EBS COMPLETE SUMMARY NOTES

Comprehensive summary of lectures, e-learning, readings, key tutorial content, and relevant research for Environmental Building Systems.

CONTENTS

EBS SUMMARY NOTES

LECTURE 1 – Introduction to EBS

'Environmental' – external conditions or surroundings, especially those in which people live or work.

'Building' – something built with a roof and walls, such as a house or factory.

'System' - an assemblage or combination of things or parts forming a complex or unitary whole.

'Environmental Building System' – something built with a roof and walls, which has a combination of parts to form a whole unit that responds to external conditions or surroundings.

A well-designed house keeps you:

- **Dry**: roof, gutter, downpipes, and stormwater pipes
- **Warm/cool**: insultation, ventilation, heating, cooling
- **Clean**: water supply, wastewater removal, sewage and rubbish disposal
- **Supplied**: storage of food, water and objects
- **Fun**: live, play, relax etc.

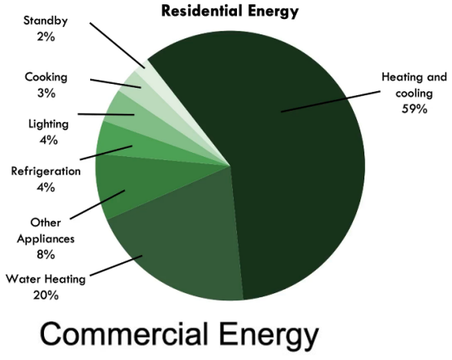
Sustainable buildings:

- Excellent *climate responsive design*
- High quality *services* and *materials* specification
- Construction quality
- Responsible users

Differences between **residential** and **commercial** environmental systems:

- Hours of operation
- Heating and cooling loads
- Lighting needs
- Electrical needs
- Fire needs
- Transportation and access needs
- Ownership / responsibility

Residential	Commercial
Simple.	Complex.
Mainly needs heating.	Mainly needs cooling.
Easy shading in summer.	Difficult to shade all year round.
Want to get sunlight on thermal mass to give free heating.	Want to avoid direct sunlight. Thermal mass used to absorb heat load.
Lighting and equipment not significant.	Lighting and equipment give larger component of heat load.



Commercial Energy

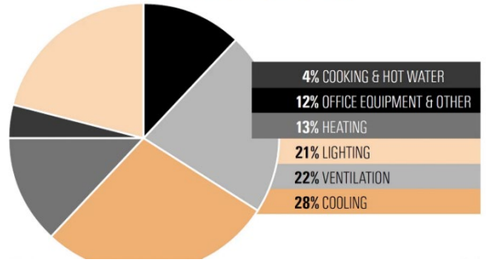


Figure 6: Commercial building greenhouse gas emission share by end use 1990 (EMET 1999)

Energy Comparison

Energy	Residential	Commercial
Heating	~30%	13%
Cooling	~7%	28%
Ventilation	0%	22%
Hot Water	28%	3%
Lighting	5%	21%
Appliances	30%	13%
Total	100%	100%

Sustainable development meets the needs of the present *without* compromising the ability of *future generations* to meet their own needs.

Sustainability is good design in *every* part of Architecture and Construction.

LECTURE 2 – Passive Design

Passive Design: comfort in the absence of energy. Balance of heat energy flow without adding extra heating and cooling.

Building envelope: area that separates conditioned space from unconditioned space or the outdoors.

Factors to control *for*: temperature (average, daily, seasonal), humidity, solar gain (daily, seasonal), wind, internal loads.

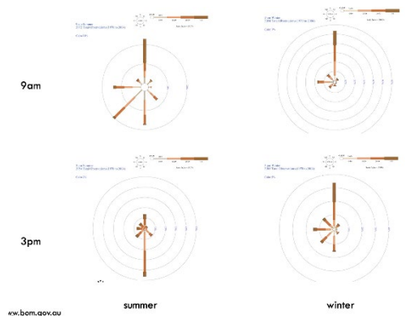
The sun creates: warmth, wind, storms, waves, plant and animal life.

Winter solstice: shortest sun path & daylight hours of year.

Summer solstice: longest sun path & daylight hours of year.

Diurnal shift: difference in temperature between night and day. Thermal mass balances diurnal shift and helps maintain constant temperature throughout night and day.

Wind roses: graphic tool used by meteorologists to represent wind speed and direction at a particular location.



Characteristics of Melbourne Climate:

- Medium diurnal (day/night) temperature range near coast to high diurnal range inland.
- Four distinct seasons. Summer and winter can exceed human comfort range. Spring and Autumn are ideal for human comfort.
- Mild to cool winters with low humidity.
- Hot to very hot summers, moderate humidity.

Shading

Shading reduces summer temperatures, improves comfort and saves energy.

- Shading glass is the best way to reduce unwanted heat gain, as it is one of the biggest sources.
- Shading uninsulated and dark coloured walls can also reduce the heat load on a building. Light coloured roofs can reflect up to 70% of summer heat gain.
- **Evergreen** plants are recommended for shading for hot humid and some hot dry climates. For other climates, use **deciduous** vines or trees to the north, and deciduous or evergreen trees to the east or west.
    - Deciduous plants allow winter sun through their bare branches and exclude summer sun with their leaves.
    - Pergolas covered with deciduous vines provide self-adjusting seasonal shading.
    - Trees with high canopies are useful for shading roofs. Shrubs are good for shading windows.
    - Wall vines and ground cover insulate against summer heat and reduce reflected radiation.
- Correctly designed **eaves** are generally the simplest and least expensive shading method for northern elevations.
- **Fixed louvres** assist in allowing winter heating and summer shading. Generally, spacing between fixed horizontal louvres should be 75% of their width.
- **Adjustable Awnings** good for fixing to windows to block hot summer sun, especially east and west. Retractable in winter to allow solar heat.
- **Vertical shading** structures are also useful in allowing light, views and ventilation while excluding sun, especially for west and east low sun angles.
    - Adjustable shading allows user to control for desired level of shade, useful for variable spring and autumn needs, as well as facilitating for adaptation to changing climatic conditions.
- Use **shaded skylights** to compensate for any resultant loss of natural daylight.

Angle of the sun in sky at noon can be calculated for these times as follows:

- **Equinox** = 90° - latitude
- **Summer solstice** = equinox + 23.5°
- **Winter solstice** = equinox – 23.5°

Glazing

Windows let in light, fresh air and offer views which connect interior living spaces with the outdoors.

Up to 40% of a home's heating energy can be lost and up to 87% of heat gained through windows.

To increase thermal comfort, objective should be to achieve an inside glass surface temperature as close as possible to desired room air temperature. This means glass is neither cold in winter nor hot in summer.

For all orientations, low U-value outperforms a high U-value.

Thickness of glass doesn't affect U-value or SHGC, but significantly affects noise transmission.

Glazing and framing types:

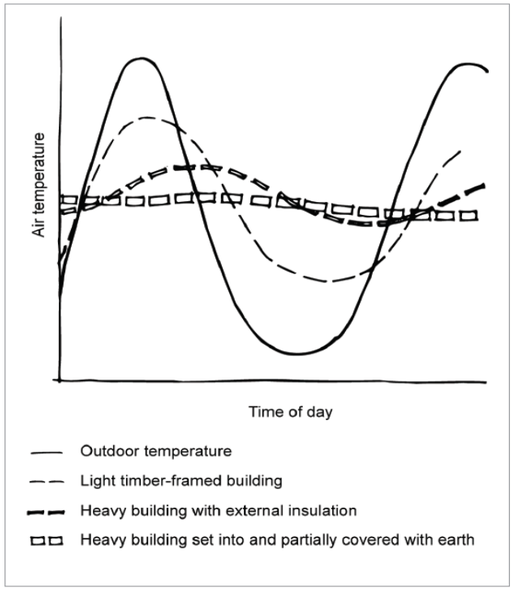
- **High transmission/low-e glass** has a coating that allows daylight from sun to pass into house but reduces amount of long wavelength infrared heat that can escape through window.
- **Low transmission/low-e glass** has coating that reduces amount of solar heat gain while still maintaining good levels of visible light transmission.
- **Laminated glass** has plastic glazing interlayer, improving impact resistance for areas such as bathrooms, doors etc.
- **Insulated glass units (IGUs)** use combo of two or more glazing layers sealed with a gap in between. Useful insulation for both hot and cold climates.
- **Secondary glazing** allows single-glazed windows to be retrofitted with a transparent acrylic or glass sheet attached to the inside of frame via secondary frame or magnetic strips. Air space between glass reduces U-value and air infiltration.
- **Aluminium window frames** are light, strong and durable, with a variety of powder coated and anodised finishes, but aluminium is also good conductor of heat and can decrease insulating value of a glazing unit. Especially dark coloured frames in full sun absorb a lot of solar heat and conduct it inside.

Security shutters for glazed areas are good at stopping solar gain and providing a small amount of insulation when closed, although they block light.

Thermal Mass

Thermal mass, correctly used, moderates internal temperatures by averaging out *diurnal (day-night)* extremes. This increases comfort and reduces energy costs.

A lot of heat energy is required to change temperature of high-density materials like concrete, bricks and tiles, which have high thermal mass. Lightweight materials such as timber have low thermal mass.



Daily temperature fluctuations for different construction methods.

To be effective, thermal mass must be integrated with sound **passive design techniques**. Consider:

- Glazing facing appropriate directions.
- Appropriate levels of shading.
- Ventilation and insulation in building.

Thermal mass is not a substitute for insulation. Thermal mass stores and re-releases heat; insulation stops heat flowing into or out of a building. A high thermal mass material is not generally a good thermal insulator.

Use surfaces such as quarry tiles or simply polish the concrete slab. Don't cover areas of the slab exposed to winter sun with carpet, cork, wood or other insulating materials: use rugs instead.

Green walls are external or internal vertical building elements that support a cover of vegetation rooted either in stacked pots or growing mats.

- Constructed with plants rooted in sheets of fibrous material, or vertical arrays of pots or planters.
- ‘Green wall’ techniques can be used on homes in suburban settings as part of aesthetic enhancement, to improve the overall climate responsiveness of individual dwellings, and to treat wastewater.
- Can act as evaporative air conditioner, especially if water is used. Can humidify and oxygenate the air and improve indoor air quality by acting as filters, trapping dust and absorbing pollutants such as volatile organic compounds that may be given off by carpets, paints, adhesives and sealants.

Green roofs and walls contribute towards a wide range of **sustainable development objectives**, including:

- Stormwater management
- Climate change mitigation and adaptation
- Conservation and enhancement of biodiversity.

Retention and binding of contaminants (bird droppings or atmospheric pollution) can help remove harmful pollution from runoff into aquatic ecosystems.

On top of the structural components, a green roof typically has seven layers:

1. Waterproofing membrane
2. Root barrier (polyethylene sheeting, copper membrane)
3. Insulation (optional)
4. Drainage layer (synthetic drainage mesh, granular aggregate)
5. Filter fabric (geotextile)
6. Growing medium — planting medium or substrate (manufactured soil, crushed brick or other inorganic material)
7. Vegetation (shallow rooted on extensive roofs, deeper rooted on intensive roofs).

Earth-sheltered housing:

- Building with earth is one of the oldest types of construction, dating back to prehistory.
- Building up banks of earth (berming) is one of the simplest ways to provide the basics of shelter.
- Using turf is one of the oldest known ways of creating a long-lasting, low-maintenance, waterproof roof covering.

Importance of trees:

- Fewer trees in cities create **urban heat island** effects – where buildings and footpaths absorb the sun’s heat and then radiate it back out.
- Apart from providing shade, trees cool cities through the process of **transpiration**, in which water is absorbed through the roots and pushed into the air via tiny pores in leaves.

Resilient Homes

Spaces should be *flexible and adaptable*. Children want to be in same space as parents – open planning is good. Teenagers want more separation and privacy. Eventually, house may become home to multi-generations, with parents and adult children (and their partners) living together, or it may house empty nesters. A well-designed house should be able to adapt to these changes without needing to go through multiple renovations. Think loose-fit design too, like adjustable shelves and panels that can adapt to suit different needs such as fridge or storage.

Consider materials thoroughly. For example:

- **Inert metal cladding** materials such as zinc and copper come at a cost premium upfront but can be maintenance-free for 60+ years. Conventional metal roof sheeting can come with a premium finish such as Colourbond Ultra.
- **Internal polished timber floorboards** can only be sanded back three times before they become too thin, so for longevity, use oil finishes that can be touched up without sanding, or provide coverings to areas with most wear.

Star Ratings

Each rating tool has different *categories* (with number of *criteria* to be met), each having an *associated point value*. *Specific calculators* are often used to determine how many points each criterion can be awarded.

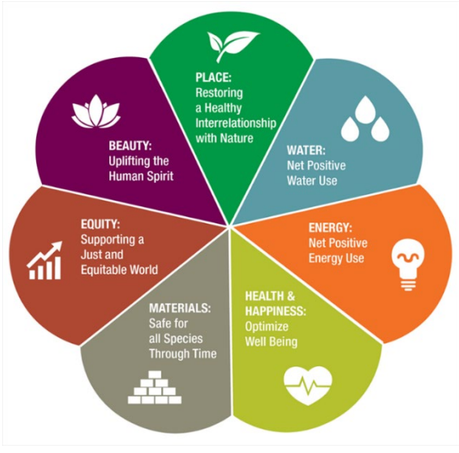
Assumptions need to be made on building usage, density of users etc, even if they don’t follow those numbers in real life, need to standardise ratings across all buildings.

- **Simulation effect**: simulation can in fact be quite accurate, but data inputted into simulations may not reflect actual conditions.

Greenstar uses a credit system to rate sustainability of buildings at a world scale.

Living Building Challenge consists of seven performance categories, or “petals”: *place, water, energy, health + happiness, materials, equity and beauty*.

- Also categorises different project types into four typologies: *new building, existing building, interior, landscape or infrastructure*.
- Most rigorous. Requires generation of own energy, harvest own water, deal with all waste on-site. And enhances the environment, hence flower logo – is beautiful *and* gives back to environment.



Consider circular economies. Zero waste.

Cogeneration (and trigeneration): simultaneous production of two useful forms of energy.

Chemical fire suppression systems are effective for certain applications. Methods include:

- **High expansion foam systems**
  - Forms layer of air-filled bubbles throughout contained area, holding flammable materials, effectively smothering combustion and blanketing flames.
  - For highly combustible materials and areas.
  - Minimal water damage.
  - Reduced hazardous run-off.
- **Low expansion foam systems**
  - Good for fires from flammable liquids.
  - Foam cools surface of flame by coating liquid.
- **Carbon dioxide systems**
  - Effective in unoccupied areas.
  - Forces oxygen out of enclosed area to avoid combustion.
- **Condensed aerosol systems**
  - Releases minute particles which attack fire's free radicals, slowing, extinguishing fire.

Types of fire detection systems:

- **Spot-type heat-sensing detectors**
  - For detecting robust fires in confined spaces
- **Smoke particle-sensing detectors**
  - Smouldering fires
- **Flame-sensing radiant energy detectors**
  - High-value hazards, flaming fires
- **Gas-sensing detectors**
  - Hazardous gas

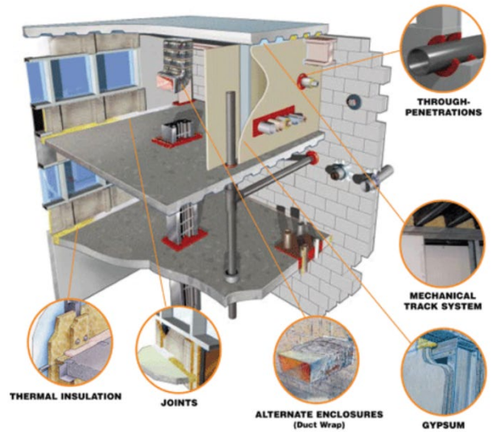
PFP = Passive Fire Protection, accomplished through:

- Preventing collapse through *structural fire resistance*.
  - Fire-proofing material, use concrete building.
- *Compartmentation*
  - Fire barriers, firewalls, partitions, smoke barriers – limits spread, allows safe egress.
- *Opening protection*
  - Fire doors and windows installed in opening of a fire barrier to maintain fire resistance.
- *Fire-stopping materials*
  - Properly sealing membrane penetrations with fire-proof material if viable.

Sprinkler system types:

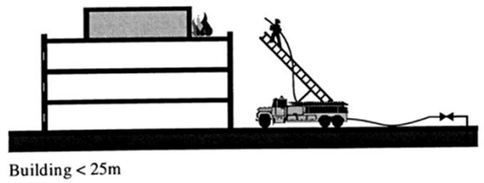
- **Wet-pipe system**
  - Contain water at sufficient pressure, provides immediate, continuous discharge through sprinkler heads, opens automatically in fire.
  - Used in hospitals, other situations of life safety.
- **Dry-pipe system**
  - Contain pressurised air that is released when sprinkler head opens in event of fire, allowing water to flow through piping and out nozzle.
  - Used where piping is subject to freezing.
- **Pre-action systems**
  - Dry-pipe, water flow controlled by valve operated by fire-detection devices more sensitive than sprinkler heads.
  - Used where accidental discharge would damage valuable materials.
- **Deluge systems**
  - Sprinkler heads open at all times, water flow controlled by valve operated by heat-, smoke-, or flame-sensing device.
  - Used for high-risk areas, such as transformers, but not areas susceptible to water damage.
- **Water mist systems**
  - Water converted to steam, which cools, wets, and moves oxygen away from flames, extinguish fire.
  - Can be used as part of either system above.
  - Used for areas with equipment sensitive to water, but frequently occupied.
- **Hybrid suppression systems**
  - Incorporate water and nitrogen as extinguishing agents discharged together from single emitter, system atomizes water to dense homogenous suspension, uses cooling and oxygen reduction mechanisms.
  - Used for total flooding applications, including data centres, museums, libraries, flammable liquids storage, industrial machine spaces.

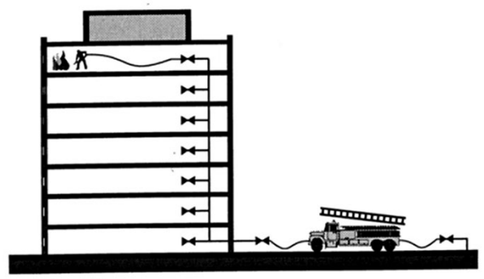
Note, colour of liquid alcohol in the glass bulb of sprinklers represents the trigger temperature.



COMMON EXAMPLES of PASSIVE FIRE PROTECTION. COURTESY OF SPECIFIED TECHNOLOGIES INC.

Fire booster pumps


Building < 25m


Building > 25m