Energy efficiency in sustainable building

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1 author:

Abbas M. Abd
University of Diyala

Energy efficiency in sustainable buildings

By: Dunya Sabah
Supervised by:
Prof Ass Dr Abbas M Abd

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OBJECTIVE

- The main aim of this subject is :
- To know the main energy consumption in buildings
- Shows some techniques to reduce energy used to make buildings more efficiency

CONTENTS

- 1.Introduction
- 2. The major energy consumption in buildings
- 3.Technique use to reduce energy consumption in buildings
- 4.Heat island
- 5.Green power

1.INTRODUCTION

- Worldwide, buildings consume massive amounts of energy
- The United Nations Environment Programme has reported that **30–40 percent of all primary energy** produced worldwide is used in buildings.
- -In 2008, the International Energy Agency released a publication that estimated that existing buildings are responsible **for more than 40 percent** of the world's total primary energy consumption and for **24 percent** of global CO2 emissions

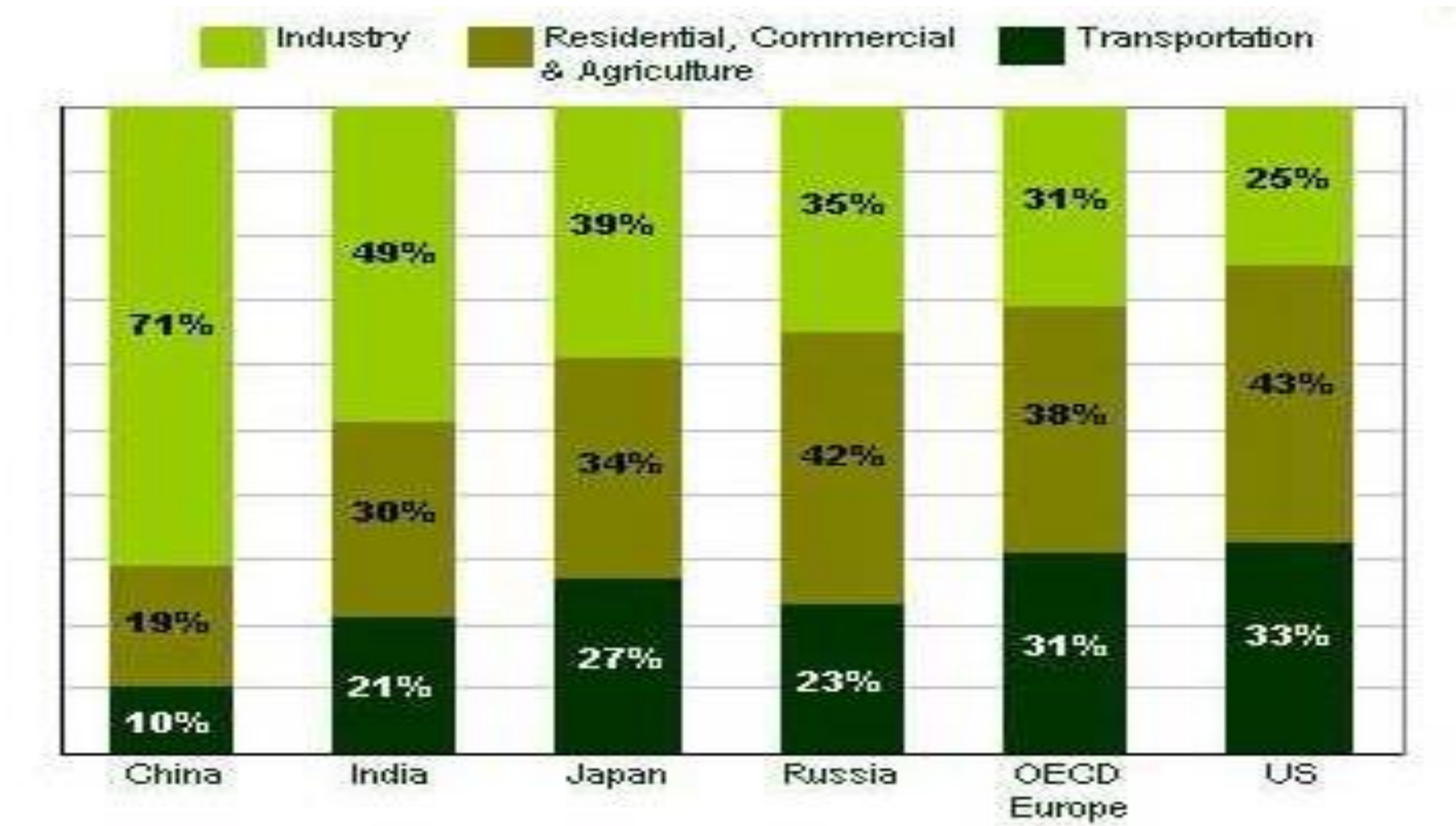
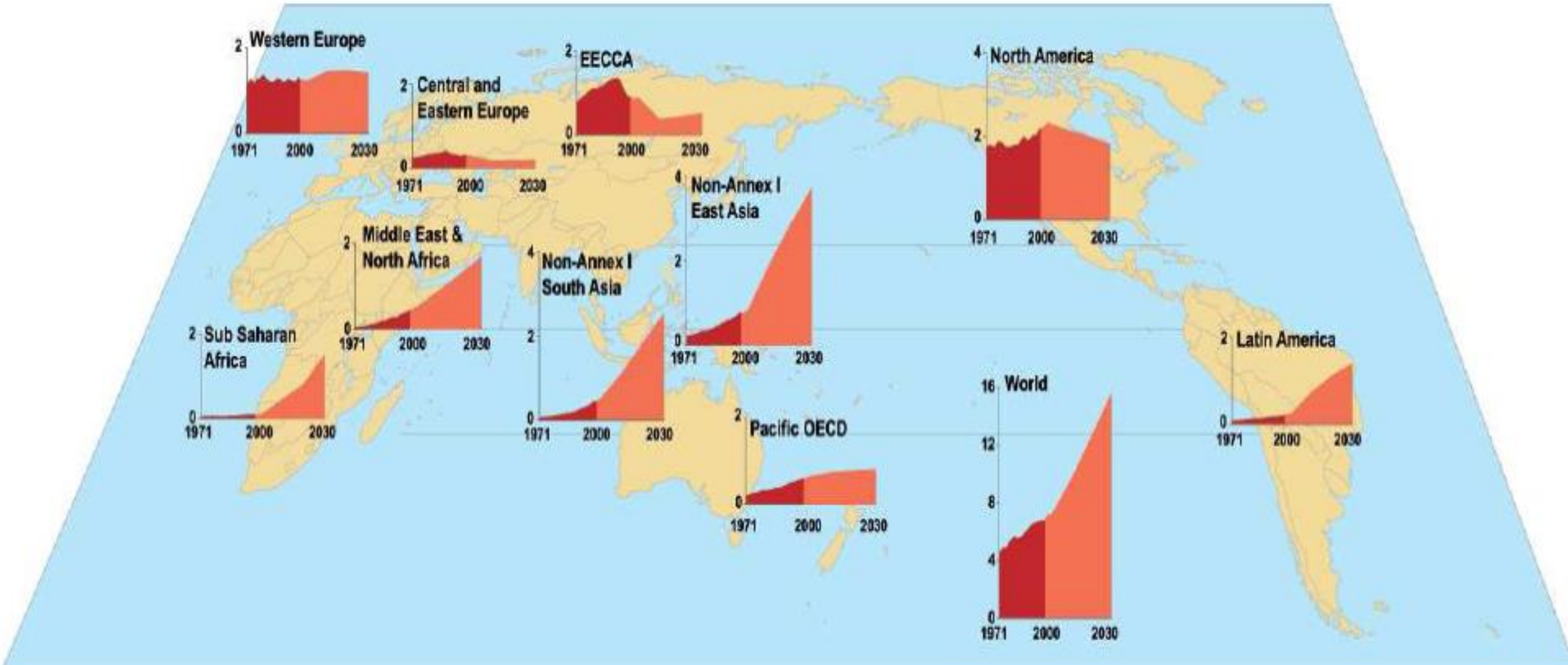


Figure 1: Global energy demand by sector in 2005 (source: IEA, 2008)



Note: Dark red – historic emissions; light red – projections 2001–2030 data; 2000–2010 data adjusted to actual 2000 carbon dioxide emissions. EECCA = Countries of Eastern Europe, the Caucasus and Central Asia. Source: Levine et al., 2007.

Figure 2. CO2 emissions from building sector under high growth scenario (including the use of electricity). (Source: Levine et al., 2007)

1.1The benefits of energy efficiency in building

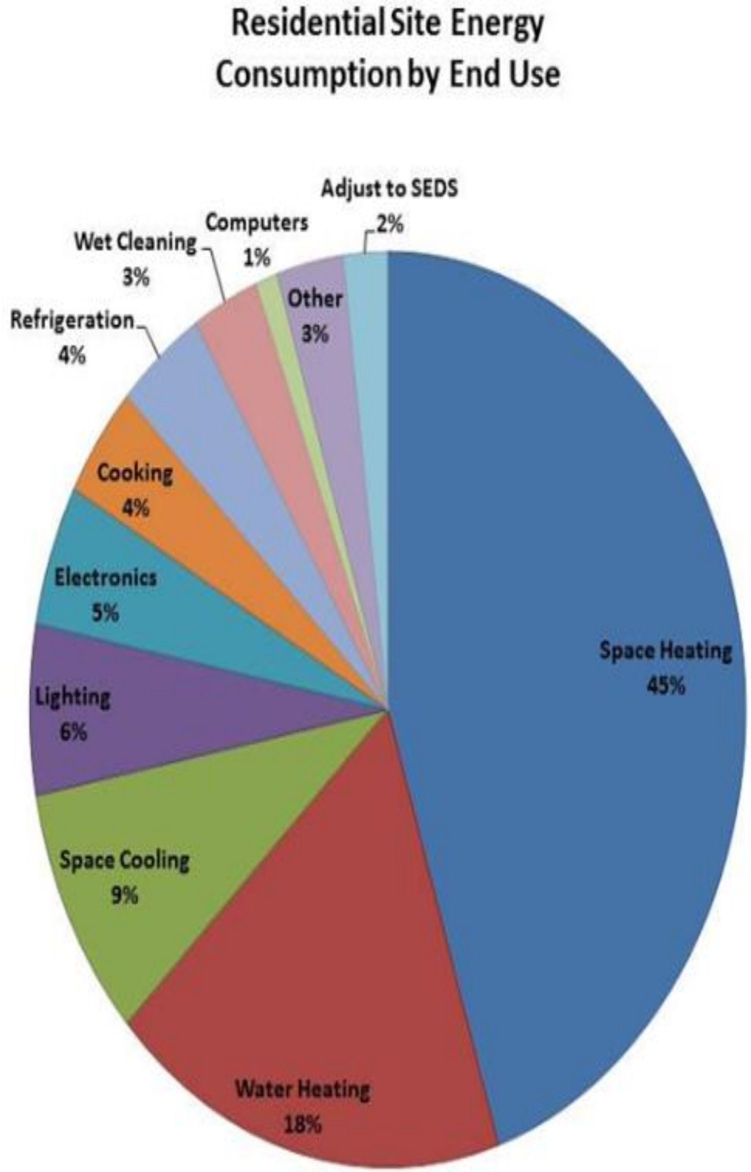
- Lowering household energy bills
- Increasing energy available for export
- Increasing comfort
- Reducing local air pollutants

*It was estimated that cutting UK building emissions by **25%** would have a similar impact to take every car off the road in the UK

2. The major energy consumption in buildings

2.The major energy consumption in buildings

- heating, ventilation and air conditioning (HVAC) cooling
- Lighting
- Water heating
- Electronics
- Cooking
- other



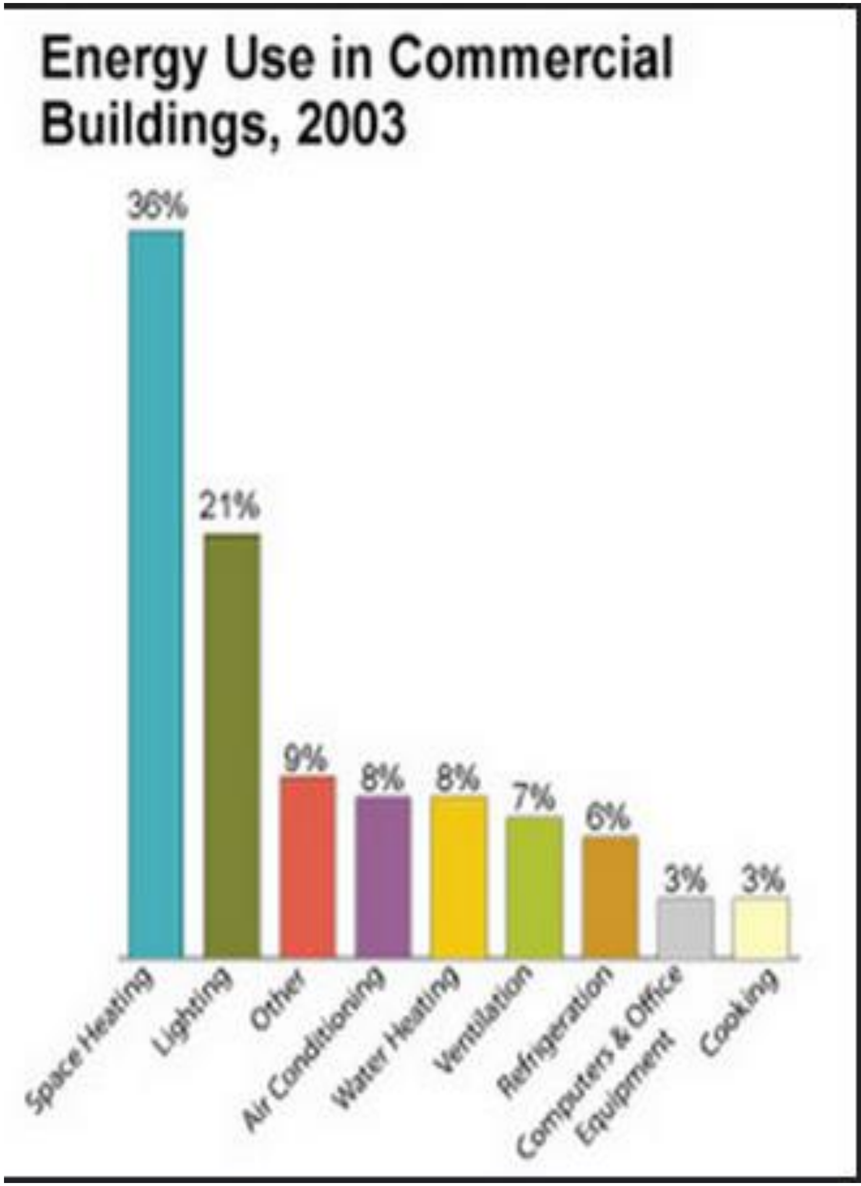


Figure3:show the energy consumption in (commercial and residential) buildings

3. Technique use to reduce energy consumption in buildings

- **3.1 Technique use to reduce energy consumption in HVAC**
- **3.2 Using Day lighting to Save Energy for lighting**
- **3.3 SWH use to reduce energy consumption for heating water**

3.1 Technique use to reduce energy consumption in HVAC buildings

- 1.Insulation

Thermal insulation is the reduction of heat transfer (the transfer of thermal energy between buildings of and its surroundings)

Measures the heat transfer

To calculate heat transfer through walls, roofs & windows by three method:

1.Condection :is the transfer of heat between substances that are in direct contact with each other

q=KA$\frac{\Delta T}{L}$

R=$\frac{L}{KA}$

- q= heat transfer (W)
- A = heat transfer area (m^2)
- k = thermal heat coefficient (W/m K)
- ΔT =temperature difference (K)
- L=thickness (m)
- R= Thermal Resistance (m^2K /w)

- **2.Convection**
- Thermal energy is transferred from hot places to cold places by convection. Convection occurs when warmer areas of a liquid or gas rise to cooler areas in the liquid or gas
- q=H*A*ΔT
- R=$\frac{\Delta T}{q}$
- h = heat transfer coefficient (W/m^2K)

- **3.Radiation**
- Radiation is a method of heat transfer that does not rely upon any contact between the heat source and the heated object as is the case with conduction and convection
- q=$\sigma * A * T^4$
- σ = Stefan-Boltzmann constant (5.67x10^8 W/$m^2 k^4$)

Consideration of materials used

Factors affecting the type and amount of insulation to use in a building include:

- thermal conductivity
- moisture sensitiveness
- compressive strength
- Ease of installation
- Durability - resistance to degradation from compression, moisture, decomposition, etc.
- Ease of replacement at end of life

- Cost effectiveness
- Toxicity
- Flammability
- Environmental impact and sustainability
- Considerations regarding building and climate:

Insulation materials

Some type of insulation materials to insulate wall , roof &floor

A . Polyurethane Spray foam

is a type of insulation that is sprayed in place through a gun.

-**Polyurethane and Isocyanate** foams are applied as a two-component mixture that comes together at the tip of a gun, and forms an expanding foam.

-Polyurethane foam is sprayed directly onto **wall** and **floor cavities** as a liquid and quickly transforms into thick, hard foam insulation.

- In fact, with spray foam, HVAC sizing can be reduced as much as **35%** without the loss of efficiency and comfort


More Energy Efficient

- **B . Cellulose**
- Cellulose insulation is often made by hammer milling waste newspaper .
- The thermal conductivity of loose-fill cellulosea is approximately is 0.035 W/m K at 10 degrees c
- Subsequent real world surveys have cellulose performing 20-30% better at reducing energy used for heating than fiberglass

- Long-term cost savings , One installer claims cellulose insulation "can save homeowners 20 to 50 percent on their utility bills.
- cellulose acts to distribute moisture throughout the cavity, preventing the buildup of moisture in one area and helping to dry the moisture more quickly.
- Weight For a given R-value, loose cellulose weighs roughly three times as much per square foot as loose fiberglass .
- Four major types of **loose-fill cellulose insulation products** .
- **dry cellulose**
- **spray applied cellulose**
- **stabilized cellulose and**
- **low dust cellulose.**

- **C. fiberglass**
- Fiberglass is manufactured from sand and recycled glass, and mineral fiber ("rock wool ") is made from basaltic rock and/or recycled material from steel mill wastes
- Two types: (Batts or Rolls)
- Easy Installation
- Most common insulation type and cheap
- Thermal conductivity 0.04 w/m k

- **D . Nansulate® Coatings**
- Nansulate® coatings are a patented technology by Industrial Nanotech, Inc.
- that utilize a nanomaterial with an extremely low thermal conductivity of 0.017 W/m K .
- This material allows the coatings to effectively inhibit heat transfer in a thin layer.

- It can be applied on walls, ceilings, and other areas of the building envelope
- Nansulate® Translucent GP over windows and skylights allows in diffused light
- Nansulate® **allows 92% visible light** transmittance and provides the opportunity to daylight without sacrificing building thermal
- .

- **Thermal resistance** (1/U), measured in m2*k*w1, of the wall section coated with Nansulate® **was increased by 28.98%**

Table 1: shows the R- value of some insulation materials

Materials 1" (2.5 cm) thickness	R-value(m2.k/w)	R-value(ft2.˚f.h/BTU)
Spray foam	0.63	R-3.6
Cellulose	0.52-0.67	R-3-R-3.8
Fiberglass	0.55-0.76	R-3.1-R-4.3
Brick	0.03	R-0.2
glass	0.025	R-0.14
poured concrete	0.014	R-0.08

Table 2: shows amount of heat flow reduction and energy efficiency for different R - value

R-Value Reality Check		
Insulation R-Value	Amount of heat flow reduction	Improvement in Energy Efficiency vs. R-8 Insulation
R-8	90%	-
R-12	93%	3%
R-16	95%	5%
R-20	96%	6%
R-32	97%	7%

Based on heating and cooling costs of 4,000 sq. ft of insulation

- Some type of insulation glazed to insulate windows
- **E. Double-glazed**
- Double-glazed windows have two sheets of glass with a gap in between
- usually the gap about **16mm**, to create an insulating barrier that keeps heat in. This is sometimes filled with gas.

- The most energy-efficient type for double glazing is low emissivity (Low-E) glass.
- This often has an invisible coating of metal oxide, normally on one of the internal panes.
- This lets in light and heat but cuts the amount of heat that can get out.

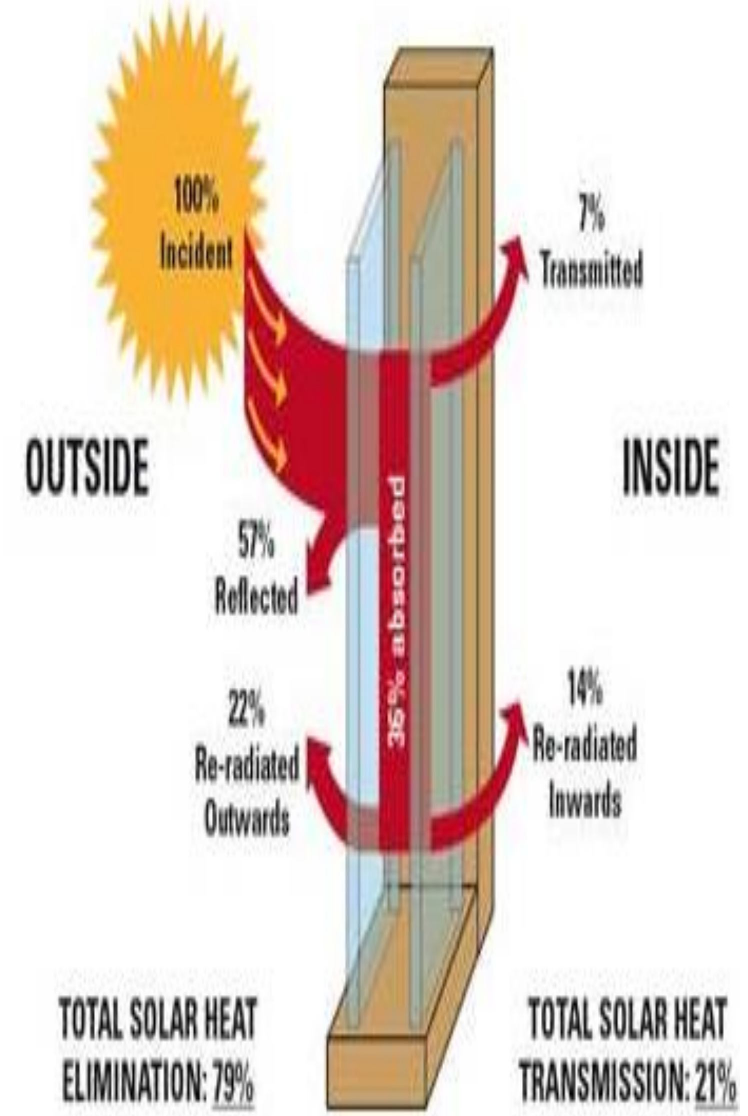
- **Gaps between the glass**
- Very efficient windows might use gases such as argon, xenon or krypton in the gap between the sheets of glass.

- savings for energy-efficient glazing will be different for each home and each window, depending on **its size, material and the installer you choose**

-

When around **25% of the gas has evaporated**, the thermal performance of the windows will be reduced


Low-E Insulating Glass
Argon Gas Fill (optional)
Double Panes
Spacer
Sill


100% Incident
7% Transmitted
OUTSIDE
INSIDE
57% Reflected
36% absorbed
22% Re-radiated Outwards
14% Re-radiated Inwards
TOTAL SOLAR HEAT ELIMINATION: 79%
TOTAL SOLAR HEAT TRANSMISSION: 21%

- **F . Smart glasses**
- Smart glass windows can automatically change their tint based on outdoor temperature and lighting conditions
- The recent development of electro chromic (EC) windows, often called “smart windows”
- They are ‘smart’ because they can be programmed to absorb and reflect a different amount of light throughout the day in order to cool or warm up a room

- It is estimated that the technology can reduce heating and cooling costs by up to 35% for office buildings and improve natural lighting

- Smart glass windows are about 70 per cent more energy efficient during the summer season and **45 per cent** more efficient in the winter compared to standard dual-pane glass.

* according to window manufacturer Anderson Corporation.

- In summer, Smart Glass actively reduces the amount of solar heat that enters a home.
- In winter, it works in reverse, reflecting warmth back inside your home

- Smart windows can provide even more savings in terms of the amount of greenhouse gas emissions that can be reduced
- Some major buildings have already installed smart windows
- In its first year after installation, the Empire State Building reported energy savings of US$2.4 million and cut carbon emissions by 4,000 metric tones, equivalent to planting 750 acres of pine forests.

- The River Centre in St. Paul, Minnesota installed smart windows as part of its initiative to reduce its carbon footprint by 80 per cent in three years.

- **2.colure of buildings**
- Dark roofs may become up to **39 C° (70 F°)** hotter than the most reflective white surfaces.
- US Studies have shown that lightly colored roofs use **40 percent less energy** for cooling than buildings with darker roofs.

- White roof systems save more energy in sunnier climates.

- Advanced electronic heating and cooling systems can moderate energy consumption and improve the comfort of people in the building

- **3.Programmable thermostats and building automation systems.**
- adjust temperature to preset levels.
- For larger or more complex buildings, consider using a building automation system, a centralized control system that automates operation of HVAC and lighting.
- These systems can save an average of **5 to 15 percent** of total building consumption

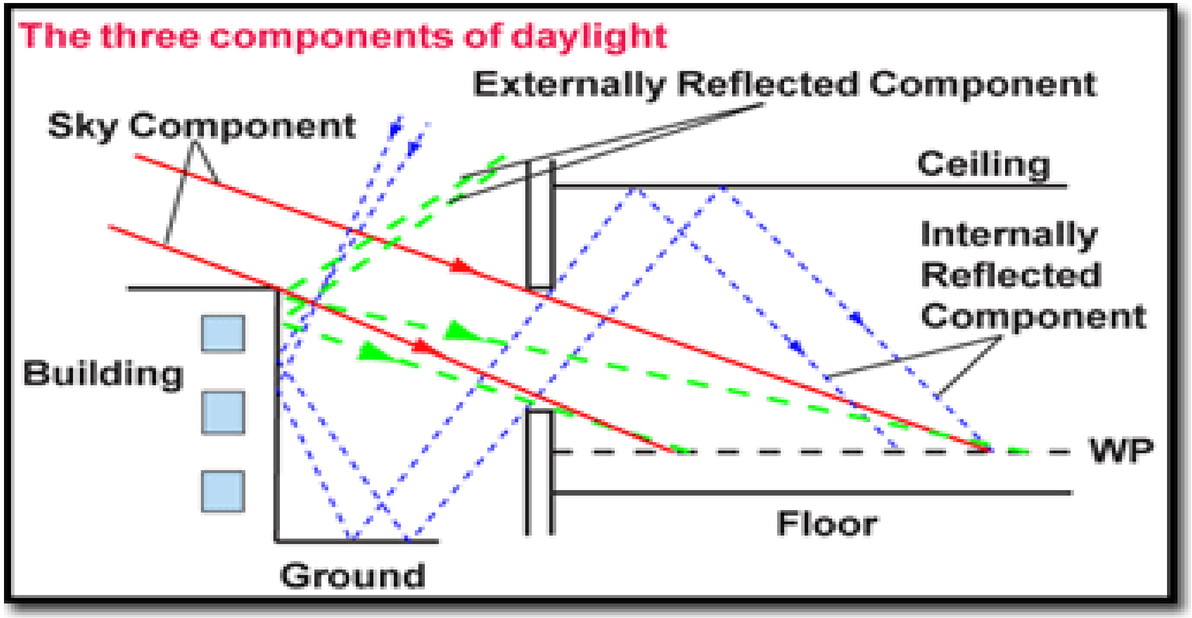
3.2 Using Day lighting to Save Energy for lighting

- On a clear day, the sun provides **8,000 to 10,000foot-candles of light (86114.1- 10764.3 lux)**
- Even **through the glass, it provides 5,000 foot-candles on a clear day (5382.1 lux)**
- **1,000 foot-candles (1076.4 lux) on a cloudy day**

- A good day lighting design can **save up to 75 percent of the energy** used for electric lighting in a building
- Both the **location and interior characteristics** of a building are important in day lighting design and should be the first things to consider

$$\text{Daylight factor} = \frac{\text{Indoor illuminance (at a point)} \times 100\%}{\text{Outdoor illuminance (from unobstructed sky)}}$$

The daylight factor is the amount of daylight reaching a point or a surface


The three components of daylight
Externally Reflected Component
Sky Component
Ceiling
Internally
Reflected
Component
Building
WP
Floor
Ground

Day lighting strategies

- Day lighting strategies can be divided into two main categories:
- Side lighting and
- top lighting strategies.
- The key difference of the two strategies is that:
- side lighting admits light from the perimeter walls of the building while
- top lighting strategies admit light through the top of the building.

- The selection of day lighting system will depend on the layout, the orientation and the surroundings of the building.

Day lighting strategies

- (a)Side lighting
- Side lighting is a technique that provides daylight through apertures located in the perimeter walls of a building.
- In order to maximize the daylight penetration and reduce window glare the daylight glazing are placed as close to the ceiling as possible for bouncing daylight deep into the room by the ceiling.

- The accessibility of daylight in side lighting strategy is highly dependent on building's facade orientation
- Several shortcomings hamper their applications.
- Firstly, day-light gained depends on the area of window or clerestory. Some buildings do not have enough area for windows openings.

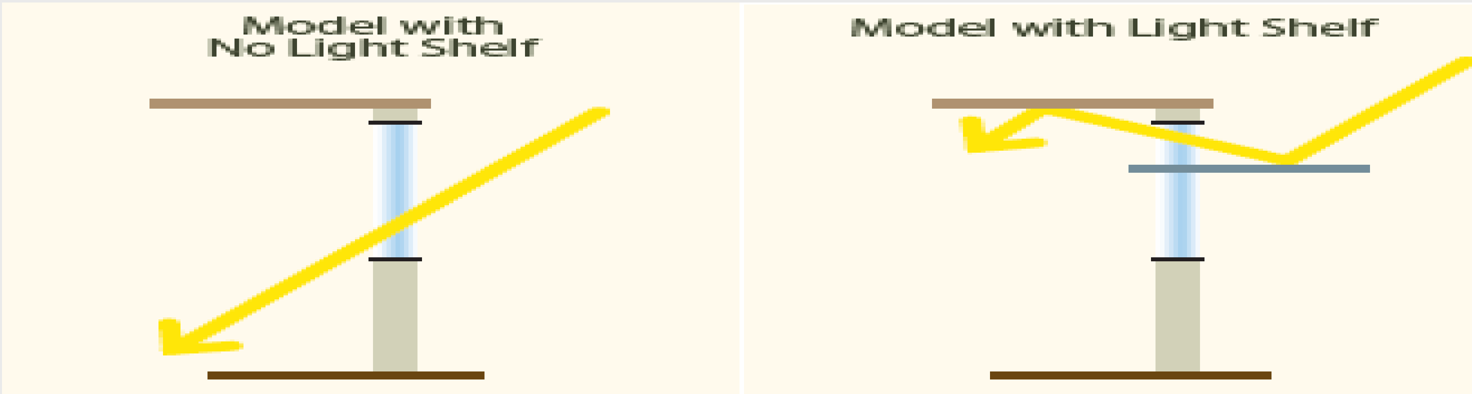
- Secondly , daylight concentrates on area near the windows and it decreases as room is deeper.

- Thirdly, windows cannot automatically control the daylight if the sun is excessive which makes occupant sun comfortable

- (1) Clerestory windows
- These are high, vertically placed windows
- Increased Light
- Reduce energy consumption is not much
- Better Privacy
- Cross Ventilation
- High Cost
- Heat Absorption

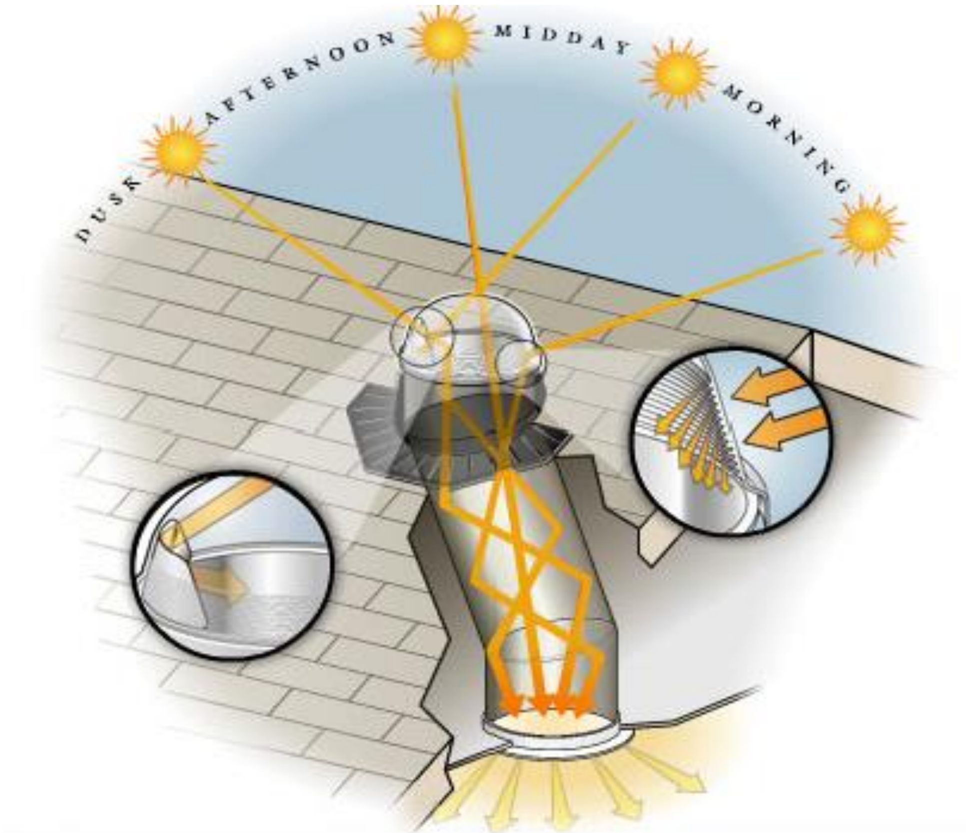
- (2) **light shelves**
- A light shelf is an architectural element that allows daylight to penetrate deeper into a building.
- A light shelf is a horizontal light-reflecting overhang
- which is placed above eye-level and
- has a high-reflectance upper surface.

- This surface is then used to reflect daylight onto the ceiling and deeper into a space.
- In the tropics, light shelves may be most effective on the north side of the building to exclude summer sun.
- and awning width should be designed to exclude unwanted sun.


Model with
No Light Shelf
Model with Light Shelf

- (B)Top lighting
- Top lighting strategies provide daylight through rooftop apertures
- These strategies can provide uniform daylight distribution to the entire top floor area if the entire top floor uses rooftop apertures distributed across the roof area.
- Large single level floor areas and the top floor of multi-story buildings can benefit from top lighting

- (1) solar tube
- a smart technology which takes skylights one step further by **refracting, reflecting and concentrating solar light into a small tube using mirrors and lenses**
- Solar tubes range from **$200 to $500** depending on their size and produce **3,750 lumens.**
- A solar tube could replace four 60 Watts light-bulbs – which roughly corresponds to $100 a year.


DUSK
AFTERNOON
MIDDAY
MORNING

- (2) Saw tooth roof
- Saw tooth roofs employ a series of either vertical or sloped glasses
- which are separated by sloped roof elements
- Saw tooth roof can be used to uniformly illuminate a large floor area
- minimizing impacts on building's overall height
- The orientation of the glazing can be selected so as to maximize daylight level while reducing direct solar radiation and heat gain

•

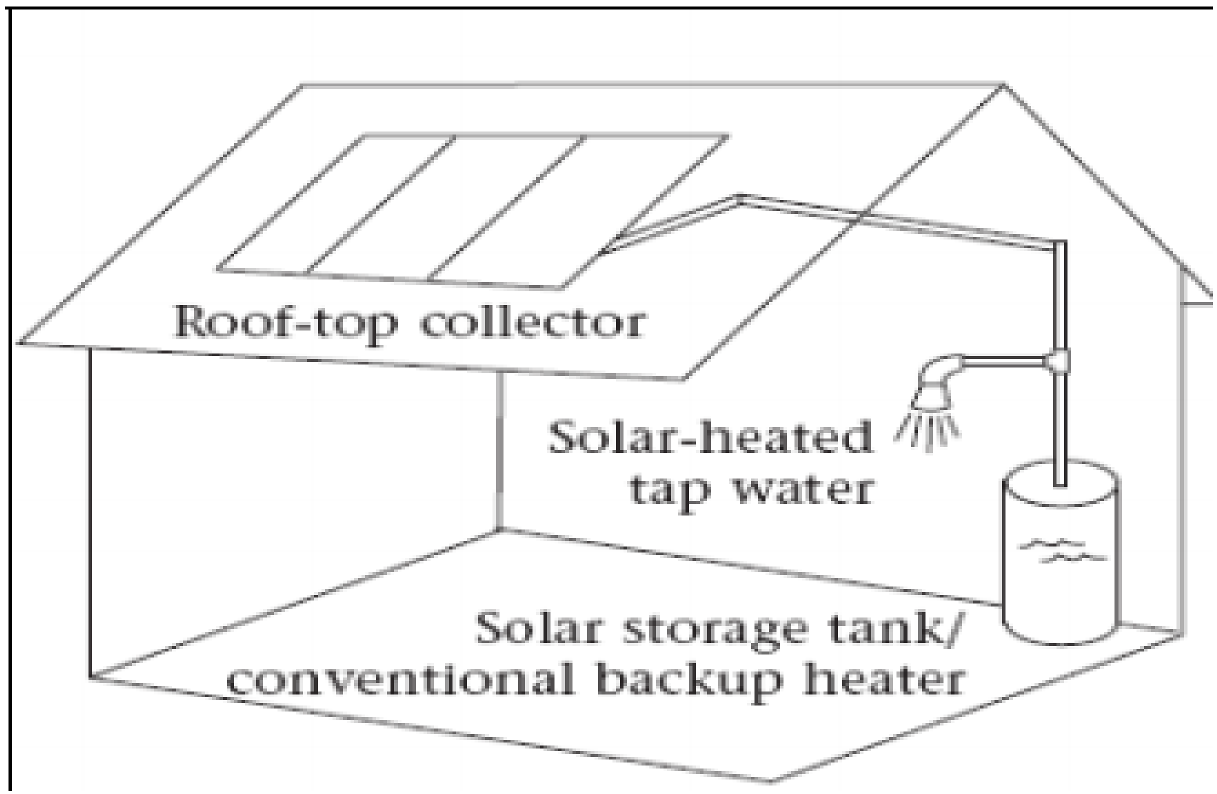
3.3 SWH use to reduce energy consumption for heating water

- **Solar Water Heating System Performance**

- This base system represents current technology, using a selective surface collector and glycol as the heat transfer fluid.

- The performance of a SWH system may be defined by its solar fraction

- A system with a **60% solar fraction** reduces the water heating demand (and also the water heating energy costs) **by 60%**


Roof-top collector
Solar-heated
tap water
Solar storage tank/
conventional backup heater

4.Heat island

4.1 What Is an Urban Heat Island?

4.2 Why Do We Care About Heat Islands?

4.3 What Can Be Done?

4.1 What Is an Urban Heat Island?

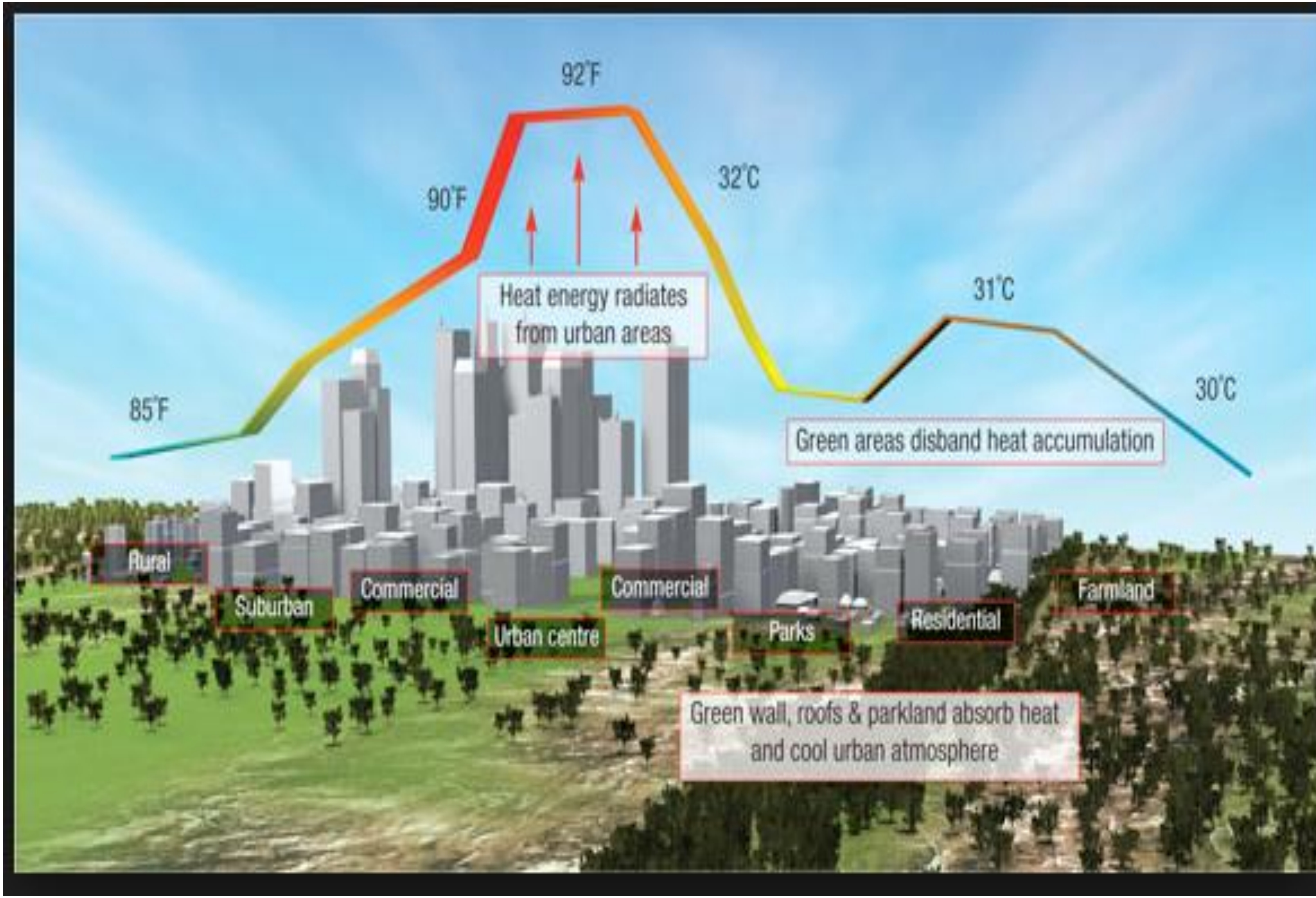
- As urban areas develop, changes occur in their landscape.
- Buildings, roads, and other infrastructure replace open land and vegetation.
- Surfaces that were once permeable and moist become impermeable and dry.
- These changes cause urban regions to become warmer than their rural surroundings, forming an "island" of higher temperatures in the landscape.

- Heat islands occur on the surface and in the atmosphere.

- On a hot, sunny summer day, the sun can heat dry, exposed urban surfaces, such as roofs and pavement, to temperatures 50–90°F (27–50°C) hotter than the air.

- while shaded or moist surfaces often in more rural surroundings remain close to air temperatures

- Surface urban heat islands are typically present day and night, but tend to be strongest during the day when the sun is shining.


92˚F
90˚F
32˚C
85˚F
Heat energy radiates from urban areas
31˚C
30˚C
Green areas disband heat accumulation
Rural
Suburban
Commercial
Urban centre
Commercial
Parks
Residential
Farmland
Green wall, roofs & parkland absorb heat and cool urban atmosphere

4.2 **Why Do We Care About Heat Islands?**

- Elevated temperature from urban heat islands, particularly during the summer, can affect a community's environment and quality of life.

- **most impacts are negative and include:**

1.Increased energy consumption:

the heat island effect is responsible for **5–10%** of peak electricity demand for cooling buildings in cities.

2.Elevated emissions of air pollutants and greenhouse gases

3. Compromised human health and comfort

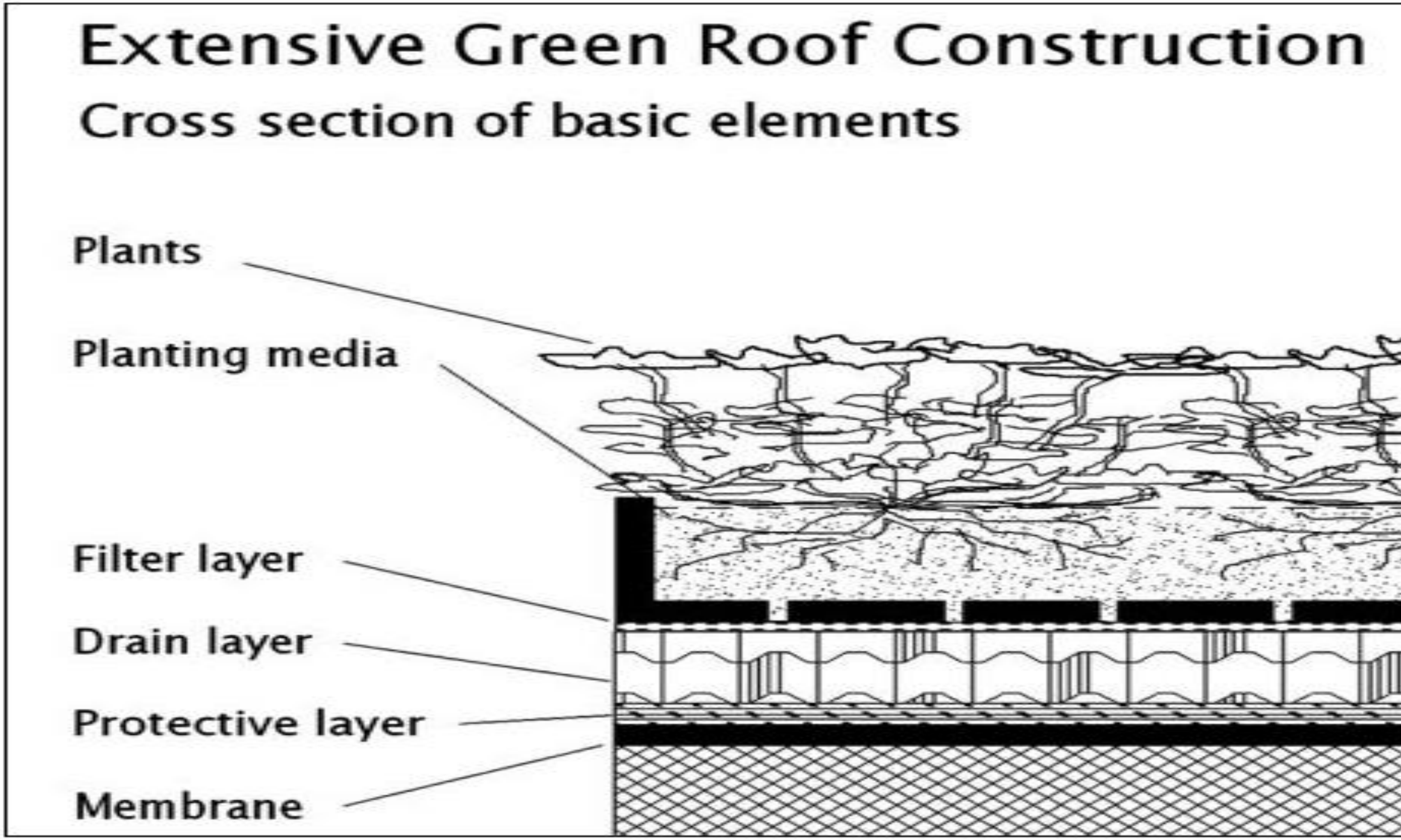
4. Impaired water quality

4.3 What Can Be Done?

- increasing tree and vegetative cover
- creating green roofs (also called "rooftop gardens" or "eco-roofs")
- installing cool—mainly reflective—roofs; and
- using cool pavements

Green roofs

- A **green roof** or **living roof** is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a water proofing membrane



Basic elements of an extensive green roof.

Benefits Green roofs

- **1.Public Benefits**
- **Aesthetic Improvement**
- **Waste Diversion**
- The use of recycled materials in the growing medium
- Prolonging the service life of heating, ventilation, and HVAC systems through decreased use

- **Storm water Management**
- taken up by the plants from where it is returned to With green roofs, water is stored by the substrate and then the atmosphere through transpiration and evaporation.

- In summer, depending on the plants and depth of growing medium, green roofs retain 70-90% of the precipitation that falls on them

- in winter they retain between 25-40%..

- Green roofs not only retain rainwater, but also moderate the temperature of the water and act as natural filters for any of the water that happens to run off.
- Green roofs reduce the amount of storm water runoff and also delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods.

- **Moderation of Urban Heat Island Effect**
- Through the daily dew and evaporation cycle, plants on vertical and horizontal surfaces are able to cool cities during hot summer months and reduce the Urban Heat Island (UHI) effect.
- The light absorbed by vegetation would otherwise be converted into heat energy.
- UHI is also mitigated by the covering some of the hottest surfaces in the urban environment – black rooftops.

- Green roofs can also help reduce the distribution of dust and particulate matter throughout the city, as well as the production of smog.
- This can play a role in reducing greenhouse gas emissions and adapting urban areas to a future climate with warmer summers.

- **New Amenity Spaces**
- Green roofs help to reach the principles of smart growth and positively affect the urban environment :
- by increasing amenity and green space and reducing community resistance to infill projects.
- Green roofs can serve a number of functions and uses, including:
- Community gardens (e.g. local food production or co-ops)
- Commercial space (e.g. display areas and restaurant terraces)
- Recreational space (e.g. lawn bowling and children’s playgrounds)

- **2.Private Benefits**
- **Energy Efficiency**
- The greater insulation offered by green roofs can reduce the amount of energy needed to moderate the temperature of a building, as roofs are the sight of the greatest heat loss in the winter and the hottest temperatures in the summer.

- For example, research published by the National Research Council of Canada found that an extensive green roof reduced the daily energy demand for air conditioning in the summer by over 75% (Liu 2003).

- **Reduction of Electromagnetic Radiation**
- The risk posed by electromagnetic radiation (from wireless devices and mobile communication) to human health is still a question for debate.

- Nevertheless, green roofs are capable of reducing electromagnetic radiation penetration by 99.4%

- **Noise Reduction**
- Green roofs have excellent noise attenuation, especially for low frequency sounds.
- An extensive green roof can reduce sound from outside by **40 decibels**,

5.Green power

5.Green power

- Solar power
- Wind power
- Hydro power
- Geothermal