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Building Design and Construction – Time for a Radical Rethink?

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Bizarre!

Even more bizarre!

- Not smart, just plain dumb!

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Key impacts of the built environment

- Energy used within buildings accounts for nearly 50% of UK CO_2 emissions with a further 10% arising from the production of construction materials
- Each year the UK construction industry uses 6 tonnes of building materials per head of population
- Waste from materials production and construction amount to 151 million tonnes per annum or 35% of UK total waste.
  - 90+ million tonnes p.a. construction & demolition waste
    - *20% of which is new material!*

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If we are serious about tackling climate change

We need less of this!

To deliver less of this!

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Lessons from the past - vernacular architecture

- Vernacular architecture has a form and function which enables:
  - comfortable conditions to be achieved (often in very hostile climatic conditions)
  - optimum and sustainable use of indigenous materials
  - low environmental impact

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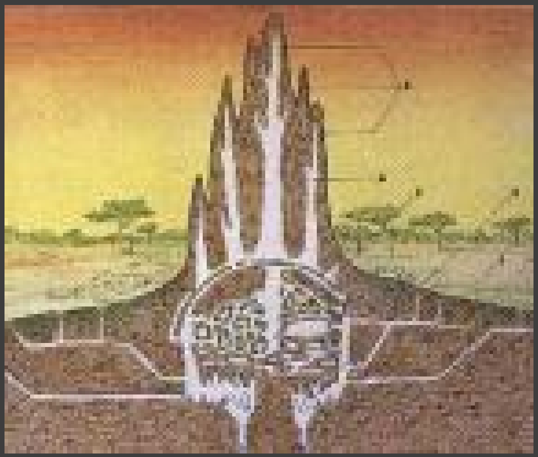
Lessons from nature - biomimicry



- Buildings should fully exploit the natural systems available **for free** to provide :
  - ventilation
  - cooling
  - heating
  - Daylighting
- Climate excluding vs. climate adaptive buildings
  - Bio-climatic design is much more challenging
  - Greater care required in construction, operation and maintenance to achieve optimum performance

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What is a sustainable building?

Comfortable, healthy internal conditions are achieved, whilst minimising environmental impact associated with construction and operation

Four key principles :

- Reducing embodied energy and resource depletion
- Reducing construction waste and energy in-use
- Minimising external pollution and environmental damage
- Minimising internal pollution and damage to health

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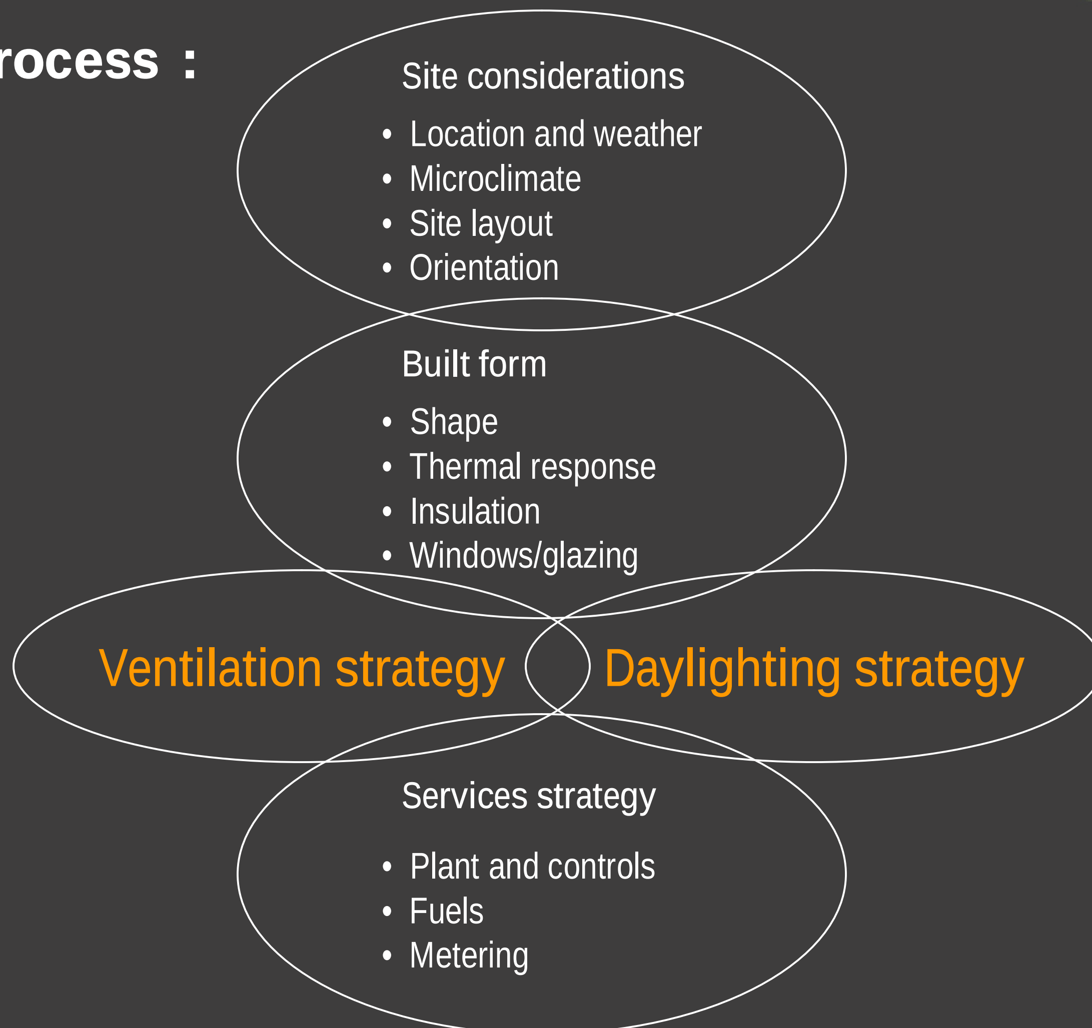
Sustainable building - design principles

Integrating the design process :

"Normally all the really Important mistakes are made on the first day of the design process!" - Amory Lovins



Source: CIBSE Energy Efficiency in Buildings Guide

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Low and zero carbon systems

- In the UK Part L changes “encourage” the incorporation of renewable technologies, however:
  - Over 80 LA’s have incorporated 10% renewable requirements into Unitary Development Plans and/or Local Development Frameworks
- Danger of promoting/requiring LZC technologies on/in inherently inefficient buildings.
- Major concerns regarding the actual performance of some LZC technologies
  - No magic bullets/panacea technologies
  - Independent objective evidence required to determine whole-life performance

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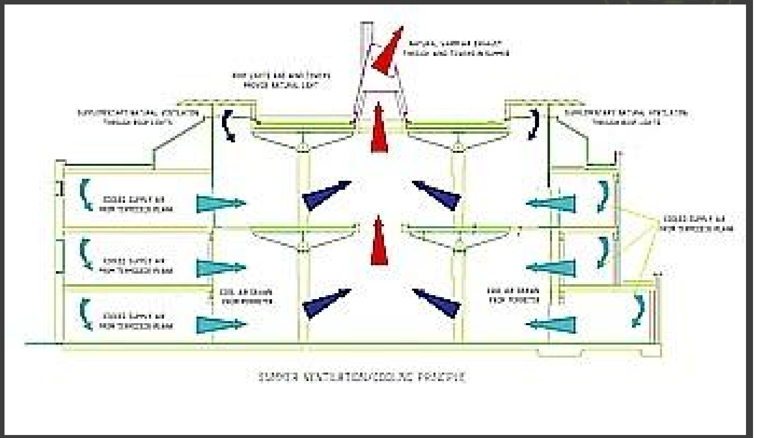
Passive Renewable Systems

- Greater integration of passive energy systems:
  - free cooling/heating
  - passive/natural ventilation
  - optimised use of daylight
  - exploiting the thermal mass



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Issues influencing energy efficient design philosophy

Building envelope	Building services	Human factors
Climate excluding or climate responsive? Use building fabric for thermal storage? Thermally heavyweight or lightweight? Deep or shallow plan? Highly glazed or little glazing? Openable or fixed windows?	Heavily serviced, mixed mode or passive solutions? Use natural daylight/ventilation? Complex or simple systems/controls? Use flexible comfort criteria? Use heat recovery and free cooling? Use combined heat and power? Integrate renewable energy systems?	Balance between central automation and local occupant controls? Responsive to occupancy/activity or fixed systems? Do occupants require loose comfort bands or tight regimes? Easy or difficult to manage? Easy or difficult to maintain? Allow for future flexibility?

Source: CIBSE Energy Efficiency in Buildings Guide

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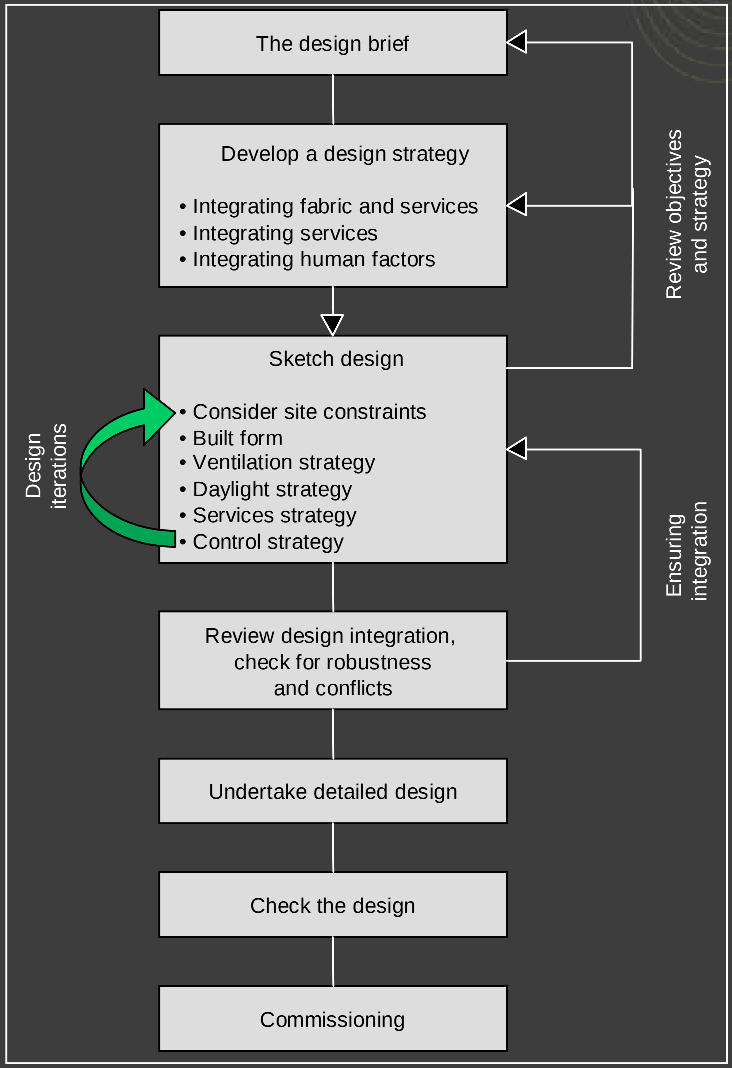
Integrating the design process

- Design process must be integrated and iterative and tested against the performance criteria :
  - cost
  - quality of the internal environmental
  - energy use
  - robustness
  - cost and ease of operation
- If air conditioning is unavoidable integrated design can still reduce:
  - size and cost
  - complexity
  - operational and maintenance cost



Source: CIBSE Energy Efficiency in Buildings Guide

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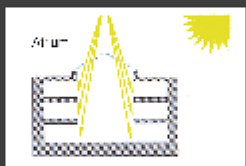
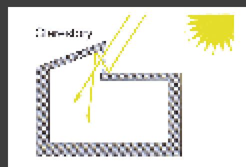
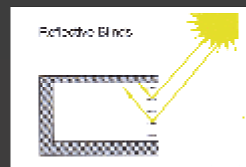
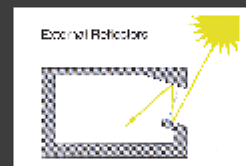
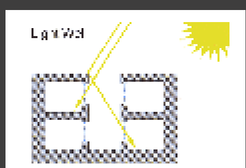
Iterative design example - Daylighting

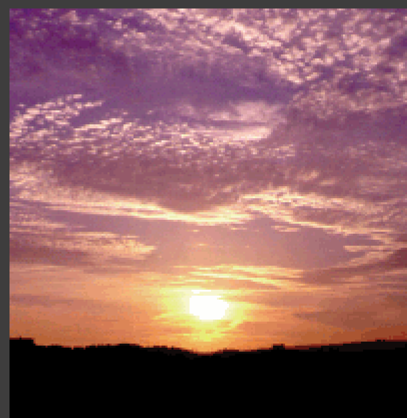


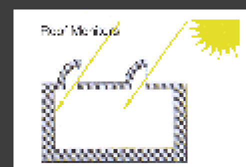


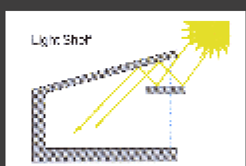


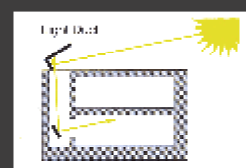


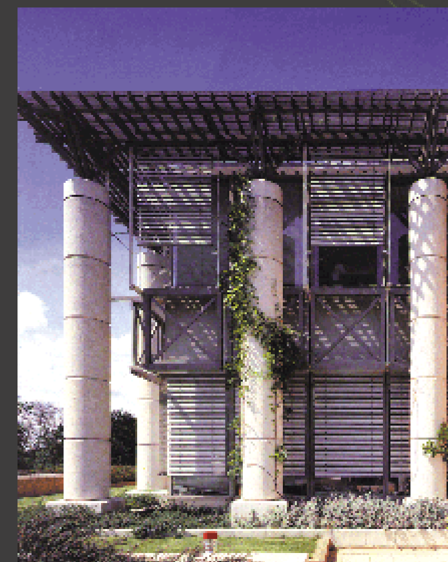












- Window design and building design has a direct affect on :
  - need for solar control and/or air conditioning
  - size and capacity and space required for central plant
  - air and water distribution system
  - artificial lighting design

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Interaction between building services

	Cooling	Heating	Electric lighting	Daylight/glazing	Natural ventilation
Heating	Avoid simultaneous heating and cooling				
Electric lighting	Reduce incidental gains from lights to minimise cooling	Include contribution of lighting towards heating			
Daylight/glazing	Minimise solar gains to reduce cooling loads	Minimise heat loss and maximise useful heat gain through glazing	Use suitable switching and daylight linking controls to minimise use of electric lighting		
Natural ventilation	Consider mixed-mode to use natural ventilation and avoid mechanical cooling where possible	Account for effect of open windows		Balance solar gains from glazing with increased natural ventilation. Avoid conflicts between window opening and blinds	
Mechanical ventilation and air conditioning	Use free cooling and 'coolth' recovery	Use heat recovery	Reduce electric lighting to reduce loads on air conditioning	Solar gains from glazing may increase loads on air conditioning. Heat loss may require simultaneous perimeter heating	Use natural ventilation instead of air conditioning where possible, or consider mixed-mode

Source: CIBSE Energy Efficiency in Buildings Guide

Avoiding or reducing the requirement for active cooling

- Façade design/shading
- Night storage technologies
- Ground coupling systems
- Alternative HVAC
- Delivery systems

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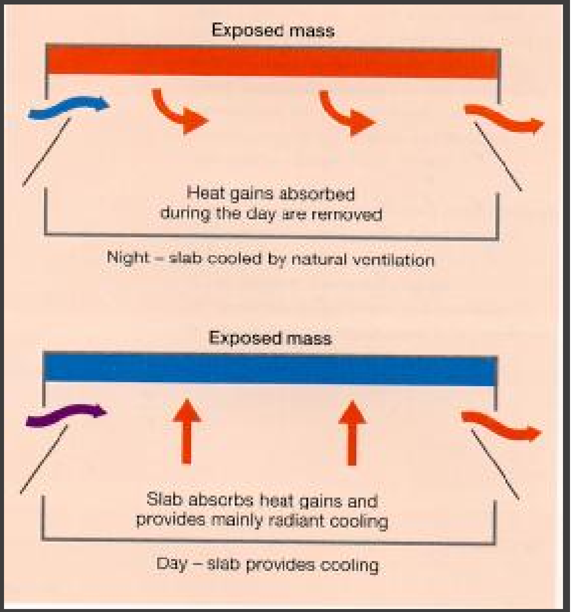
Night time cooling with natural ventilation

- **Favourable design factors**
  - *Large diurnal ambient temperature range with night-time temperatures below 20^{o}C*
  - *Cyclical heat gains*
- **Application limitations**
  - *Best if heat gains<30W/m^{2}*
  - *May be difficult if there is noise and/or air pollution*
  - *Unable to give close temperature and/or humidity control*
  - *Can be awkward in deep-plan/cellular space*
- **Design aims**
  - *Achieve cross-ventilation air flow*
  - *Avoid overcooling*
  - *Minimise internal and solar gains*
  - *Balance cooling benefit against possible winter heating impact*
- **Design requirements/concerns**
  - *Effective air/fabric thermal linking*
  - *Security and privacy*
  - *Openable windows and vents*



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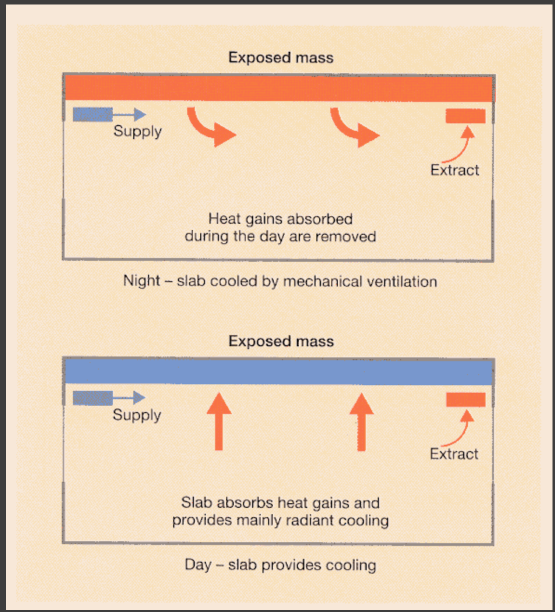
Night time cooling with mechanical ventilation

- **Favourable design factors**
  - *Large diurnal ambient temperature range with night-time temperatures below 20^{o}C.*
  - *Cyclical heat gains*
- **Application limitations**
  - *Best if heat gains <30W/m^2*
  - *Unable to give close temperature and/or humidity control*
- **Design aims**
  - *Minimise fan pressure drops*
  - *Avoid overcooling*
  - *Minimise internal and solar gains*
  - *Balance cooling benefit against possible winter heating impact*
- **Design requirements/concerns**
  - *Effective air/fabric thermal linking*
  - *Space for ventilation system*



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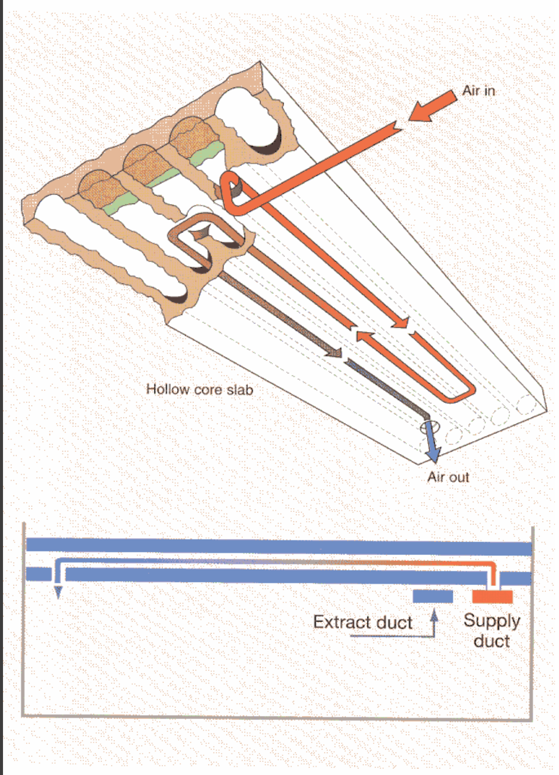
Hollow core slab using air

- **Favourable design factors**
  - *Large diurnal ambient temperature range with night-time temperatures below 20°C.*
  - *Cyclical heat gains*
  - *Use for heat storage in winter*
- **Application limitations**
  - *Best if heat gains <50W/m²*
  - *Unable to give close temperature and/or humidity control*
- **Design aims**
  - *Minimise fan pressure drops*
  - *Avoid overcooling*
  - *Minimise internal and solar gains*
  - *Balance cooling benefit against possible impact on winter heating*
- **Design requirements/concerns**
  - *Effective air/fabric thermal linking*
  - *Space for ventilation system*
  - *Provide access for cleaning of slab*



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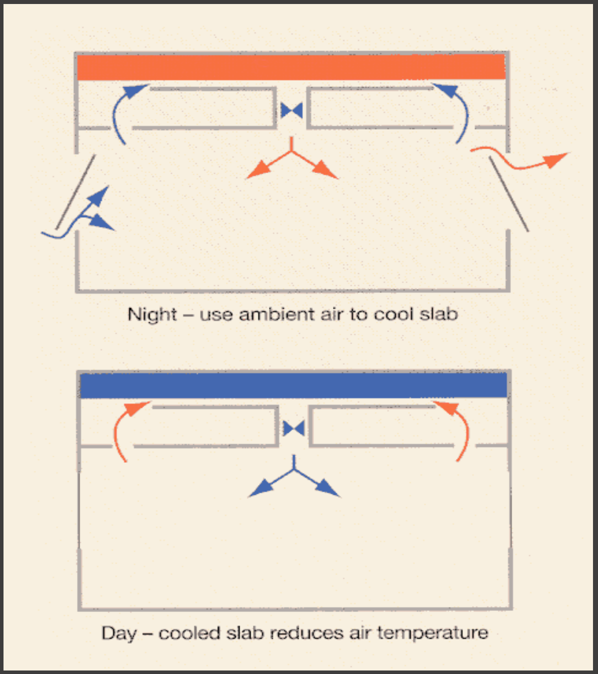
Enhanced surface heat transfer system

- **Favourable design factors**
  - *Large diurnal ambient temperature range with night-time temperatures below 20°C*
  - *Cyclical heat gains*
  - *Retrofit application*
- **Application limitations**
  - *Better if heat gains are less than 50W/m²*
  - *Difficult to get close temperature and/or humidity control*
  - *Appreciate that this is an emergent technology*
  - *Concern about multiple fan maintenance*
- **Design aims**
  - *Minimise fan pressure drops*
  - *Minimise fan noise*
  - *Avoid overcooling*
  - *Minimise internal and solar gains.*
- **Design requirements/concerns**
  - *Space for integration into void (>200mm)*
  - *Provide access for cleaning*



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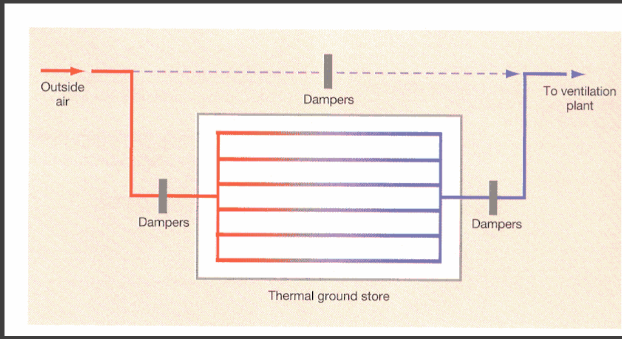
Ground coupling using air

- **Favourable design factors**
  - *Ground temperature 12ºC or lower.*
  - *Located in sand/gravel and below water table*
  - *Movement of ground water*
- **Application limitations**
  - *Difficult in rocky ground*
  - *Scope for ground pollution, eg radon in some locations*
  - *Unable to give close temperature and/or humidity control*
  - *Possibility of microbiological growth*
- **Design aims**
  - *Insulate the system from building heat gains*
  - *Minimise piping system pressure drops*
- **Design requirements/concerns**
  - *Space for piping system*
  - *Access for maintenance of underground pipes*
  - *Sealing in wet ground*



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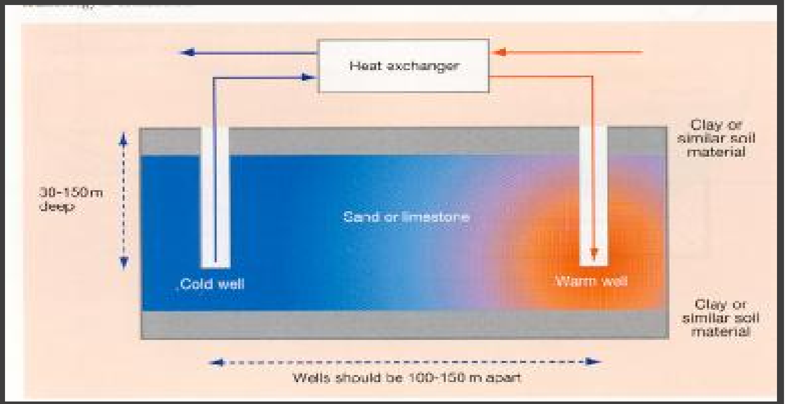
Ground water cooling (aquifers)

- **Favourable design factors**
  - *Suitable aquifer geology*
  - *Climates with a heating and cooling season for inter-season storage*
- **Application limitations**
  - *Sometimes restrictions on use and cost of extraction of ground water*
  - *Ground water movement would compromise inter-seasonal storage*
  - *Limited storage flexibility*
  - *Appreciate that the technology is relatively new to the UK*
- **Design aims**
  - *Balancing the cooling and heating extracted*
- **Design requirements/concerns**
  - *Cold and warm well sets should be 100-150m apart*
  - *Space for heat exchanger*
  - *Maintenance of well pump sets*



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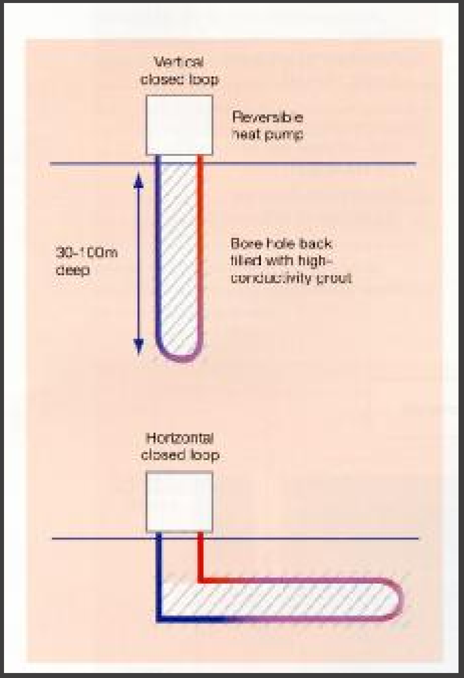
Ground coupled heat pumps

- **Favourable design factors**
  - *Suitable geology, eg high soil conductivity*
  - *Climates with a definite heating and cooling season*
  - *Movement of ground water*
- **Application limitations**
  - *Legislative or regulatory restrictions*
  - *Unsuitable site hydrology, characteristics, and space restrictions*
- **Design aims**
  - *Reduced electrical consumption from better CoP*
  - *Accurately matching building demand to the capacity of the system*
- **Design requirements/concerns**
  - *High excavation costs prohibit the provision of spare capacity*



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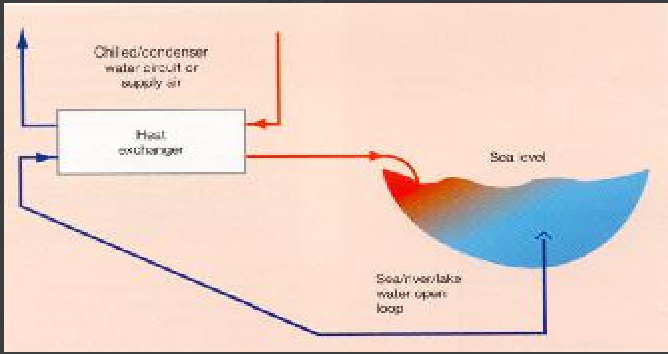
Surface water cooling (sea/river/lake)

- **Favourable design factors**
  - *Proximity to suitable surface water source*
- **Application limitations**
  - *Great depth required to reach cold water*
  - *Salinity of sea water encouraging corrosion in equipment*
  - *Legislation/regulation restricting surface water use*
  - *Possible ecological effects of raising surface water use*
- **Design aims**
  - *Minimise cold water source pumping costs*
  - *Minimise corrosion and fouling possibilities*
  - *Compatibility with conventional cooling systems*
- **Design requirements/concerns**
  - *Space for heat exchanger, etc*



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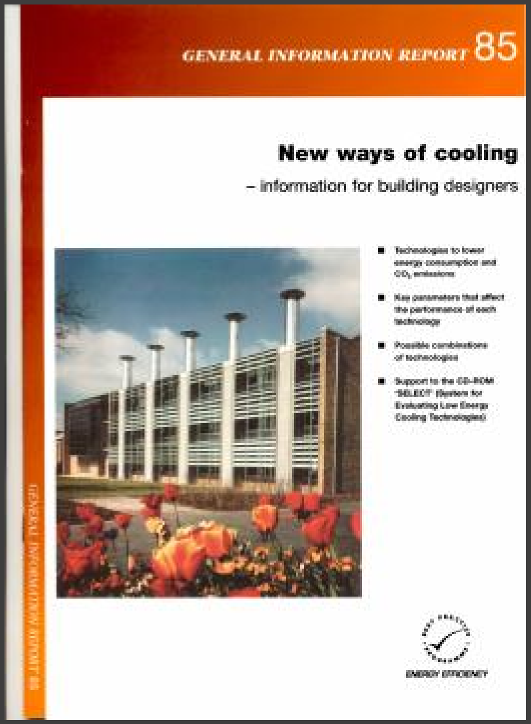
Other technologies

- Evaporative cooling (direct/indirect)
- Desiccant dehumidification and evaporative cooling
- Absorption cooling
- Ice storage
- Slab cooling using water
- Chilled beams/ceilings
- Displacement ventilation



More information from web link

http://www.actionenergy.org.uk/Action+Energy/KeywordSearch.asp?keyword=gir085

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What do green buildings cost?

	Additional Cost		
	BREEAM/EcoHomes		
	Good	**Very Good**	**Excellent**
House £76,000	+0.3% to +0.9%	+1.3% to +3.1%	+4.2% to +6.9%
Naturally Ventilated Office £731,200	-0.3% to -0.4%	-0.4% to +2%	+2.5% to +3.4%
Air conditioned Office £11,430,000	+0% to 0.2%	+0.1% to 5.7%	+3.3% to +7.0%
PFI procured Health Centre £11,590,000	0%	0%	+0.6% to +1.9%

Source: Putting a Price on Sustainability BRE Trust and Cyril Sweet ISBN 1 86081 750 5

The performance gap

Why don't most low carbon buildings perform as well as the initial designs claim?

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City Hall

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Building Design

Class of 2005

Showcasing the work of the UK's best architecture graduates: 12

Sunny outlook

Portugal breaks the holiday home mould: 10

London mayor's 'sustainable' City Hall is missing energy consumption targets by 50%

Ken's gas guzzler

"Norman Foster's City Hall, which is billed as an exemplary sustainable building, uses 50% more energy than it was designed to do."

Why? What's gone wrong? Where is the discrepancy?

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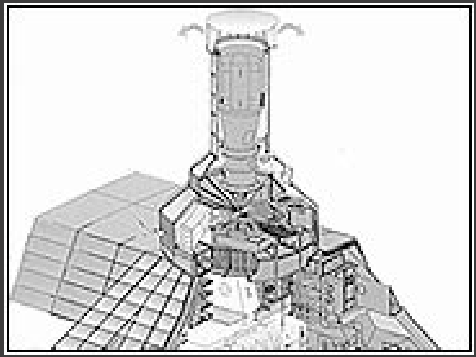
Portcullis House



"It is highly energy efficient. It uses only about one third as much fuel as a conventionally air conditioned building. Heat is recycled from exhaust air, and cooling is provided by groundwater from boreholes."

But what's the reality in practice?

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The ‘Gherkin’

“London’s first ecological tall building..”

Predicted energy consumption 150kWh/m^2

- But what happened when the fire regulations were applied?
- No independent environmental assessment
- How much energy does it use in practice?
- Are the sceptics right – and if so to what extent?

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Beaufort Court Zero Emissions Building (RES)

- Exemplar of sustainable refurbishment

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Beaufort Court – previously the Ovaltine Egg Farm

Credit:: RES

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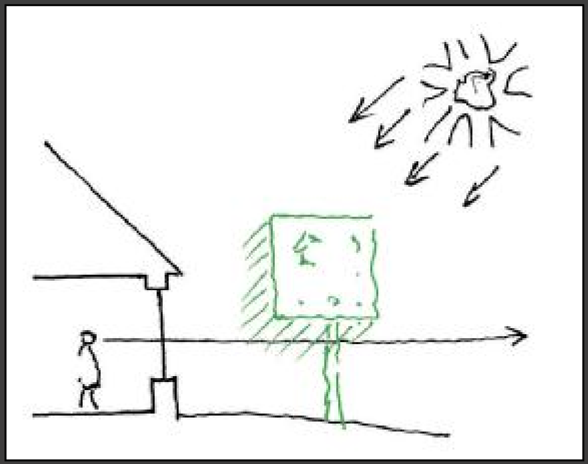
Beaufort Court Solar Shading



Credit:: Bill Watts, Max Fordham & Partners

Credit:: J. Trotman/RES

Credit:: Studio E Architects

Credit:: Max Fordham & Partners

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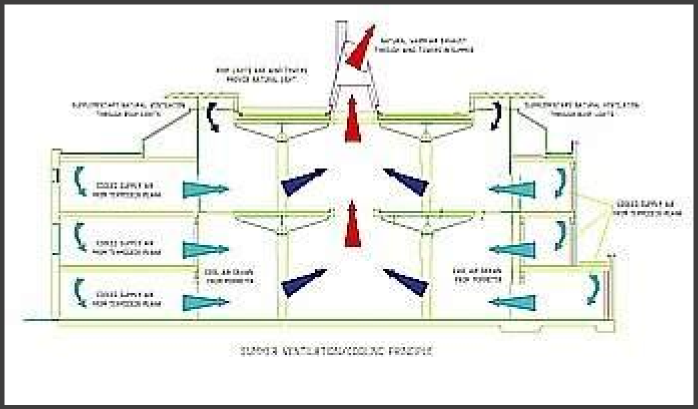
Brighton and Hove Library



- Is this the UK's most energy efficient non-domestic building?
  - Time will tell!
- Vital we learn the lessons from these buildings and share best practice

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Learning the lessons

- Every major new building is a prototype
- Desperate need for independent, objective research to determine what works and what doesn't
  - *Post occupancy evaluation*
  - *Energy monitoring*
  - *Best practice for designers and operators*
- Key role for recently launched UK Green Building Council
  - *See www.ukgbc.org*

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The UKGBC's role in delivering real market transformation

- Market demand for green buildings
  - Driven by funders/building procurers, purchasers and tenants
  - Demonstrable evidence that green buildings provide:-
    - *Better returns*
    - *Higher asset value*
    - *Greater occupant comfort/productivity/health*
- A supply side capable of responding with appropriate skills/expertise, products and services
- Less architectural greenwash
  - Environmental assessment and labelling of buildings
  - Must be rigorous, objective and independent

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Delivering sustainable buildings

- Will require a new level of architectural intelligence:
  - Integrated design
  - Interdisciplinary working
  - Innovative solutions
    - *Working with nature to service buildings for free*

- New skills in construction, operation and maintenance

- Reducing the impact of the existing building stock is a major priority
  - important role for new fiscal instruments and incentives