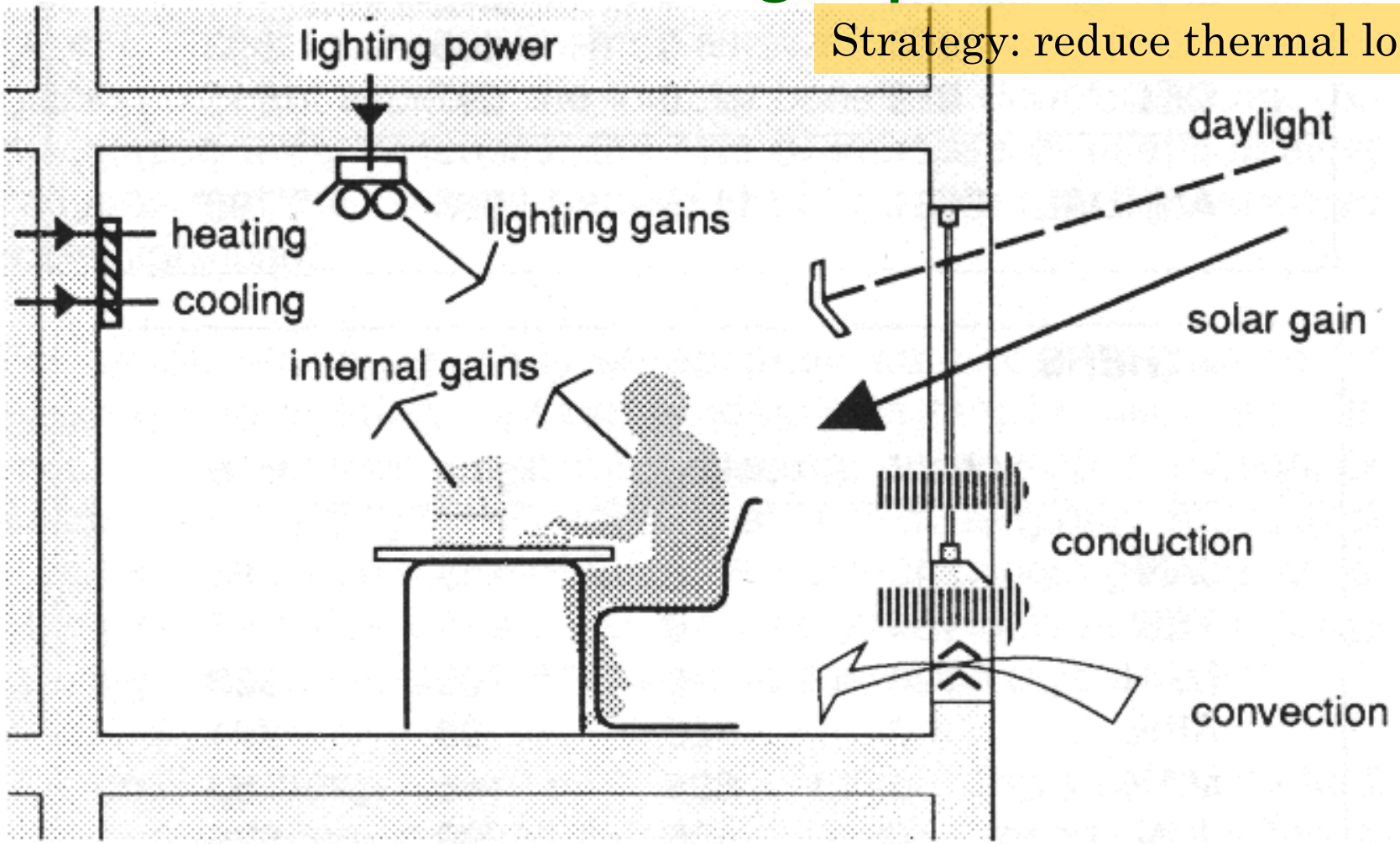
- Direction that the window faces
- Time of day
- Month
- Latitude
- Construction of interior partition walls
- Type of floor covering
- Existence of internal shading devices

Energy Ledger in Buildings



Thermal Energy Balance in a Building Space

Strategy: reduce thermal loads



Strategy: optimize building envelope

Energy Strategy

Good design practices

Integrated and total energy approach

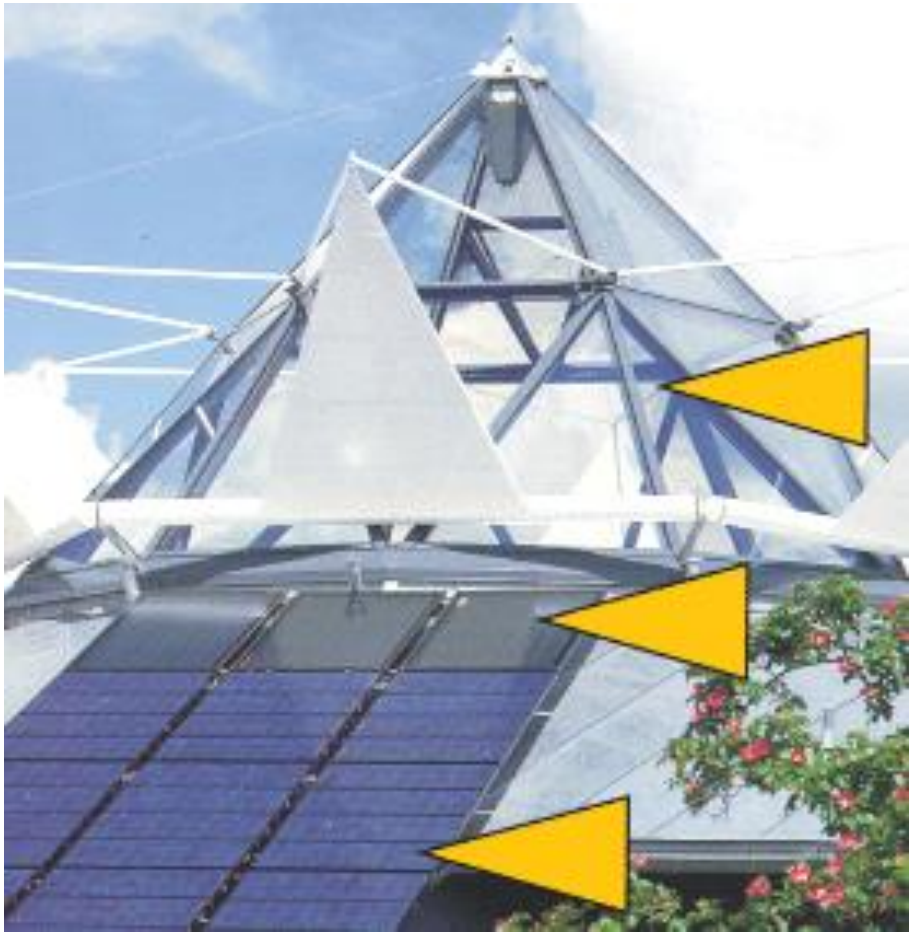
Efficient systems

Efficient operation

Good housekeeping

User education and awareness

Integration of Solar Energy Systems in Buildings

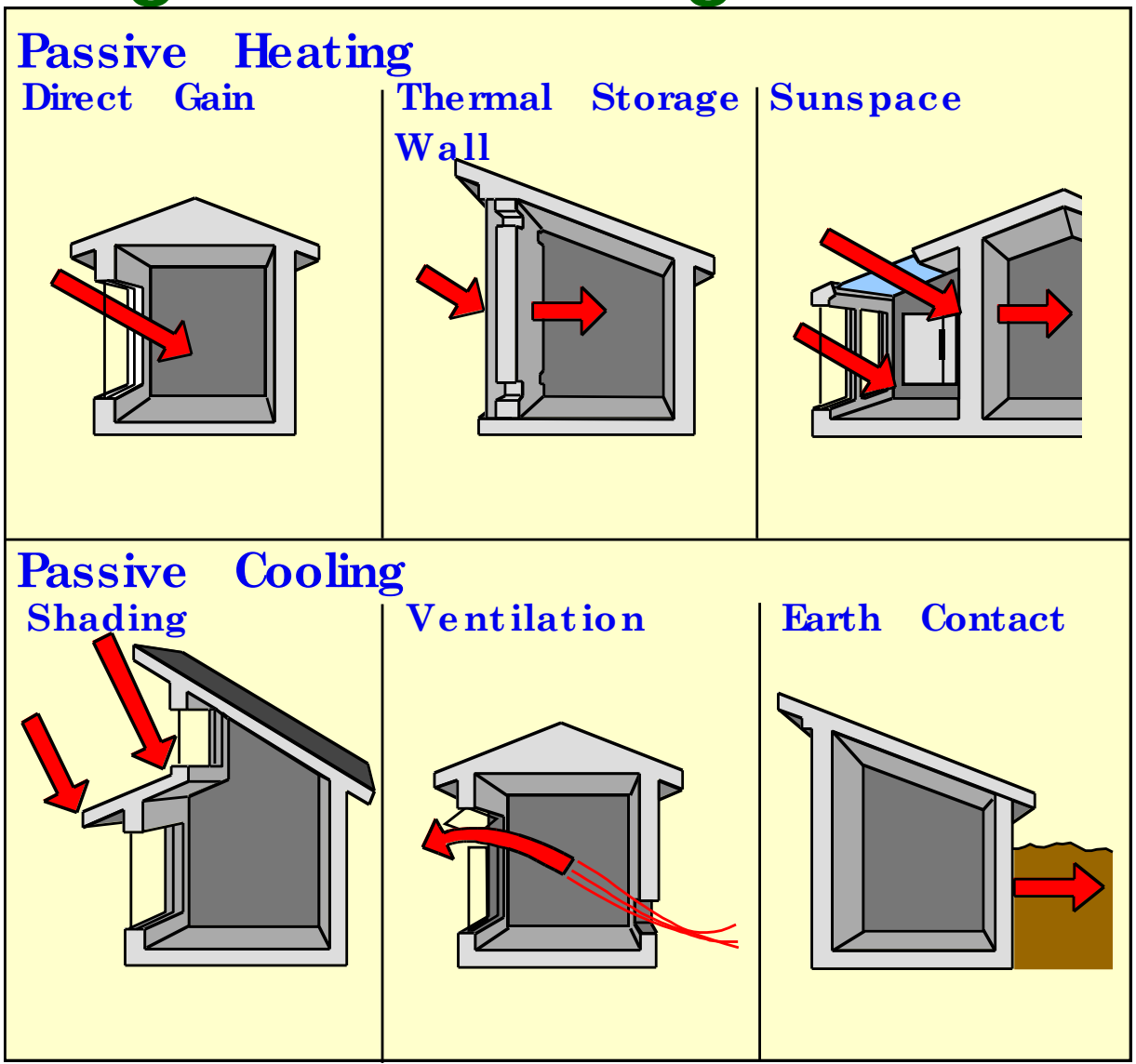


Passive solar (e.g. skylight)

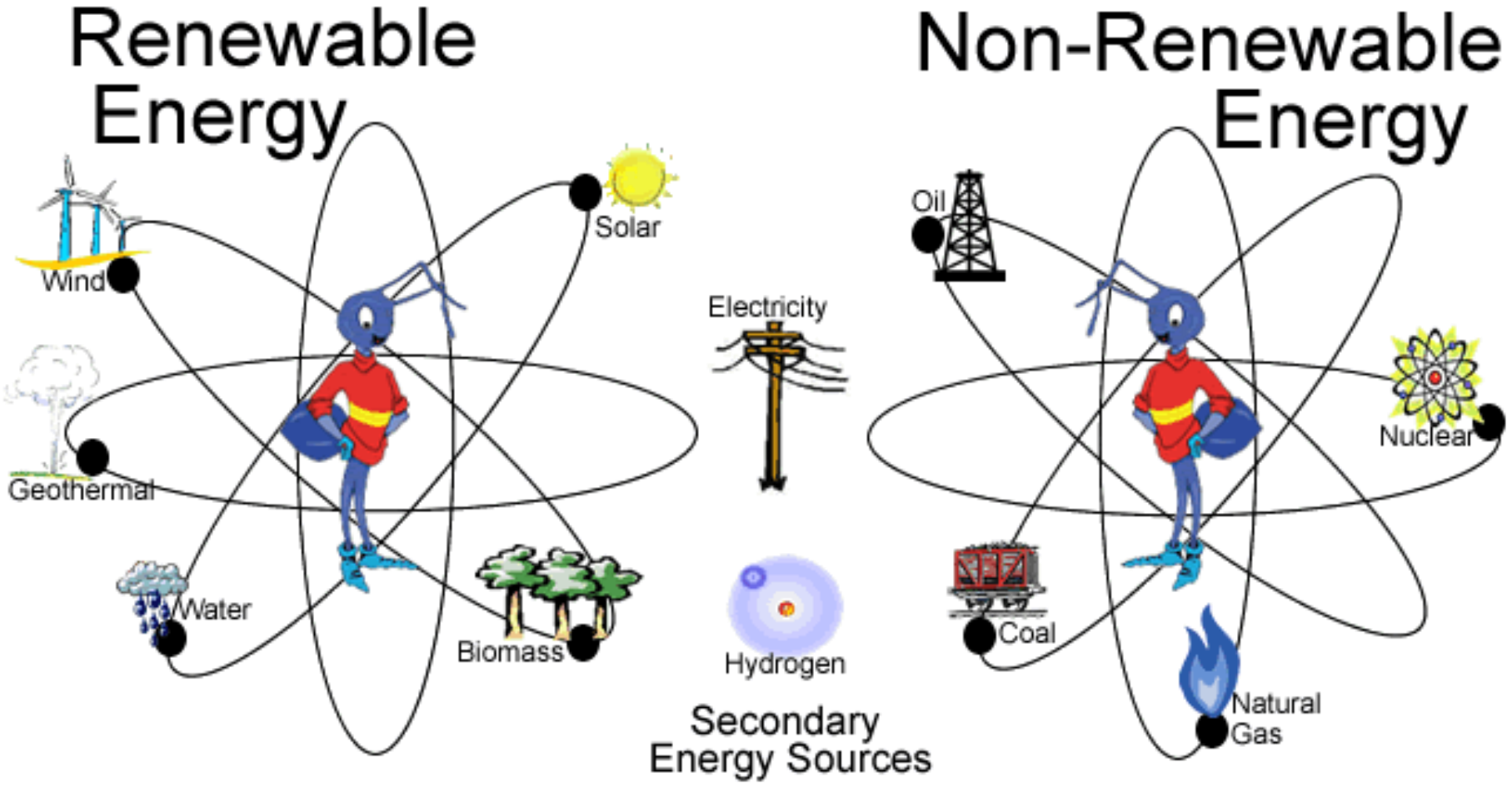
Active solar (solar hot water)

Photovoltaics

Passive Heating and Cooling in Buildings



Renewable Energy *vs.* Non-Renewable Energy



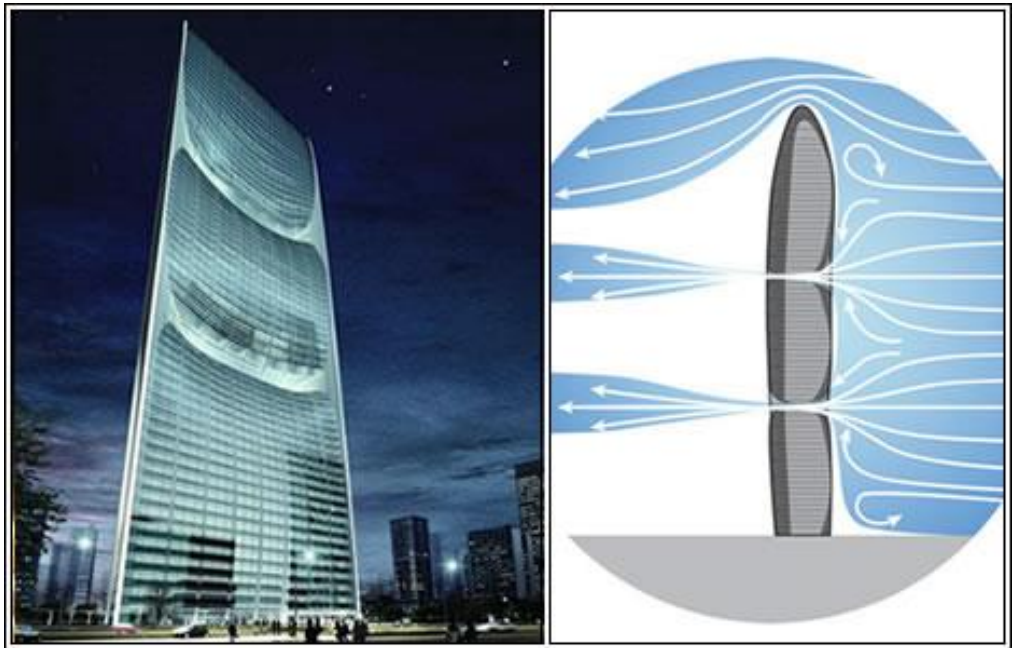
Solar PV Systems in Hong Kong Science Park

Building Integrated Wind Turbines

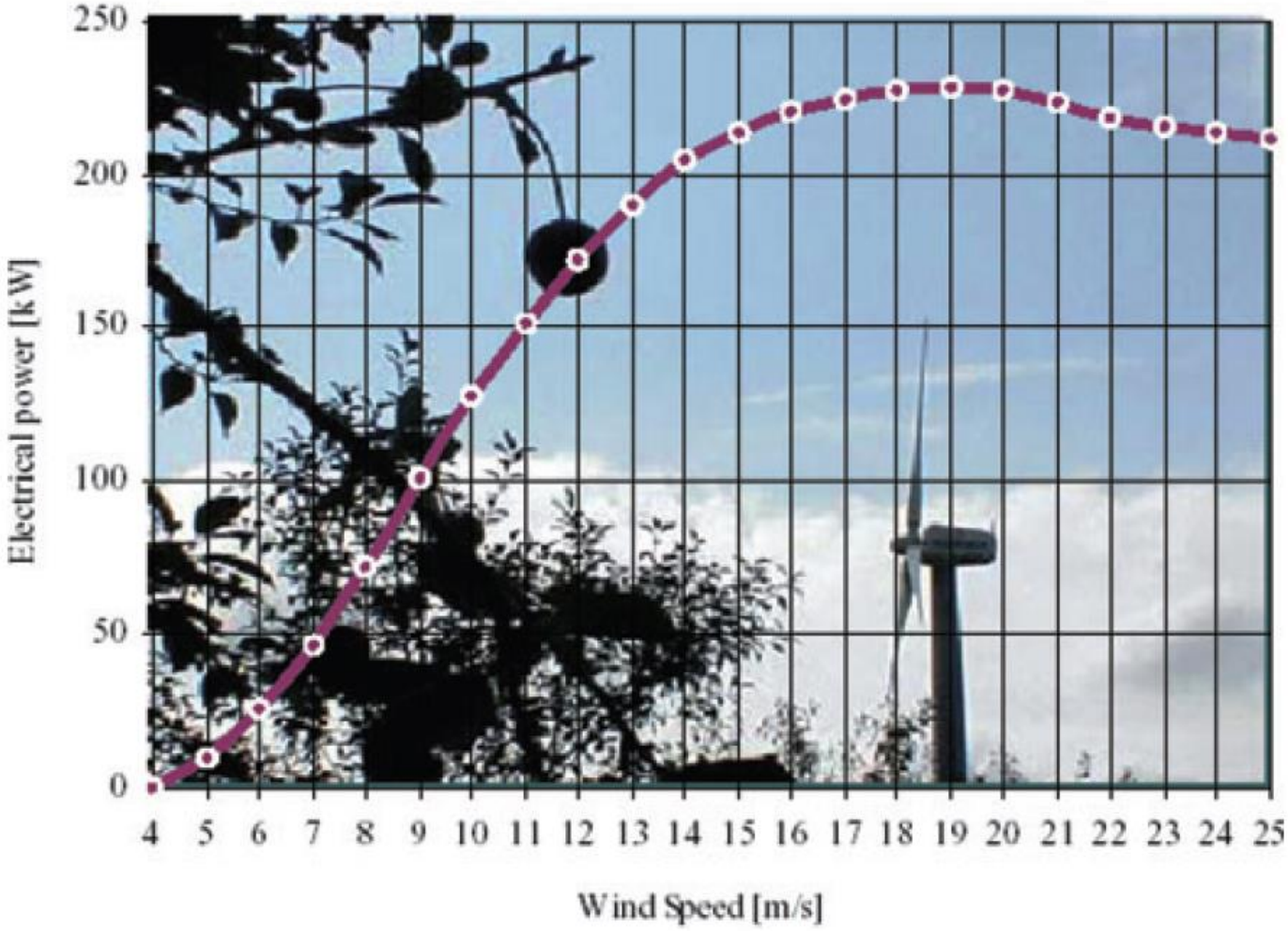
WTC towers in Bahrain

https://youtu.be/0BJM_zfI2IA

Pearl River Tower, Guangzhou



Electric Power vs Wind Speed



Richard F. Smith and Shaun Killa
W. S. Atkins & Partners Overseas, Dubai www.atkinsglobal.com
https://doi.org/10.1002/tal.416

Green Building Materials

Intension of Green Building Materials

Promotion Principles	Ecological, healthy living environment, high performance of building materials and resource reuse.
Construction System	Enhance Taiwan's Green Building System and promote the national image and international competitiveness.
Environmental Issues	Fulfill the spirits of GBM Label as Human Health and Global Sustainability.

Ecological	No shortage crisis, less labor treatment involved, utilization of local materials
Healthy	Low HCHO and TVOC, non asbestos and proclaimed toxic chemicals
High-performance	Sound insulation, permeability, special performance, conformity with CNS
Recycling	Domestic construction wastes and debris, reduction, recycle and reuse of the wastes

Re-source → Produce → Usage → Recycle

Categories of Green Building Materials

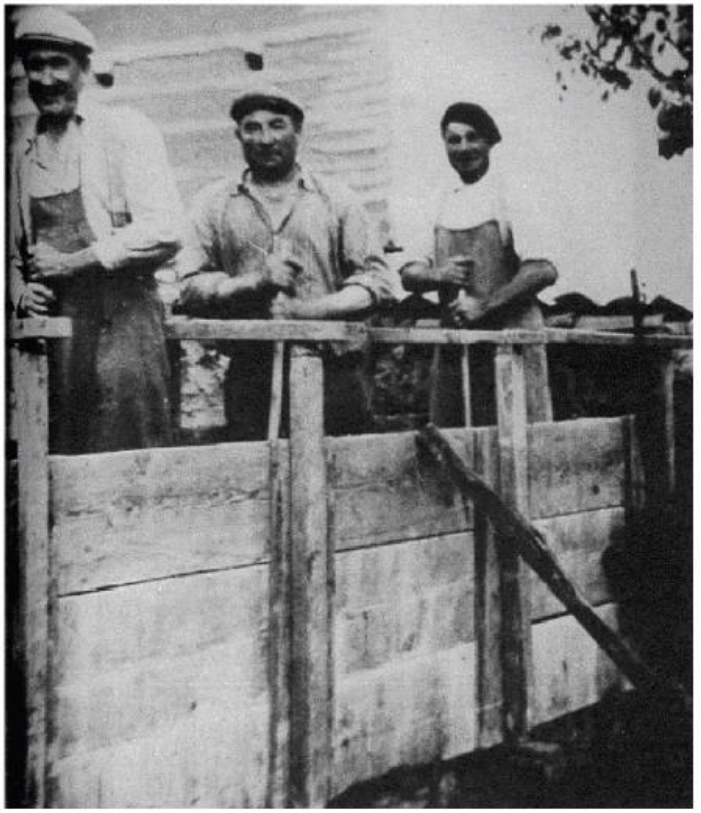
1. Ecological Green Building Materials
   - Natural materials, low artificial treatment, etc.
2. Low-emission healthy Green Building Materials
   - low health risk.
3. High-performance Green Building Materials
   - high-performance, high-efficiency, etc.
4. Recycled Green Building Materials

Rammed Earth (夯土) Building

- Sand/gravel 70%
- Clay 30%

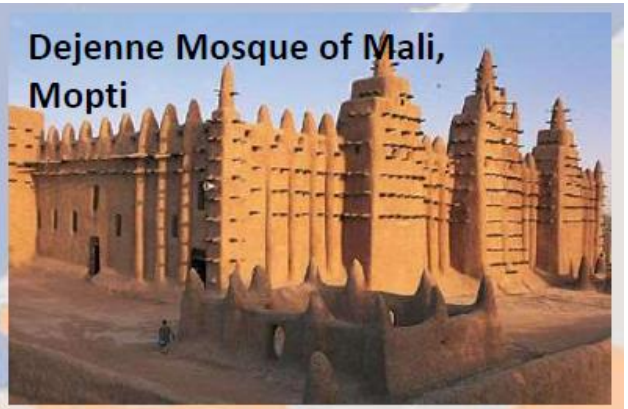
- SRE uses 6% of cement*
- Normal concrete < 12%

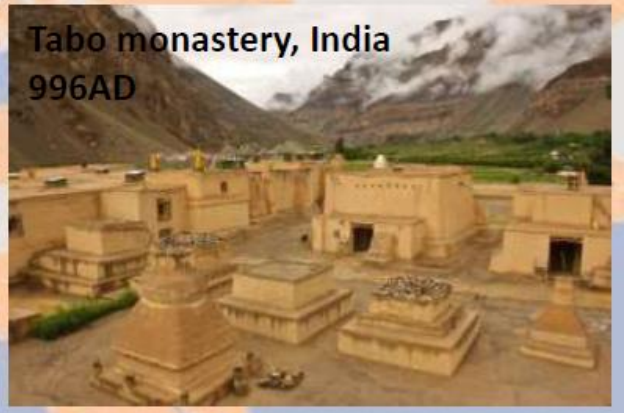
* Cement is responsible for 7% of the total CO2 production

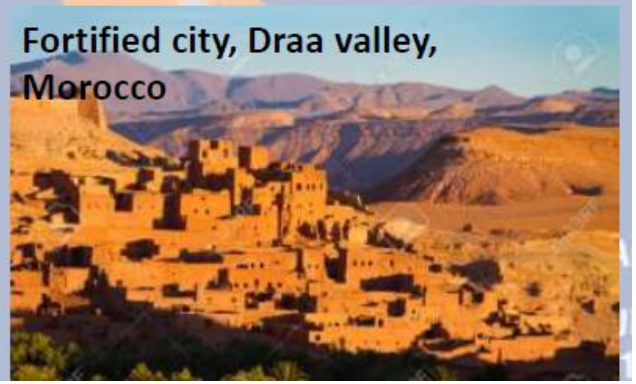


SRE= stabilized rammed earth
Ref: NAREBA.org (US) https://www.mdpi.com/2071-1050/5/2/400
eartharchitecture.org (France), rammed-earth.org (UK), www.hangtu.org (cn)

History of Rammed Earth Buildings/Structures







History of Rammed Earth Buildings/Structures

Great Wall of China

Citadel of bam, Iran, before the earthquake

Dakhla oasis, Egypt

Archaeological site of Mari Syria

Bazaar, Sirdjan, Iran

Tolou House (土樓)

https://youtu.be/Rutrgvm2Vpg

Rammed Earth Building

disadvantages

- Vulnerable to water
- Erosion due to rain
- Thick walls
- Trasslayer / plinth
- Eaves overhang

advantages

- 100% recyclable
- Low carbon foothprint
- Proven technique
- Local material
- Less transport

DIY: How to build Cheap Rammed Earth House

How to Build House of Dirt; Cheapest on Record

BY CHARLES P. STEWART
NEA Service Writer

WASHINGTON, March 25 If you want a house but can't afford to build with ordinary dirt.

Why? For centuries. The dirt turns to stone.

Look! See the accompanying picture.

Cost? Nothing for the dirt. Day wages for a little unskilled labor. Whatever you please to pay for plumbing and other accessories.

All this is according to Edward W. Coffin, a well-known Washington mechanical engineer.

"It's a very old style of building," he says, "known as 'pise de terre,' which means 'rammed earth.'

"Pliny, the Roman, tells of its use by Hannibal, 150 years before Christ. Thomas Jefferson recommended it, but wood was too plentiful in America in those days. The oldest house in the United States, at St. Augustine, Fla., was built thus.

Such a house, built in 1773, stands in Washington today, better than when it was new. And Dr. H. B. Humphrey, Department of Agriculture, has just finished a rammed earth houses here. City building inspectors say it's one of the soldiest, best-built in town.

"The system is unpatentable—free to all.

"It solves the problem of cheap home building. A rammed earth wall's cost is less than a quarter the cost of brick, much less than half the cost of concrete, at least two-thirds less than subsided frame.

"Rammed earth mustn't be confused with adobe, sod or mud and straw.

"Any earth which clods in plowing will do. Pure sand won't pack. Clay cracks.

"Twelve per cent moisture in the earth is about right. It must be sifted, to break up clods and remove vegetable matter.

"Only one mold form is needed, an advantage over concrete. But the mold must be very strong—at least 2-inch planed planks, heavily braced, and held together by iron tie-bars. The pressure of hard ramming is terrific.

"Put the mold on an ordinary foundation. Fill it 5 inches deep with sifted earth. Pound the earth with 15 to 20-pound iron rammers until it's so hard it rings, as a pavement rings.

"Then put in another 5 inches and repeat until the mold is full. After that, remove the mold, set it up again and go on.

"Openings are left for doors, windows, fire places and chimneys by putting blocks in the earth and taking them out when the earth around them has been rammed.

"During building the exposed sides won't be affected by rain, but the top should be protected, with tar paper or boards.

"After six weeks drying, in ordinary summer weather, the wall becomes rocklike. It may be finished outside as desired stucco, pebble dash, cement or tar. The inside may be treated in any of the usual ways—with paper on a coat of skim, water color paint or plaster.

"The walls are 12 to 24 inches thick and will bear 100 times the weight put on any house. They will do for a building up to three stories high."

LAUGHING AT CONTRACTORS

ABOVE—A VIEW OF THE MOLD USED IN BUILDING THE WALLS OF THE DIRT HOUSE. LOWER LEFT—THE EARTH WALLS SHOWING SPACES LEFT FOR WINDOWS AND FLOOR. LOWER RIGHT—A HOUSE WHOSE LOWER WALL IS MADE OF RAMMED EARTH, COVERED WITH A COAT OF SAND AND CEMENT.

https://www.instructables.com/id/How-to-Build-Dirt-Cheap-Houses/

https://youtu.be/TjyGOOtOFik https://youtu.be/3RyHy1bNJuU

Tolou House (土樓)

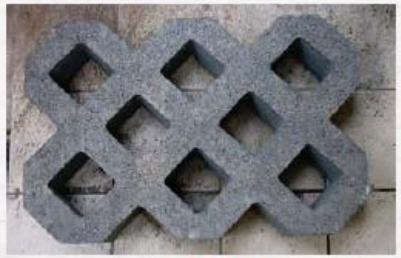
- A tulou, unique to Hakka in Fujian, Chia, is usually a large, enclosed and fortified earth building, rectangular or circular in configuration, with very thick load-bearing rammed earth walls between three and five storeys high and housing up to 80 families. These houses were mostly built in the 12th and 20th centuries
- Smaller interior buildings are often enclosed by these huge peripheral walls which can contain halls, storehouses, wells and living areas, the whole structure resembling a small fortified city.

https://en.wikipedia.org/wiki/Fujian_tulou

Green Recycling Materials

Testing Laboratory of Green Recycling Building Materials

Compressed concrete paving units



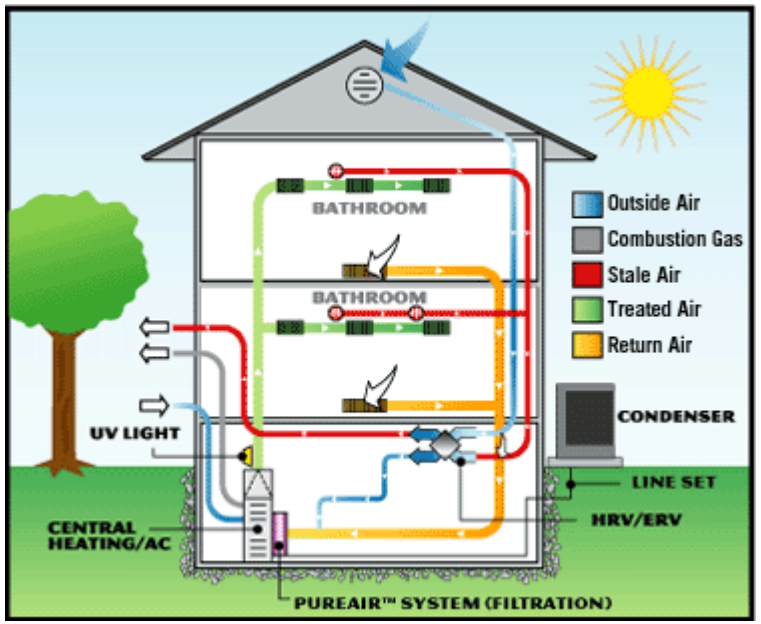
Grid bricks

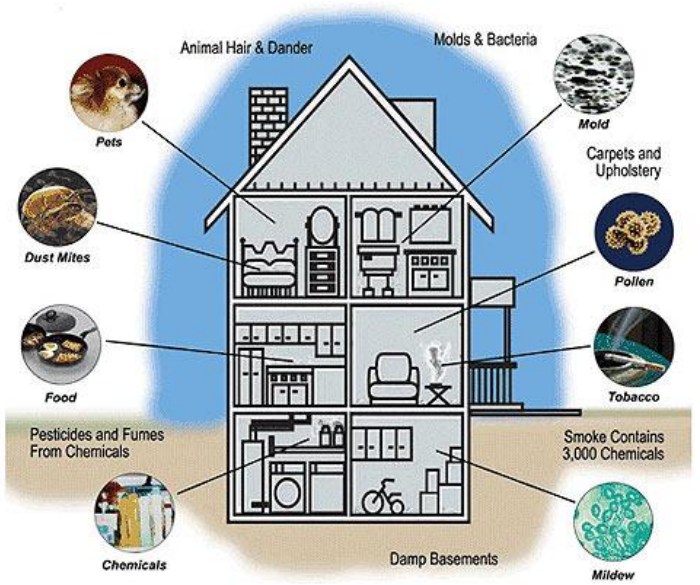
Wood-like
Building materials

Fire resistance
boards

Processing Laboratory of Green Recycling Building Materials

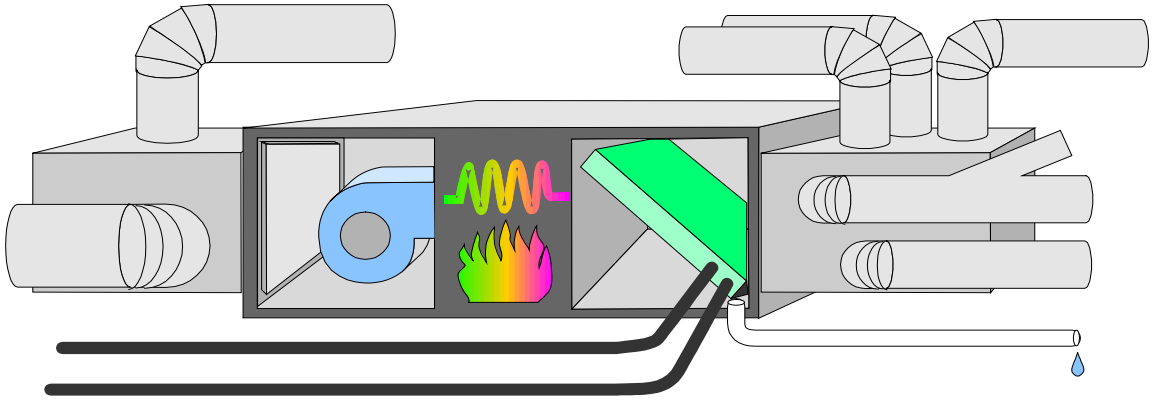
Indoor Environmental Quality



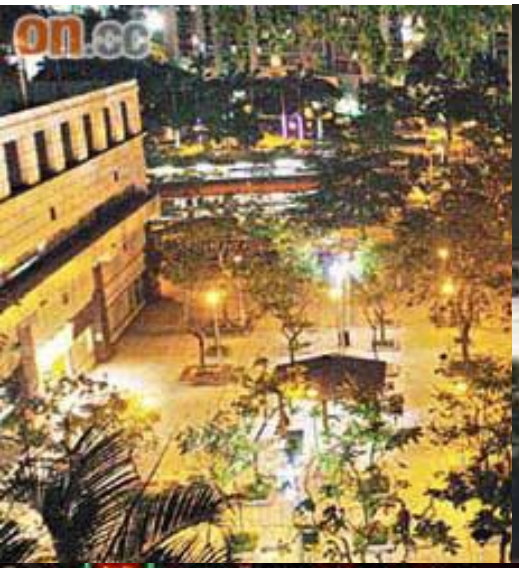


Heating, Ventilation and Air-Conditioning

- Heating, Ventilation and Air Conditioning
- Provides *comfort* for people
- Allows humans to *exist* under adverse conditions.



旺角光污染　光到人都癲



Light Pollution Affects Habitats and Behaviors

- Birds
- Amphibians
- Fish
- Insects
- Mammals

Night lighting results in ecological disturbances and mortality of individuals and entire species in ways that we are discovering in every study conducted.

Light Pollution and Plants

Light can be good: Plant factory for green vegetables
https://youtu.be/wSQFeX5VOkY

- Trees:
  - stressed when dormancy delayed and growth altered.
- Plants:
  - alteration of growth patterns, flowering, and pollination
- Water quality:
  - increases in algae bloom when lighted water inhibits movement of zooplankton

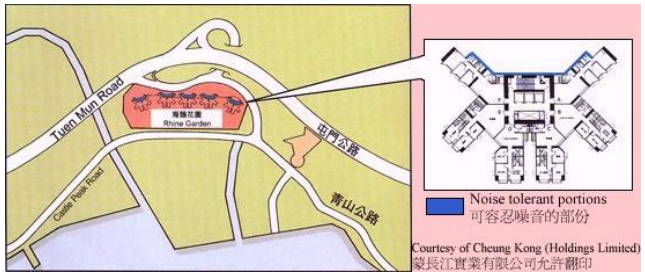
Noise Pollution in Hong Kong

- Construction
  - machines
  - building
  - demolition …
- Industrial
- Domestic
  - alarming clock
  - snoring noise
  - pets
  - doorbells
  - radios/TV …
- Traffic
  - engines
  - exhaust pipes
  - horns
  - moving…
- Aircraft
  - height and proximity
  - landing and taking-off
  - aircraft design …







Summary

Why Build Green?

- Proven environmental and health benefits
- Minimal initial cost premium
- Life-cycle cost savings




Hong Kong Wetland Park





Stanley Municipal Services Building






Fire Station at Penny's Bay






The Heritage Discovery Center