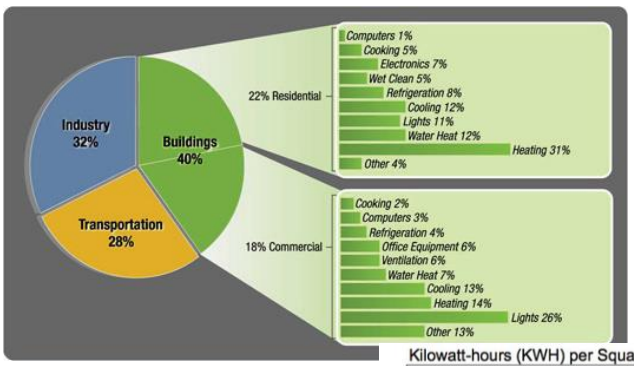
Design and renewable energy

Passive design

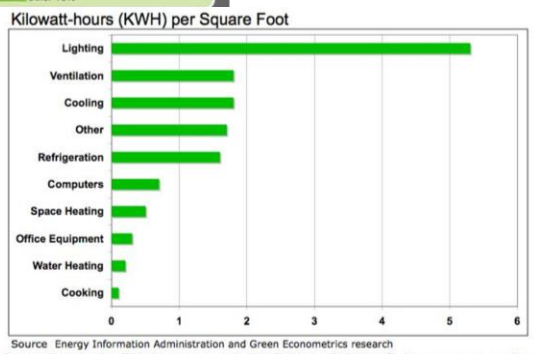
Passive design

- Daylight
- Shading
- Glazing
- Solar wall, direct solar gain, solar chimney, etc. (including thermal insulation)
- Cool roof

daylight



Energy consumption for lighting



Source Energy Information Administration and Green Econometrics research

According to the EIA. in commercial buildings, lighting fixtures consume the most electric energy, three times the energy consumption of air conditioning.

Advantages

- Enhancing productivity
- Daylight and health
- Daylight and finance
- Psychologically, daylight and a view are much desired.

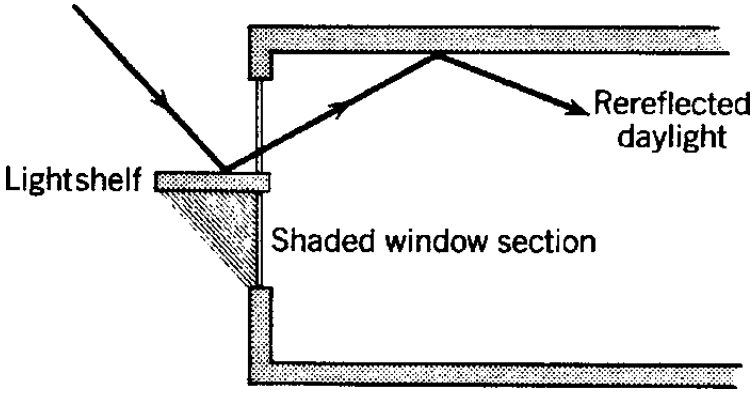
This is because daylight enhance Visual comfort

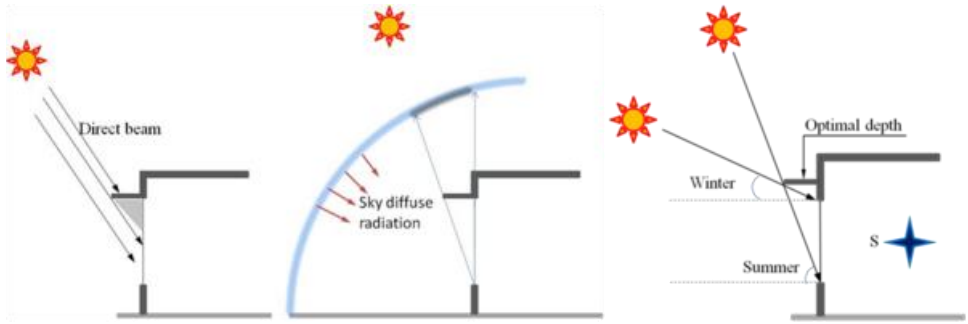
Disadvantages

- Glare
- Solar heat gain

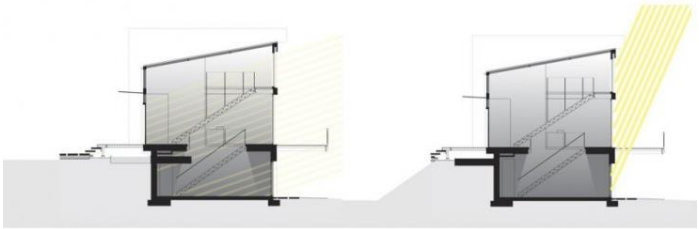
How to solve daylight problems

- Provide exterior fixed shades that exclude sunlight for all sun positions.
- Use systems that diffuse the incident sunlight sufficiently to eliminate glare potential.
- Lights shelves,
- high-reflectance interior surfaces,
- low-transmittance glazing (though such glazing will reduce light flux through the window).
- Furniture should be oriented to work with side lighting (as opposed to having an occupant face a window)





Glazing selection



Visible light transmittance:

A measure of the amount of visible light that passes through the glazing material of a window, door, or skylight. Visible light transmittance, or simply visible transmittance (VT), is a fraction of the visible spectrum of sunlight (380 to 720 nanometers), weighted by the sensitivity of the human eye, which is transmitted through a window's, door's, or skylight's glazing. A product with a higher VT transmits more visible light. VT is expressed as a number between 0 and 1

Shading coefficient (SC)

A measure of the ability of a window or skylight to transmit solar heat, relative to that ability for 3 mm (1/8-inch) clear, single glass

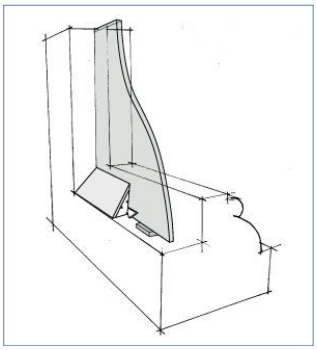
Solar Heat Gain Coefficient (SHGC)

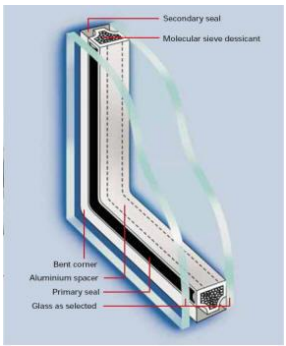
is the ratio of total transmitted solar heat to incident solar energy, typically ranging from 0.9 to 0.1, where lower values indicate lower solar gain

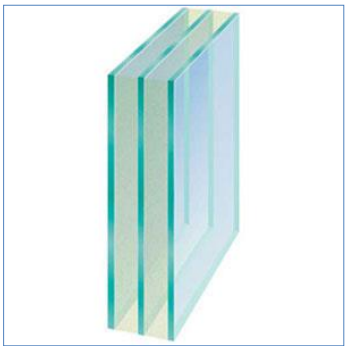
SC » 1.15 x SHGC.

Glazing types - Number of layers - U Value

- Single glazing
- Double glazing
- Triple glazing







Glazing types – Color and reflection

- Clear glazing
- Tinted glazing
- Low E glazing
- Reflective glazing
- Selective glazing
- Active glazing

Clear glazing

Relative to all other glazing options, single-glazed with clear glass allows the highest conductive transfer (i.e. heat loss or heat gain) while permitting the highest solar heat gain and daylight transmission

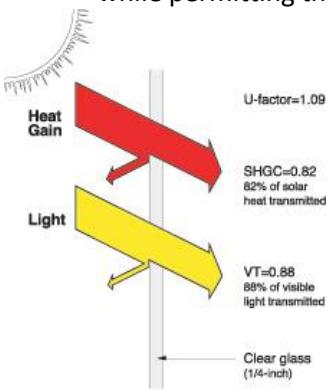


Figure 3-5. Clear single glazing
All values are for the glazing alone (center-of-glass). Values for the total window will vary with frame type.
U-factor is in Btu/hr-sf-°F
SHGC=solar heat gain coefficient
VT=visible transmittance

Tinted glazing

- Tinted glazing absorbs a portion of the solar heat and block daylight. Tinting changes the color of the window and can increase visual privacy.
- The primary uses for tinted glass are reducing glare from the bright outdoors and reducing the amount of solar energy transmitted through the glass.
- Traditional bronze and gray tinting, although they slightly reduce solar gain, they greatly reduce visible transmittance, thereby diminishing daylight opportunities.
- High-performance tinted glass, which has a light blue or light green tint, offers both higher visible transmittance and a lower solar heat gain coefficient (SHGC)

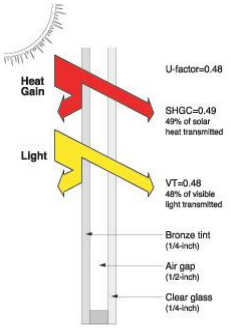


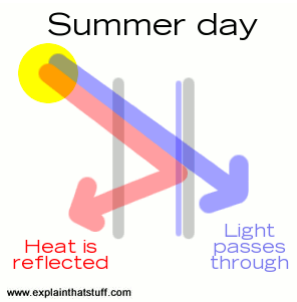
Figure 3-14. Double glazing with bronze-tinted glass on the outside layer

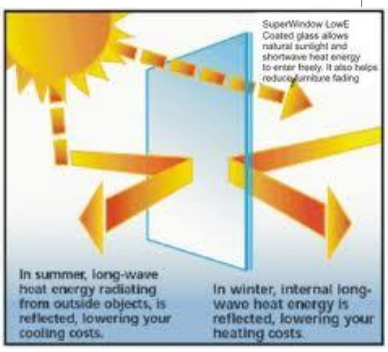
All values are for the glazing alone (center-of-glass). Values for the total window will vary with frame type.
U-factor is in Btu/hr-sf-°F
SHGC=solar heat gain coefficient
VT=visible transmittance

Low E glazing

- Low emissivity (low-e) glass has a coating that minimizes re-radiated heat. It has a clear appearance and good thermal properties.
- Low-e glazing sometimes called spectrally selective low-e glass helps to reduce the invisible, near infrared solar radiation that contributes to unwanted heat gain while permitting daylight transmission

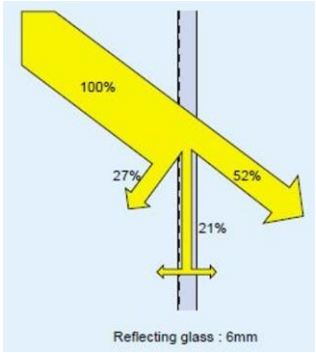
The emissivity of a material (E) is the relative ability of its surface to emit energy by radiation. It is the ratio of energy radiated by a particular material to energy radiated by a black body at the same temperature. A true black body would have an ε = 1 while any real object would have ε < 1





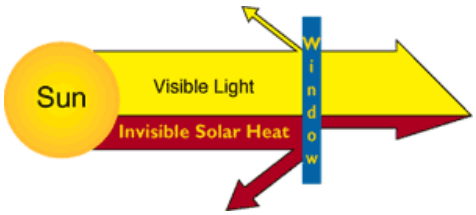
Reflective glazing

- Reflective coatings on window glazing or glass reduce the transmission of solar radiation, blocking more light than heat. Therefore, they greatly reduce a window's visible transmittance (VT) and glare, but they also reduce a window's solar heat gain coefficient (SHGC)
- Reflective coatings usually consist of thin, metallic layers. They come in a variety of metallic colors, including silver, gold, and bronze
- Reflective window glazing is commonly used in hot climates where solar heat gain control is critical. However, the reduced cooling energy demands they achieve can be offset by the resulting need for additional electrical lighting, so reflective glass is mostly used just for special applications



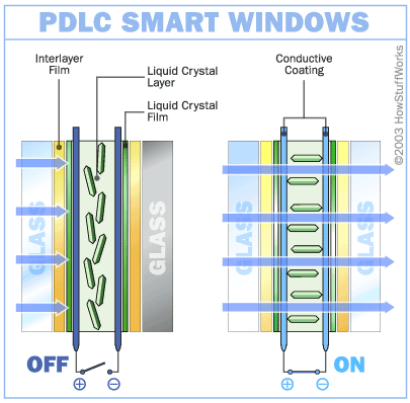
Selective glazing

- **Spectrally selective glazing** is window glass that permits some portions of the solar spectrum (visible light) to enter a building while blocking others (infrared light)
- **Angular selective glazing**
- This high-performance glazing admits as much daylight as possible while preventing transmission of as much solar heat as possible



Active glazing

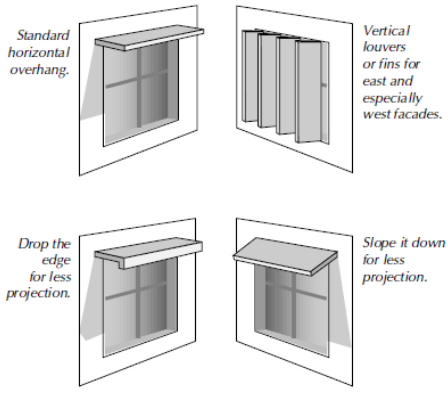
- Known as electrochromic glazing, is controlled by a current passing through the material to alter the amount of heat and light transfer
- The active layer is a film which either requires a low dc voltage (electrochromics, user controllable photochromics) or hydrogen (gasochromic) to change from a bleached to a colored state.
- However, as the glass becomes darker, the radiant temperature of the window pane will rise due to the greater absorption of light.
- The visual light transmittance of electrochromic glazing is typically between about 50 and 60% in the bleached and 5 and 15% in the colored states respectively

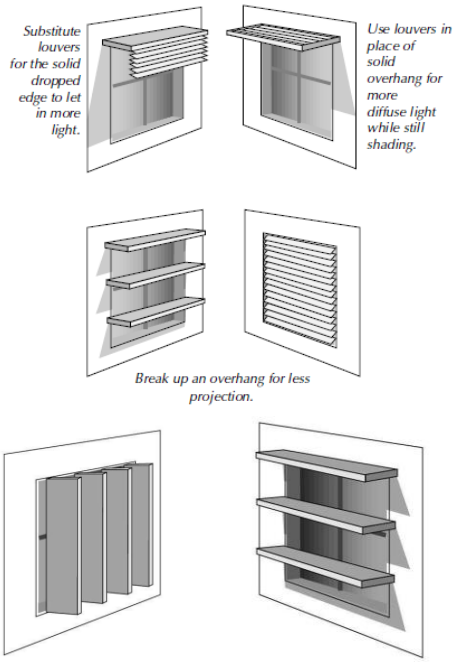


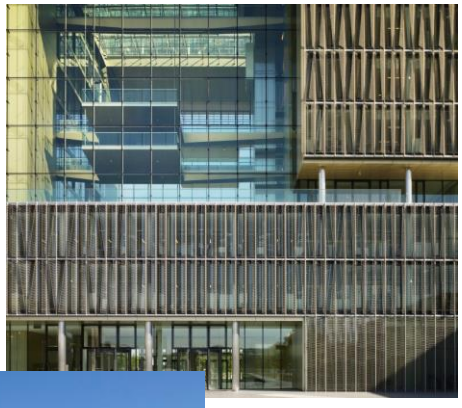
With the third column of glass darkened, this man's workspace is much more comfortable. (These SageGlass windows were specially outfitted with sensors to measure light transmission; normal SageGlass products do not have this device.)

Shading design

Shading Types





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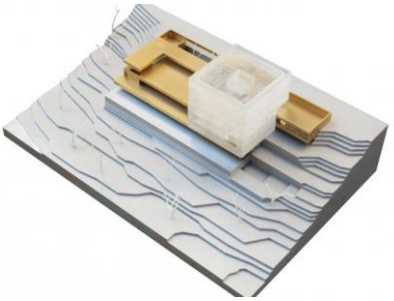
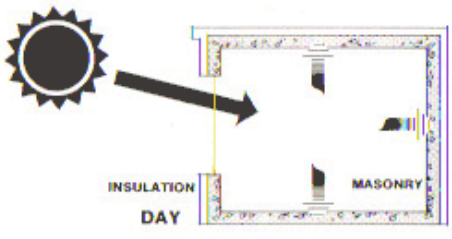
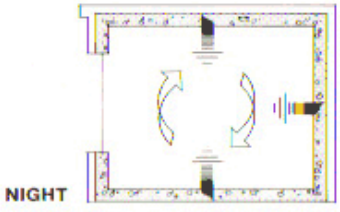


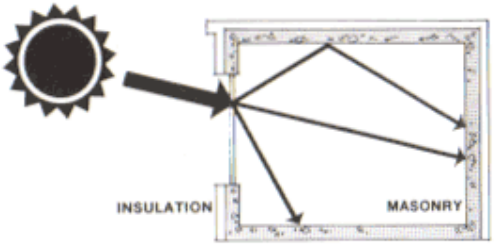
Passive solar heating

- Passive solar applications, when included in initial building design, adds little or nothing to the cost of a building

- Site and climate conditions must be evaluated carefully (No one passive design approach is most advantageous in all climates or on all sites and situations)





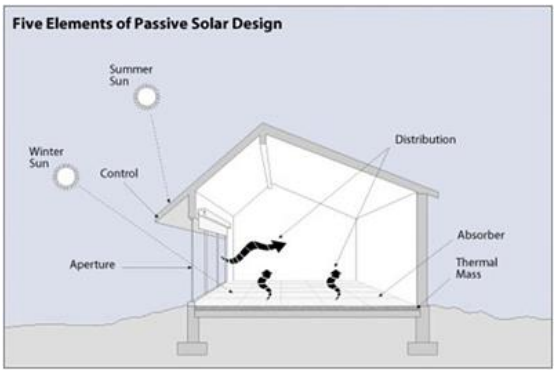


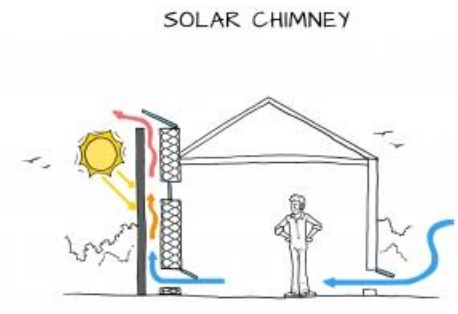
Solar window

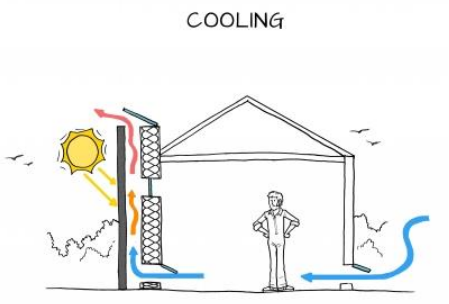
Remember to consider:

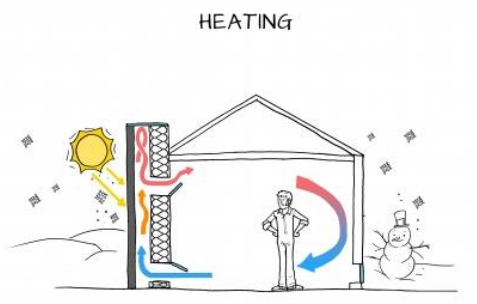
1. How much solar radiation you can get by orientation
2. Minimize heat loss (U value) - **<u>Insulation</u>**
3. Control the glare
4. Control the heat in summer (shading)
5. Use thermal mass to store heat

$\Phi = A \times U \times (T_1 - T_2) \times hours$









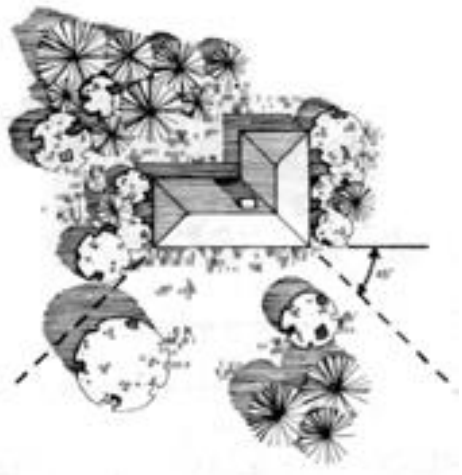
Passive cooling

Unwanted summer heat sources:

- direct solar impacts;
- heat transfer and infiltration through the materials and elements of the structure;
- and the internal heat produced by appliances, equipment, and inhabitants

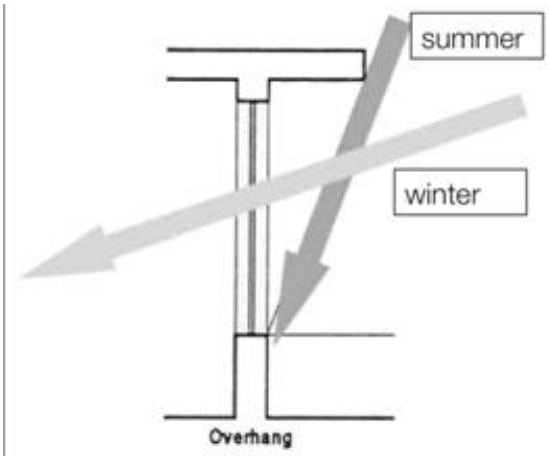
1. Landscaping

- site temperature reduction
- wind channeling
- sun control (by far its most important energy application)

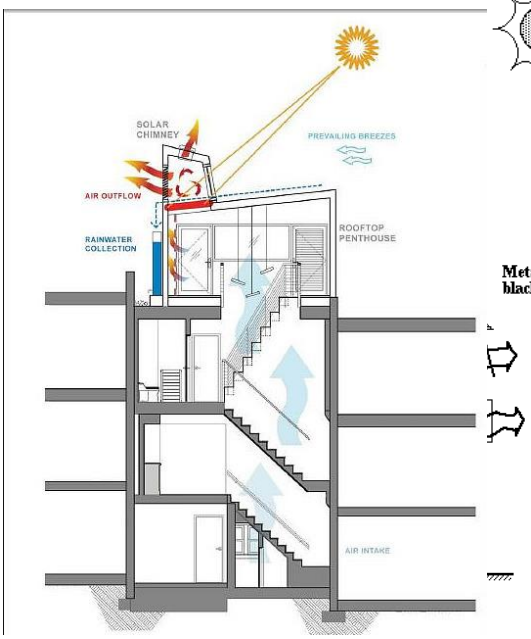


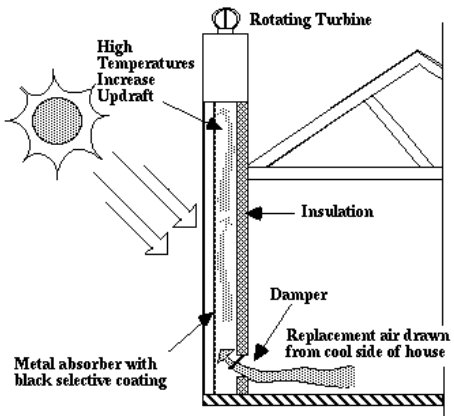
2. Shading

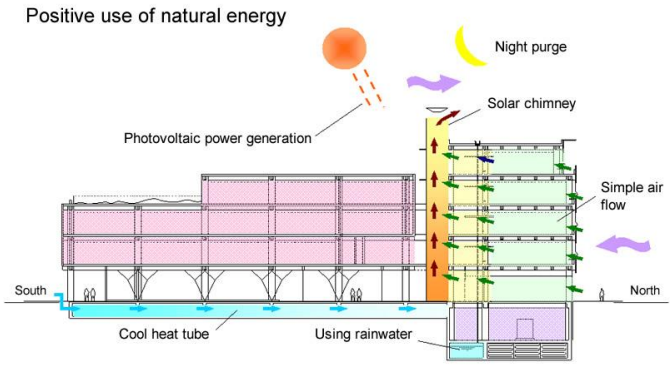
- HEAT GAIN CONTROL (done)



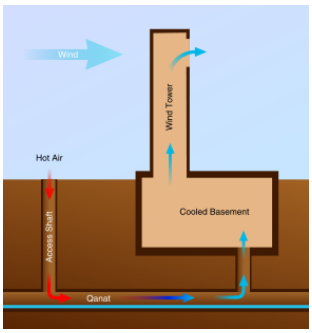
Solar Chimney

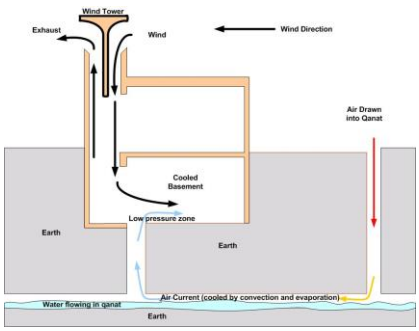


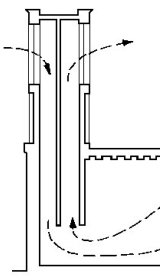



Positive use of natural energy
Night purge
Solar chimney
Photovoltaic power generation
Simple air flow
South
North
Cool heat tube
Using rainwater

Wind tower

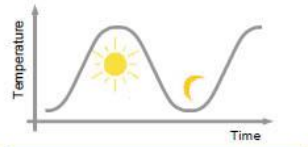

Wind
Wind Tower
Hot Air
Cooled Basement
Access Shaft
Qanat


Wind Tower
Exhaust
Wind
Wind Direction
Air Drawn into Qanat
Cooled Basement
Low pressure zone
Earth
Earth
Air Current (cooled by convection and evaporation)
Water flowing in qanat
Earth

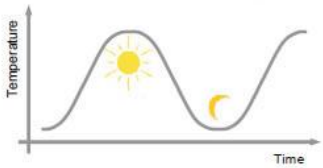


4. Thermal mass

refer to solar heating for thermal mass calculation



Daily external temperature profile



Daily internal temperature profile

Daily internal temperature profile

6. Cool Roof

A roof surface that stays relatively "cool" as compared to the ambient, or surrounding, temperature
Or…
The roof surface temperature is usually only slightly higher than the air temperature

Solar Reflectance: portion of light reflected
Thermal Emittance (infrared):portion of absorbed heat reemitted

Both measured from 0 to 1, higher value is cooler
Both important, although reflectance has the greater effect

white coatings with an **albedo of 0.72 were 40°C cooler than black coatings with an albedo of 0.08** in the early afternoon of clear summer day [Chen Zhi et al. 2007]

Benefits

- **Reduced energy bill**
- **Urban heat island mitigation (direct reduction in locally absorbed heat)**
- **Cooler Outside Air Temperature**
- **Improved comfort**
- **Longer roof life**
- **Cheap compared to green roof**