

BSc Environmental Conservation Sustainable Development



Sustainable construction:
an introduction



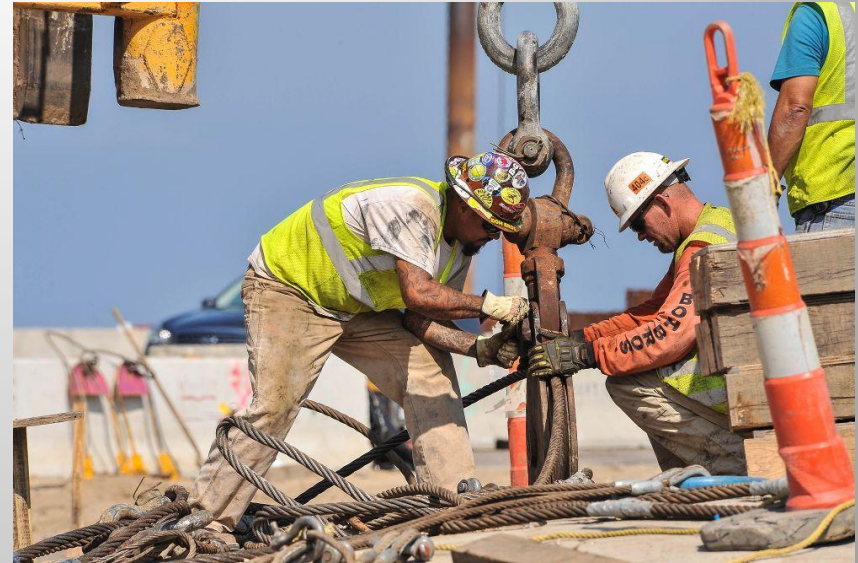
Why study construction?

Construction UK...

...has an output of some £113 billion

...contributes around 6% of total GDP

...employs more than 1.36 million workers



UK trade deficit in construction materials amounts to over £10 billion.

Imports more than double exports! (2018)

Sustainable Construction

What might be the challenges?

- Form Vs Function
- Social Vs Public Infrastructure
- Architecture Vs Humanity

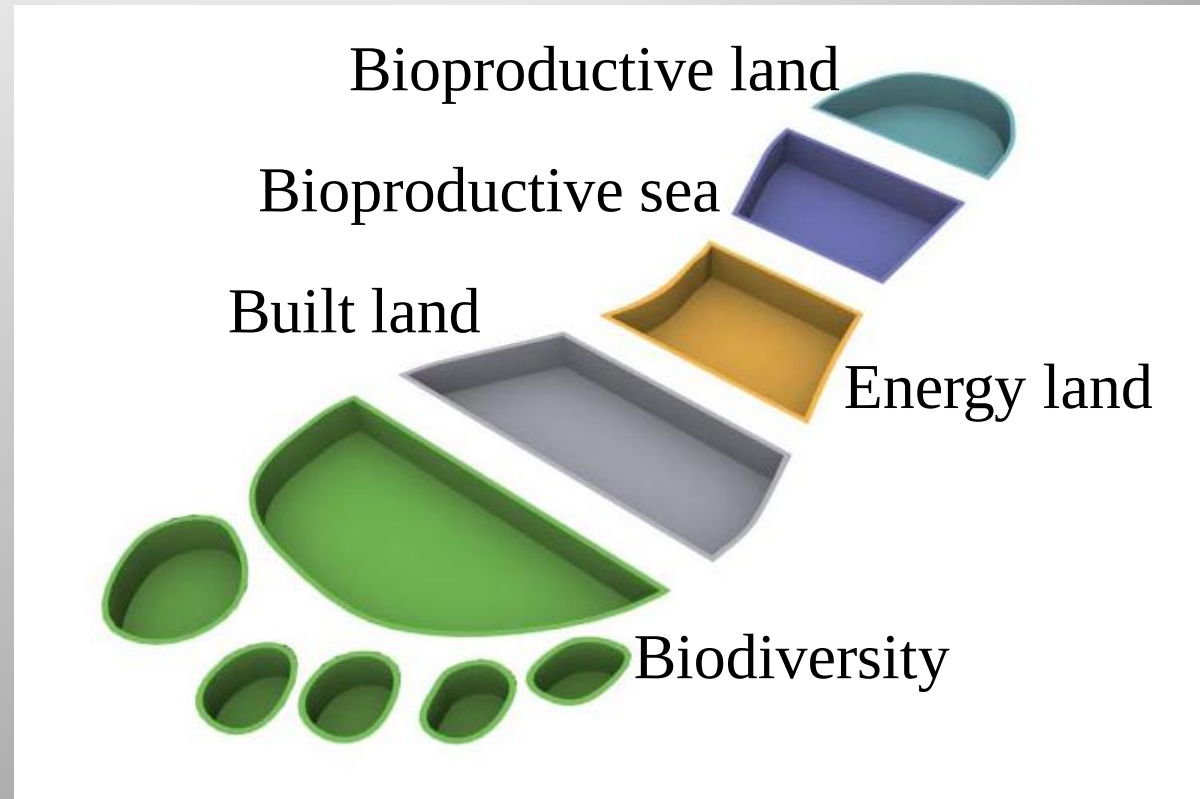


Sustainable Construction

Some key issues:

Can we achieve a sustainable way of living with a population expected to reach some 10 billion by 2050?

Are there challenges with current policies and investments?



How might construction help overcome any expected challenges?

Sustainable Construction

- UK ecological footprint 4.8ghp
-
- UK biological capacity 1.2ghp
- UK CO2 footprint 2.99ghp

Source: WWF Living Planet Report 2018

Impact of construction materials on SD

- 19% of total national ecological footprint (1)
- 23% of total national greenhouse gas emissions (1)
- 420 MT material consumption (2)
- 30% of all road freight on UK roads (3)

Source:

(1) Stockholm Environmental Institute

(2) Biffa

(3) Freight Transport Association



Sustainable Construction

Some Facts (UK)

- Construction output >£100b
- Material consumption ~ 420MT
- Materials and products cost >£30b



Source: CIRIA



- UK housing materials & products >£10b
- Material salvage market >£1b
- Materials reclaimed ~5MT

Welsh construction output some 10% of UK

Source: Welsh School of Architecture

The Impact of the Built Environment

“...when it comes to technology, reality must always take precedence over public relations. Nature cannot be fooled.”

Richard Feynman

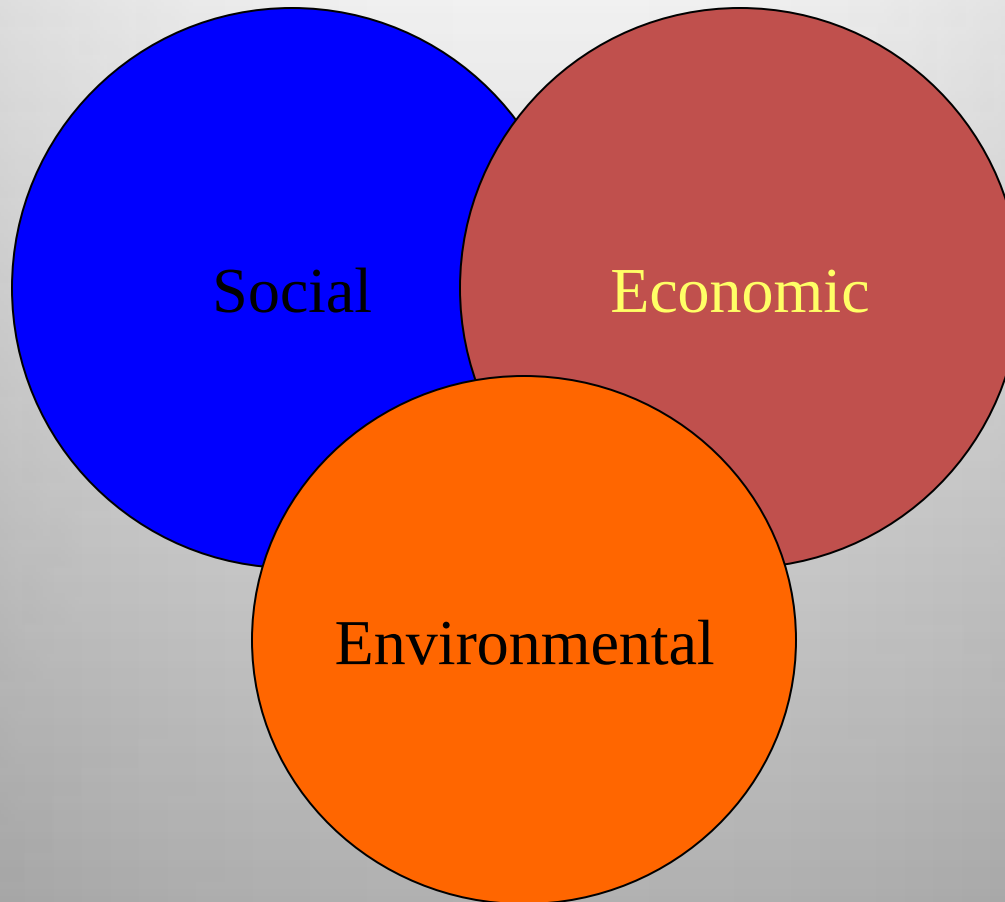
Sustainable Construction

- Building a better quality of life: a strategy for more sustainable construction

The emphasis delivered by this strategy was on the construction industry's production of buildings which promote economic growth, protect the environment and make prudent use of natural resources.

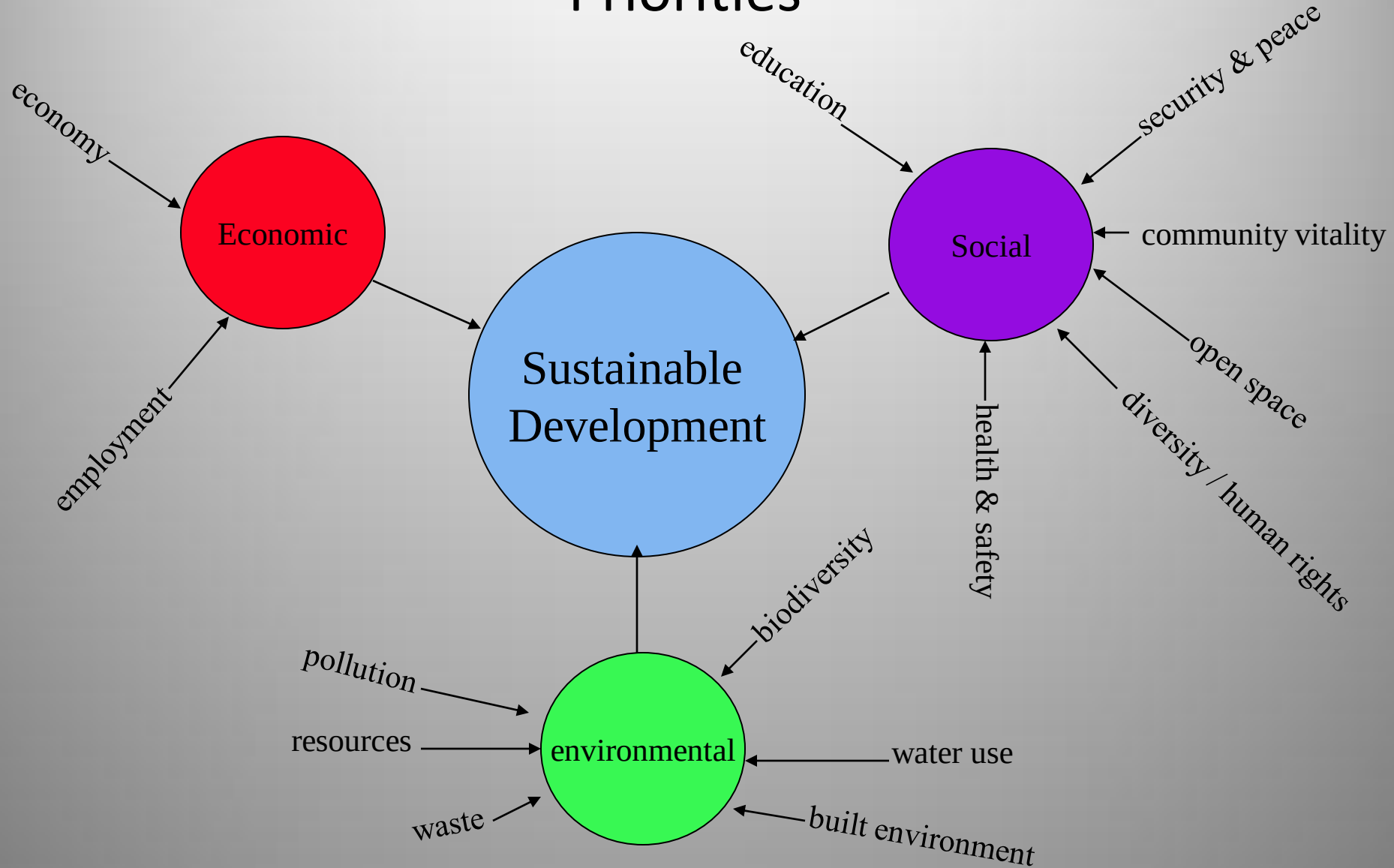


The Main Pillars of Sustainable Development



So, where does construction fit?

Construction's Sustainable Development Priorities



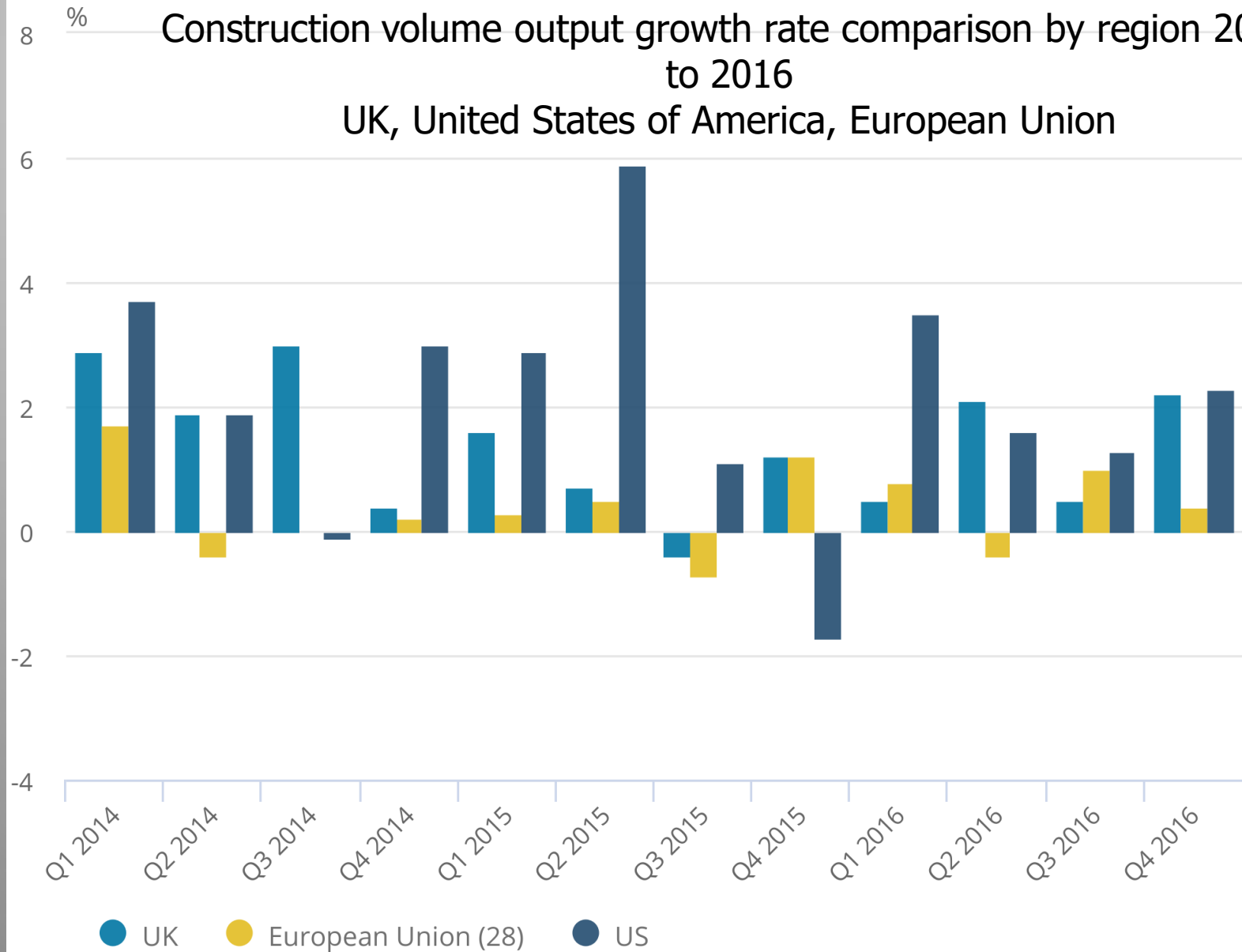
Sustainable Construction

The government proposes that the industry can contribute to the achievement of sustainable development by:

- being more profitable and more competitive;
- delivering buildings and structures that provide greater satisfaction, well-being and value to customers;

Construction volume output growth rate comparison by region 2014 to 2016

UK, United States of America, European Union



Source: Office for National Statistics, Eurostat & US Census Bureau

Sustainable Construction

- respecting and treating its stakeholders more fairly;
- enhancing and better protecting the natural environment;
- minimising its impact on the consumption of energy and natural resources.

Sustainable Construction, a definition:

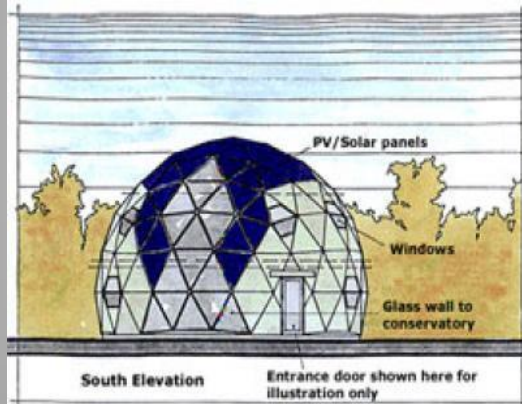
“...is conducting business in a way that meets environmental and social responsibilities whilst at the same time improving profitability.”

Construction Best Practice Programme



Maybe the solution is to apply an intelligent approach to sustainability?

An Intelligent Building is:



'a building that is able to respond continuously to the needs of its environments, and its occupants in a cost-effective way.'

Sustainable construction is built on the need for integration involving all key players:

those who develop

those who produce

those who plan

those who build

those who alter and maintain

those who design and those who

use the built environment



Reduce



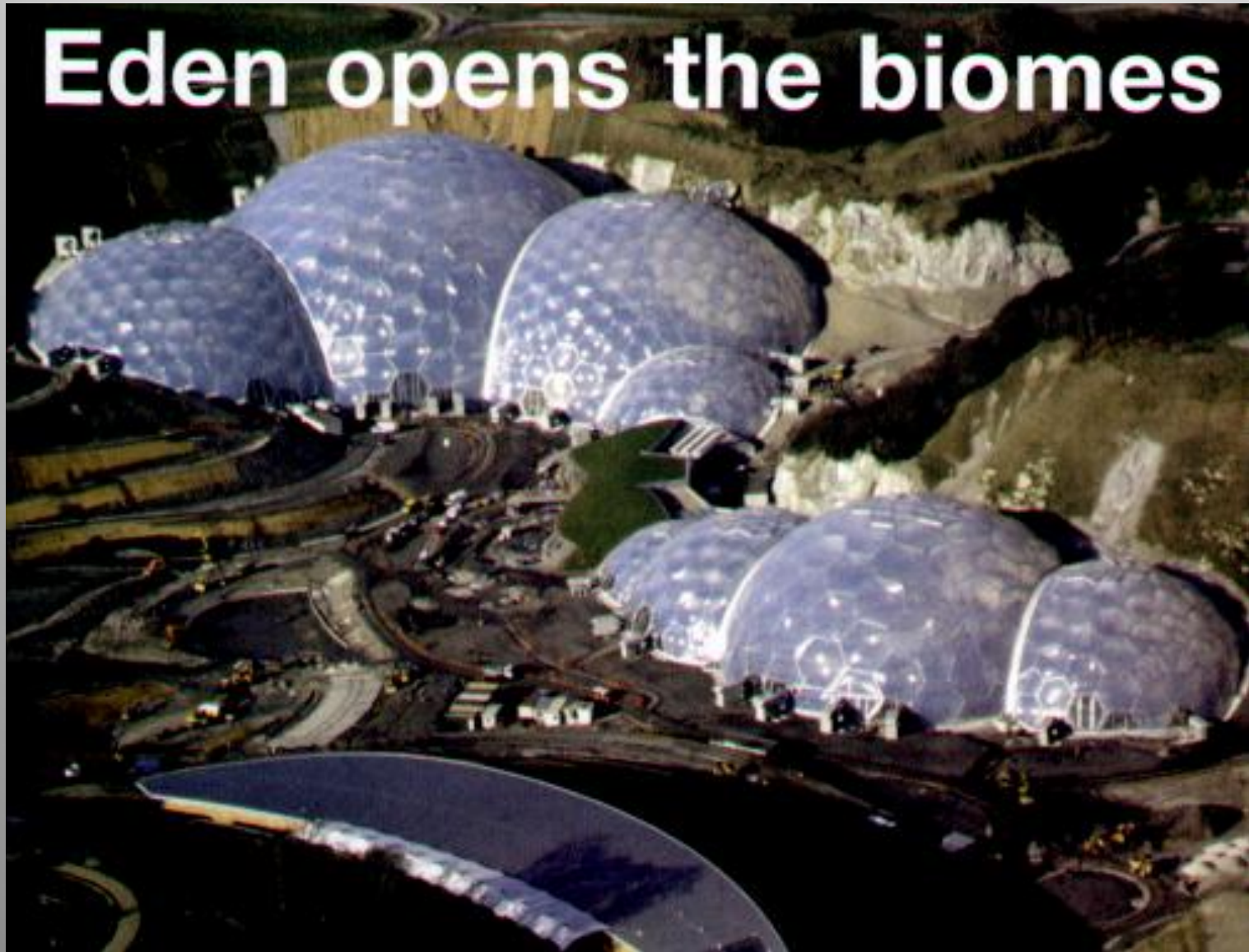
Promote

- Reduce the amount of construction and demolition materials and other construction waste going to landfill sites.
- Limit urban sprawl and the use of green-field sites.



Minimise the ecological impact of development, maximising the enhancement of sites for both new and existing buildings – people centred not car centred!

Learn from nature - Biomimicry

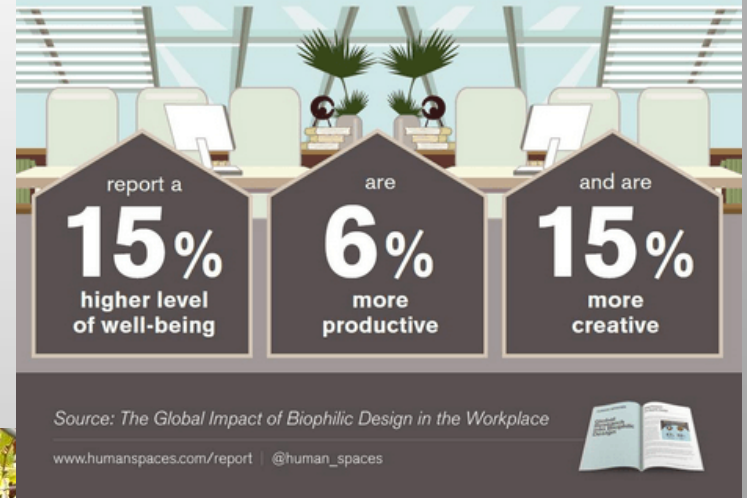




Biophilic design...



Workers in office environments with natural elements, such as greenery and sunlight



...aims to create a powerful bond between the natural and human-made environments

Biophilic Design



The Scarlet Hotel:
Location: Cornwall, UK
Architect/designer: Harrison Sutton
Partnership (architecture); Max
Bentheim (interior design).



Case Study: Green Roofs





Why have a green roof?

- Water retention
- Climate control
- Life expectancy
- Pollution control
- Thermal insulation
- Space use
- Encourages natural habitats



Some Barriers!



Structural issues

Maintenance

Guidance and support

Guarantees

Aesthetics

Research: the Swiss experience



Local substrates

Depth variation

Planting

Biodiversity

Improving the Air Quality of the Workplace



Growing fresh air



Peace Lily (*Spathiphyllum* sp.)

Chemical emissions

- Formaldehyde
- Benzene
- Trichloroethylene
- Chloroform
- Ammonia
- Alcohols
- Acetone

Growing fresh air

Sick building syndrome symptoms

- Allergies
- Asthma
- Eye, nose and throat irritations
- Fatigue
- Headache
- Nervous-system disorders
- Respiratory congestion
- Sinus congestion



Rubber plant (*Ficus robusta*)



Green roofs



To achieve effective protection of the environment and prudent use of natural resources, construction will need to action key environmental issues:

- Reduce carbon dioxide emissions.
- Reduce consumption and leakage of potable water during internal use in buildings.
- Reduce the amount of material extracted from the land.



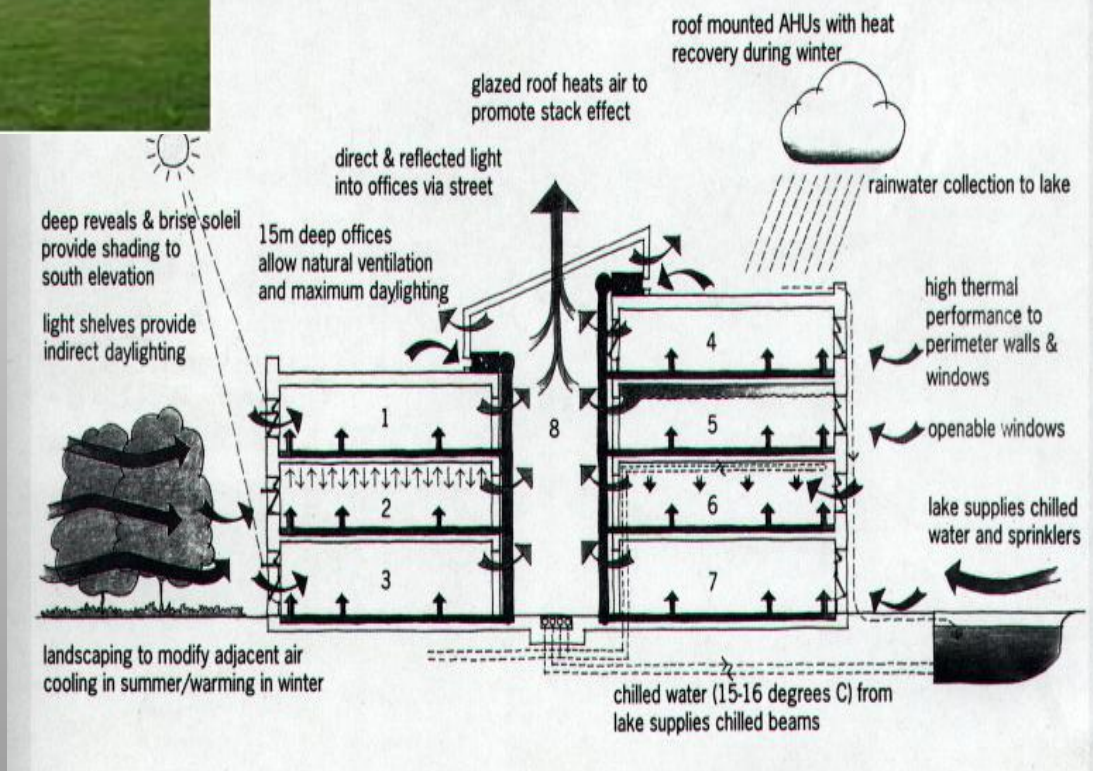
Why Sustainable Construction?

- About 50 % of the UK's CO₂ emission is due to energy used for heating, cooling and lighting in buildings.
- Some 24% of all UK energy is consumed in manufacturing and transporting building materials.
- Approximately 22% of CO₂ results from energy used by building occupants travelling between buildings.



Barclaycard HQ Northampton

Designed to create a healthy, responsive environment for staff



Measures for Reducing Energy Consumption

- Improvements in energy efficiency
- Higher efficiency in household electricity use
- Higher efficiency standards for new housing
- Taxation on vehicles, fuel, road use and workplace car parking
- Carbon tax







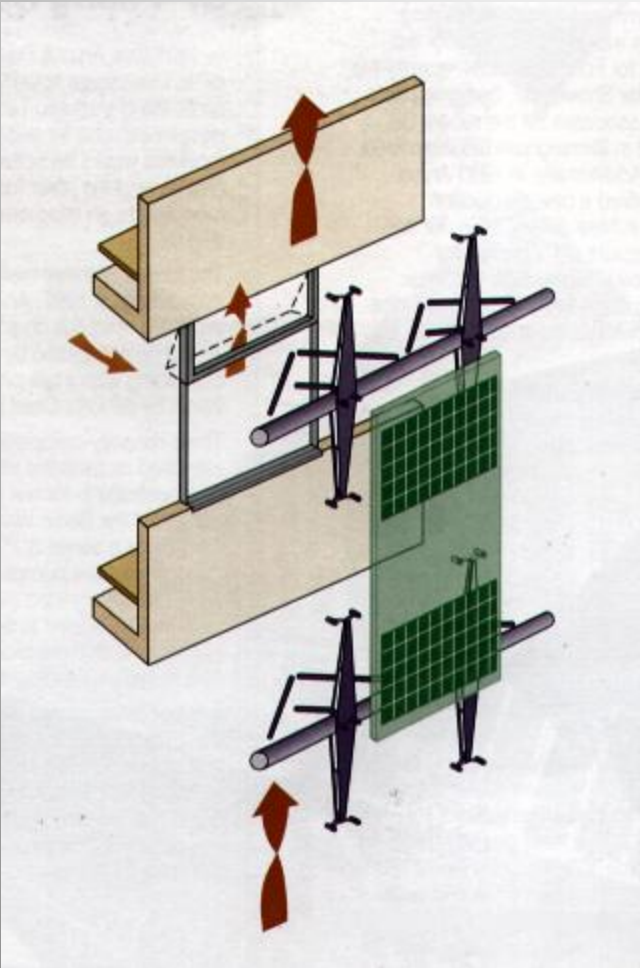
Waunarlwydd Solar Farm



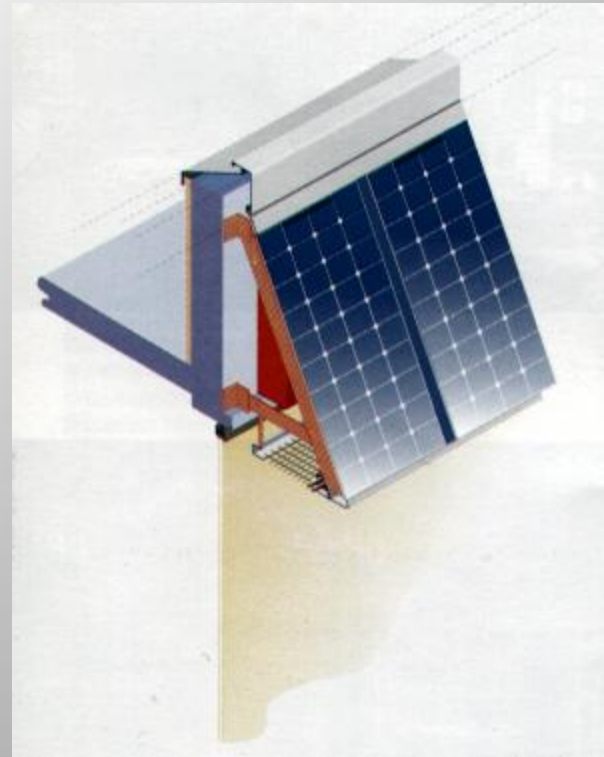
Dunvant Solar Farm

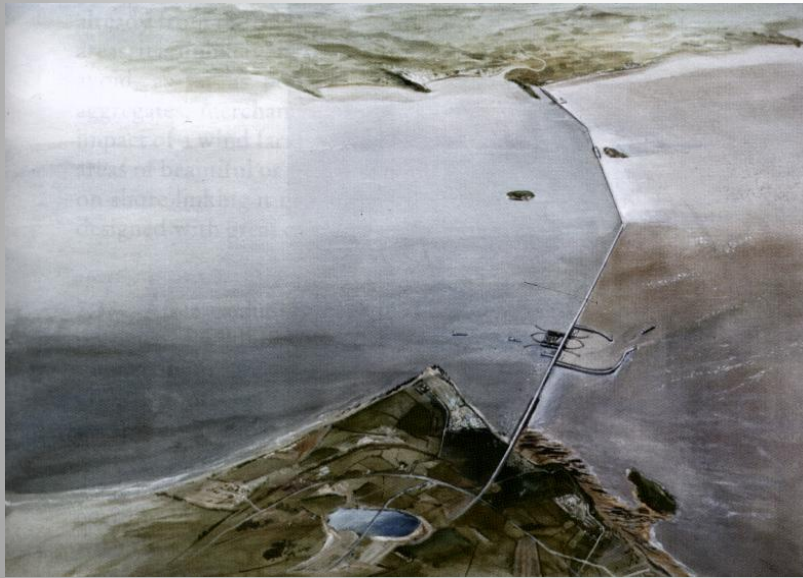


Principle of attaching PV unit to façade



PV ventilated façade





Reducing Energy Use



Wind Farms?



**Wind farm at Blyth Harbour
Northumberland. The
installation's original capacity
was 2.7MW from nine 300 kW
turbines. As of 2012 repowering
added as much as 3.4 MW from
just one turbine!**





Swansea Tidal Lagoon



Why Sustainable Construction?

- The construction industry accounts for around 30% of all UK controlled waste arising each year (over 100 million tonnes is construction and demolition waste).
- Approximately 17% of landfill waste is directly related to construction (indirect arisings, such as quarrying and other waste, probably doubles this figure).

Why Sustainable Construction?

- Water consumption has risen as much as 70% over the last 30 years. Some 30% of potable water in buildings could be saved by technical and management options.
- Whenever buildings are constructed there is always a risk to local ecology / areas of natural beauty.



Why Sustainable Construction?



Modula building

- In 1990 10% of England was urban. This year it is anticipated that this figure will rise to 12% or more.
- Some 300 million tonnes of minerals are used by UK construction firms each year.

Sustainable Construction

Choices between...

Volumetric / Modular

Panellised



Hybrids and pods

Non off-site methods

Sustainable Construction

Panellised
systems
SIPS

- Structural
- Aesthetics
- Insulation



- Design flexibility
- Tight high-performance
- Speed





Modular construction

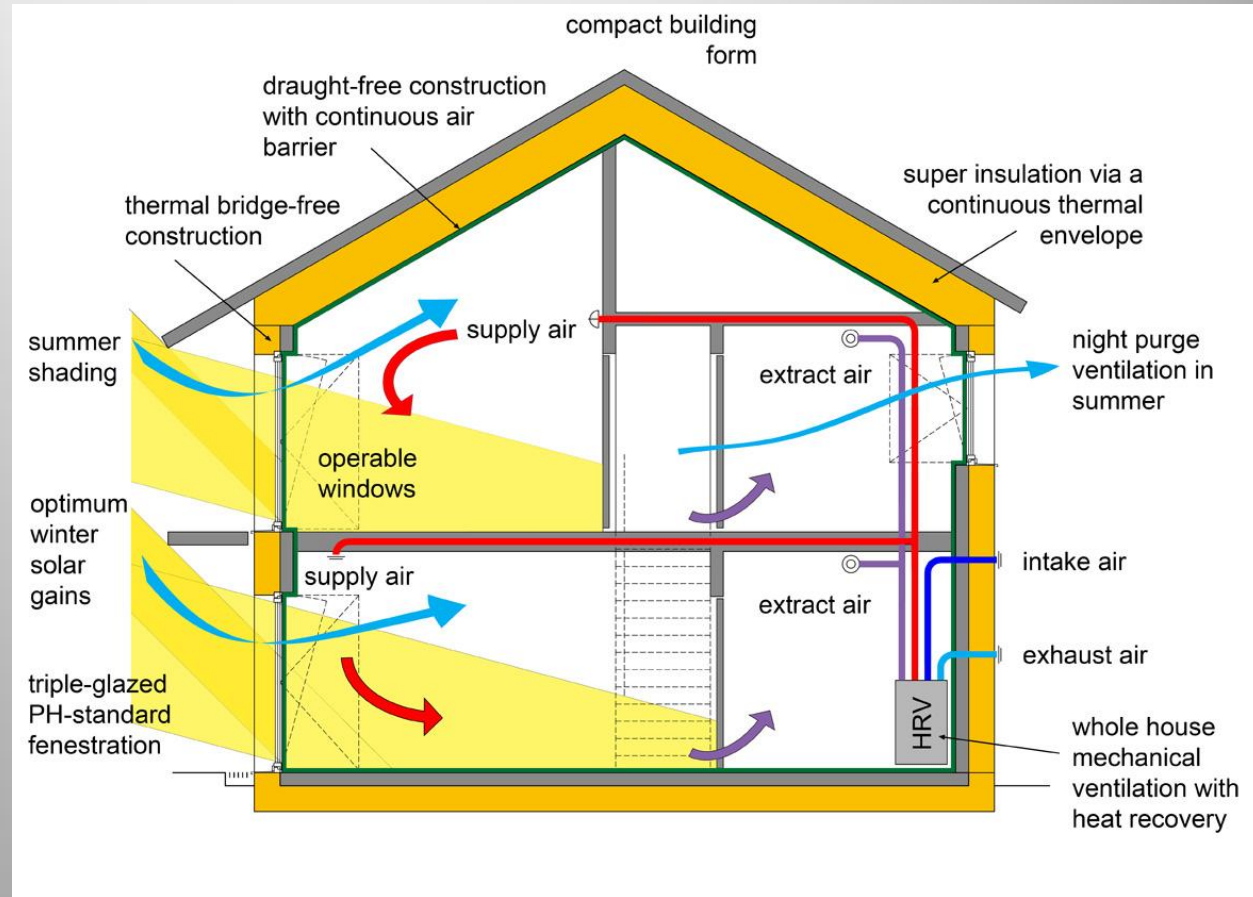


Sustainable Construction



Sustainable Construction

- Passive design
- Native landscape
- Attention to power
- Water conservation
- Reduction of emissions
- Design for operation and maintenance
- Materials efficiency
- Design for deconstruction / recycling



Perhaps an intelligent approach!

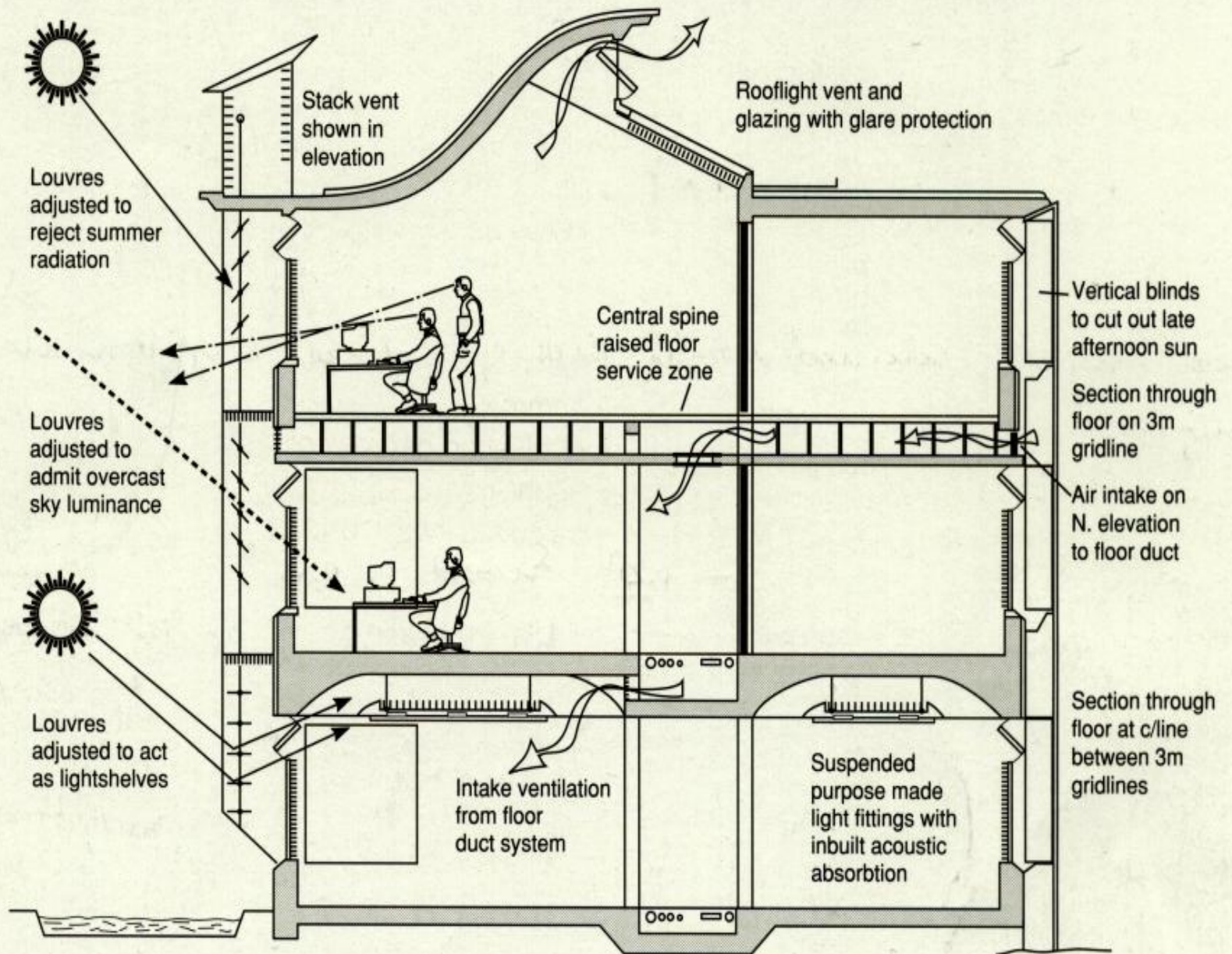
Source: Passive House Institute



Wessex Water Operation Centre



Arup Campus West Midlands



Beddington Zero Energy Development



Sustainable Construction

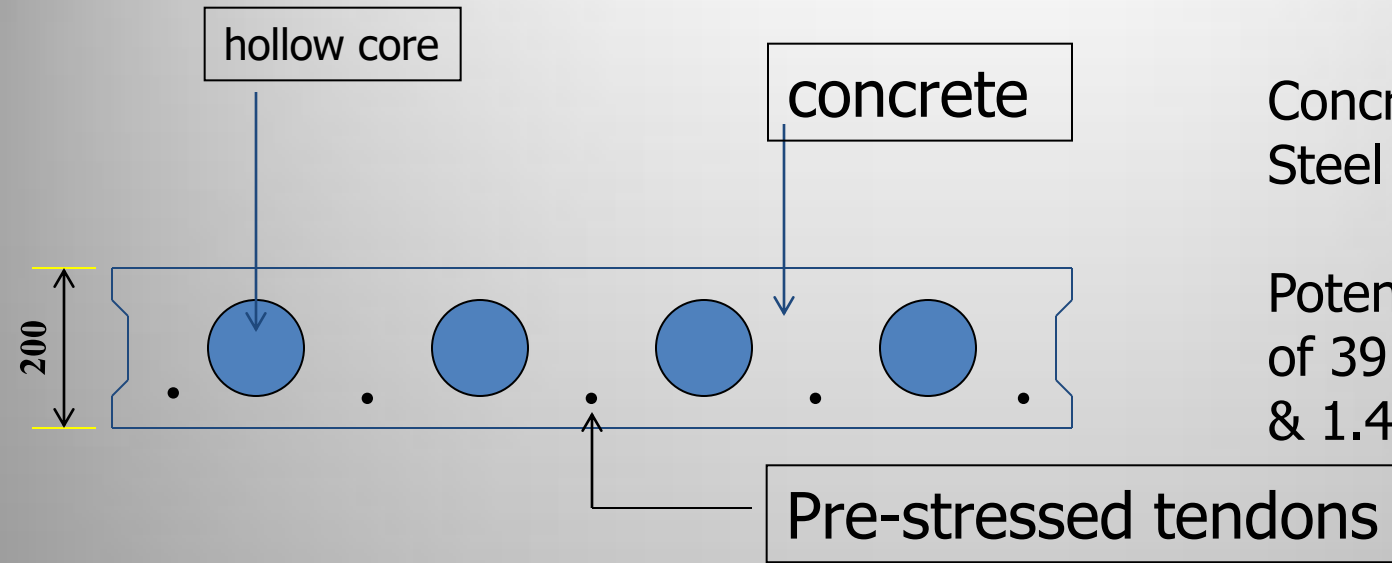
- Design must...
 - BREEAM Excellent
 - Accommodate future needs
 - Capture natural resources
 - High coefficient energy performance
 - Effective and efficient control mechanisms
 - Sustainability
- Construction must...
 - Engage with stakeholders
 - BREEAM Excellent
 - Innovative processes and products
 - Supply chain management
 - Skills training
 - SWMP
 - Environmental Performance

Case study: the BedZED project

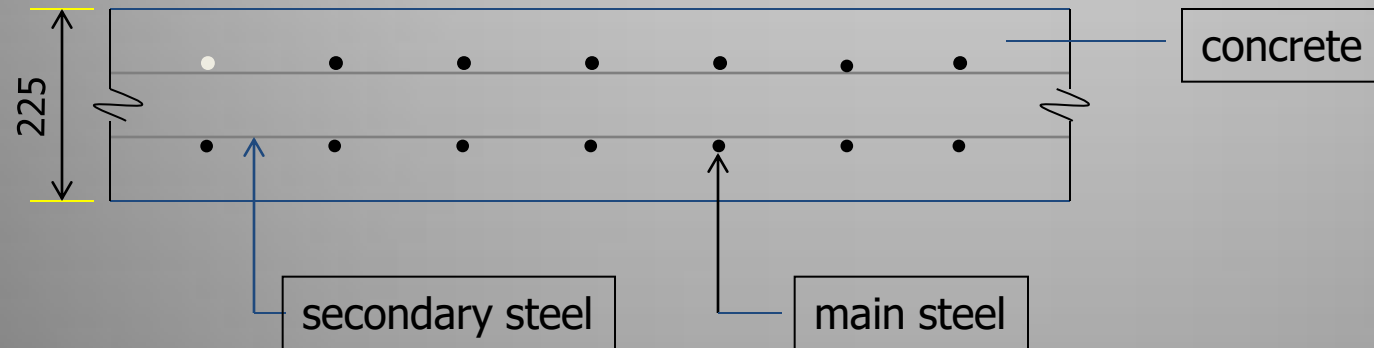
Savings (based on 8000m²)

Concrete 1960 tonnes
Steel 72 tonnes

Potential waste savings
of 39 tonnes concrete
& 1.4 tonnes steel



Pre-stressed Hollow Core Floor Slab



In-situ Reinforced Concrete Floor Slab



Earthship Brighton





Earthship Brighton



Tyre bale use in embankments



- First UK use
- Alternative to concrete
- Improved drainage and slope stabilisation
- Environmental impact reduced
- Cost and environmental benefits



The three little pigs...

Approximately 7 million tonnes of straw remain after the production of wheat flour

Up to half this amount is used for animal bedding etc

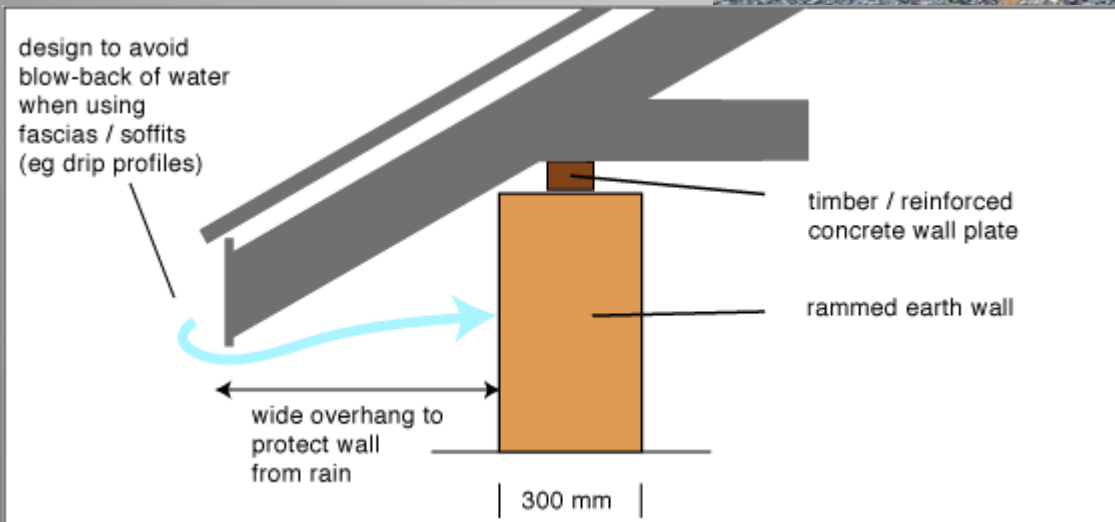
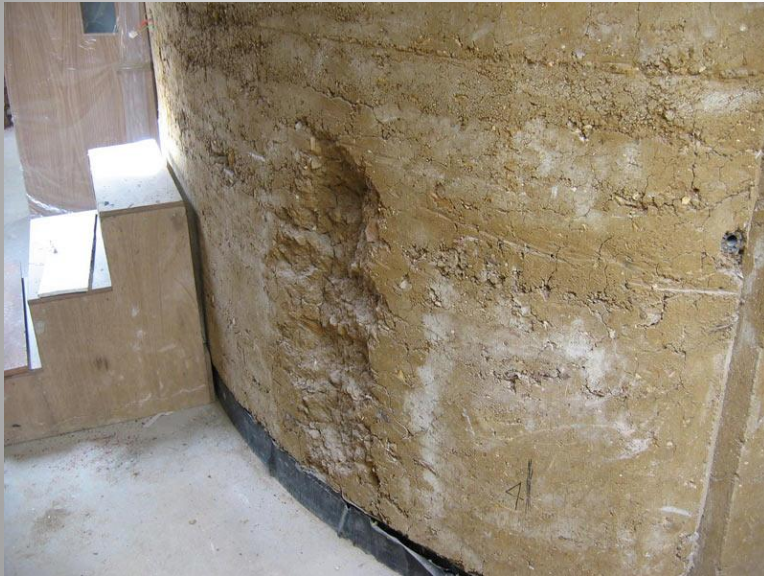
The 3.8 million tonnes left over could build some 500,000 new homes

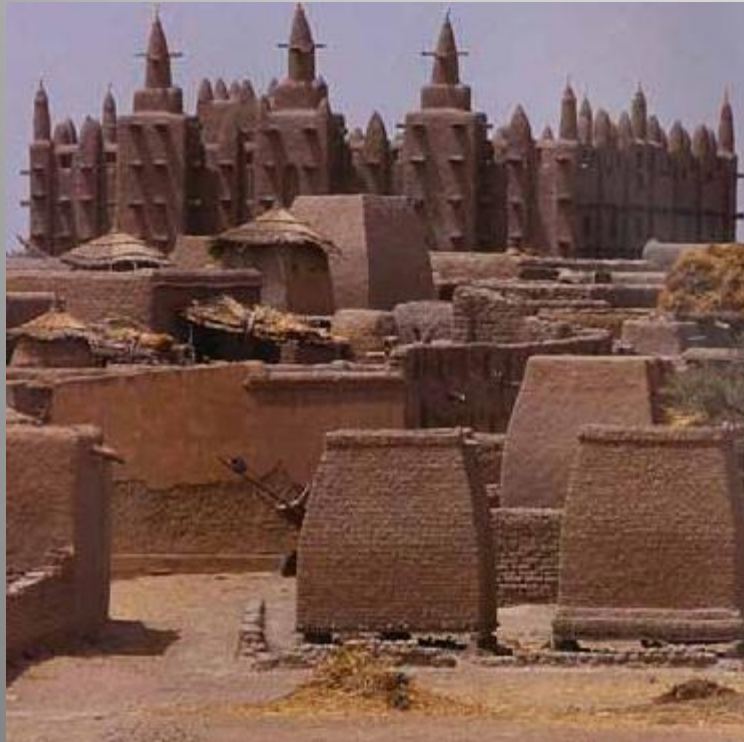
An average three-bedroom house used about 7 tonnes of straw

Straw absorbs CO_2 as it grows



Earth rammed walls







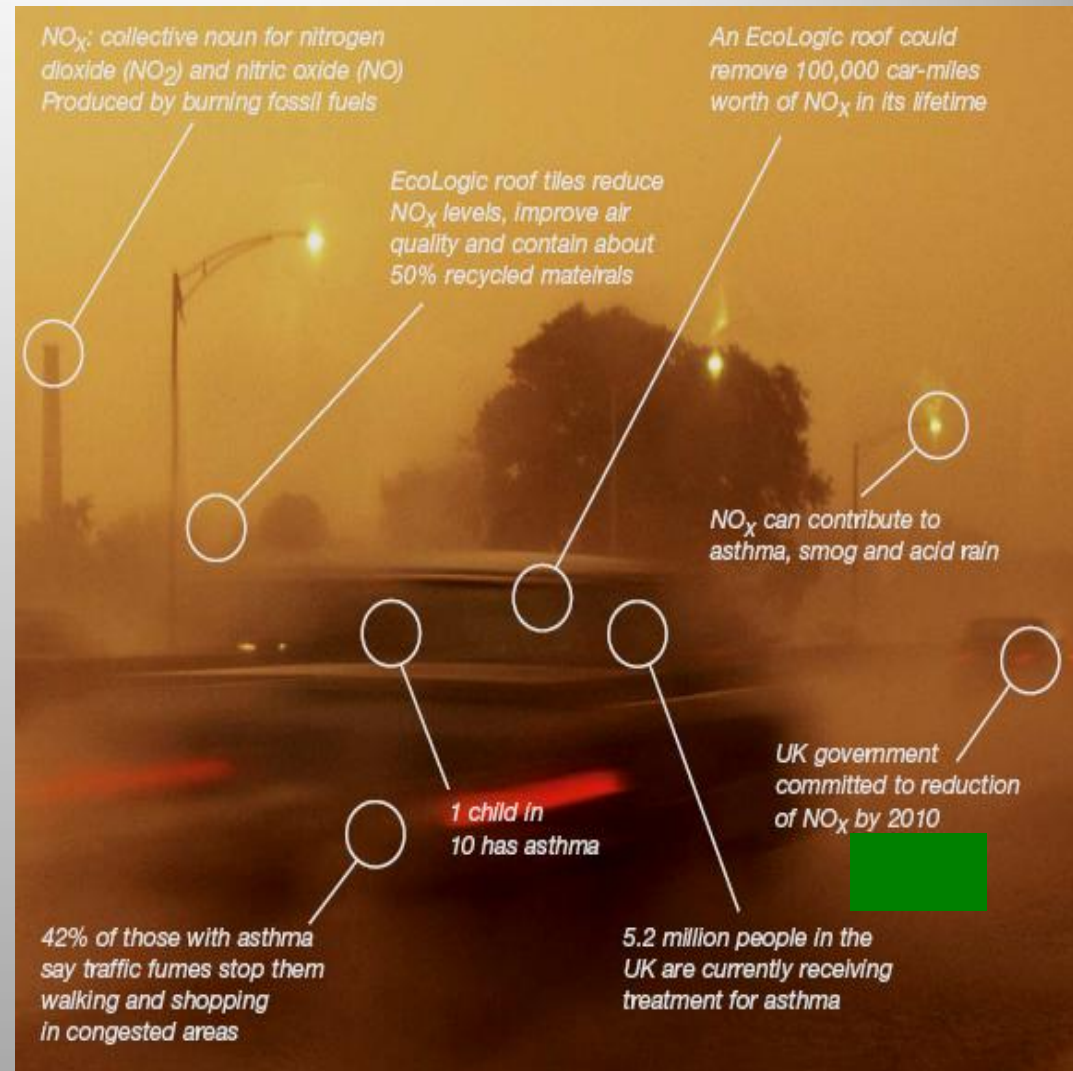
Sustainable Construction

Cleaning the built environment!

- ☐ NO_x levels reduction
- ☐ Kerb & roadside testing
- ☐ Standards under EU Emissions Directive

Eco tiles can help!

- ☐ 50% recycled materials
- ☐ 'A' rating in Green Guide



Sustainable Construction

HEMCRETE

Green concrete – a combination of lime binder with hemp



- ☐ Carbon capture ('better than carbon neutral')
- ☐ • Low density
- ☐ • High thermal insulation
- ☐ • High sound absorption
- ☐ • High thermal inertia (heat capacity)
- ☐ • Good vapour permeability ('breathability')
- ☐ • Creates comfortable healthy buildings
- ☐ • Fire and pest resistant

Sustainable Construction



Thermafleece sheep's wool



Thermally and acoustically
efficient

Local resource

Versatility

Natural insulation

Renewable source

40% moisture
absorption

Controls
condensation

Sustainable Construction

- ❑ SmartLIFE: Focuses on MMC as a means to deliver sustainable affordable communities
- ❑ Possible to build sustainable homes using either traditional or MMC methods.
- ❑ Clarity regarding needs
- ❑ Effective communication
- ❑ Improved feedback
- ❑ Knowledge transfer



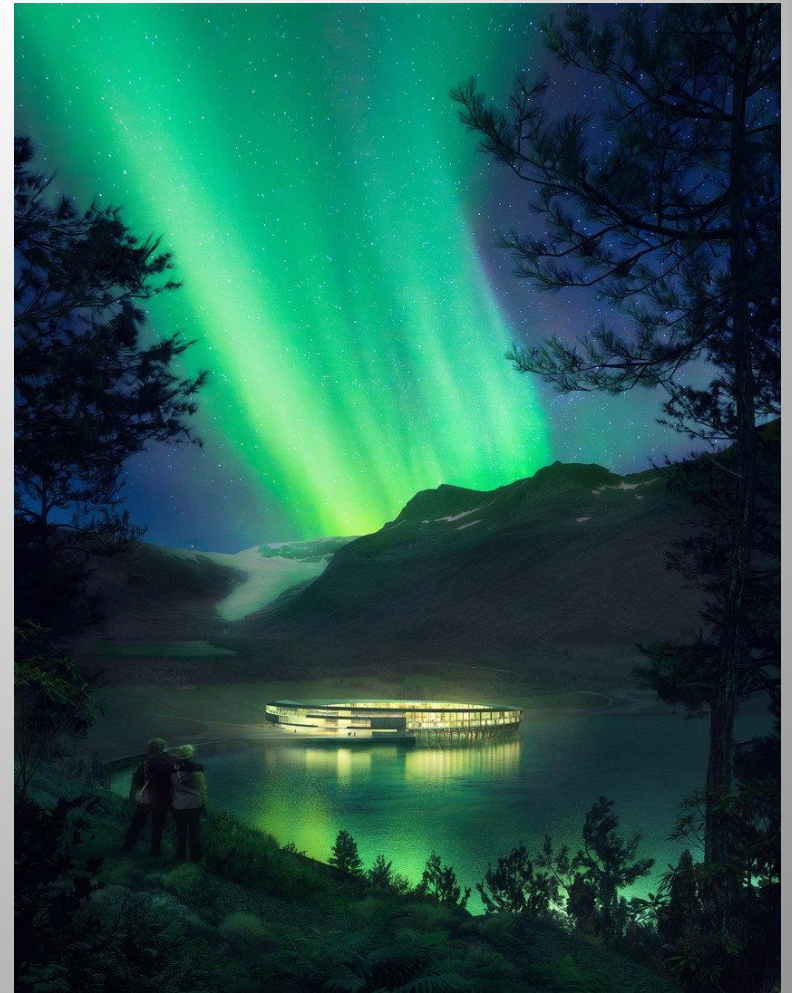
Source: Urban Design Compendium

Sustainable Construction

Repairing and maintaining

Why not retrofit?





The Norwegian Experience!

Can construction be sustainable?

- Simplicity
- Orientation
- Lighting efficiency
- Flexible design



- Energy conservation
- Avoid over-sizing
- Waste management
- Good quality air



Water Saving Plumbing

As water usage and its costs continue to rise, architects, planners and environmentalists are searching for new alternatives.

We offer a range of water saving plumbing products, including water saving cisterns, dual flush toilets, click technology taps and mixer, low capacity baths and more.

Energy efficient boilers

Boilers account for around 55% of what you spend in a year on energy bills, so an efficient boiler makes a big difference. Replacing an old gas boiler with an A-rated high-efficiency condensing boiler and improving your heating controls will significantly cut your home's carbon dioxide emissions

Solar PV

Solar panel electricity systems, also known as solar photovoltaics (PV), capture the sun's energy using photovoltaic cells.

These cells don't need direct sunlight to work – they can still generate some electricity on a cloudy day.

The cells convert the sunlight into electricity, which can be used to run household appliances and lighting.

Thermal Insulation

As thermal insulation requirements continue to grow, the industry is under increasing pressure to meet these requirements and the ever more stringent u-values demanded by them.

Heat loss reduction and energy efficiency are key considerations with all New Builds.

Energy Saving Lighting

Buildings can now be lit in a more efficient manner, using low energy LED lighting. LED lamps offer considerable savings in running costs, with much greater lifespans and greatly reduced power consumption. In some cases, a switch to LED lamps can yield electricity savings of over 90%.

Air Source Heat Pumps

An air source heat pump extracts heat from the outside air in the same way that a fridge extracts heat from its inside. It can get heat from the air even when the temperature is as low as -15°C .

Heat pumps are proven to reduce emissions by an average of 50% compared to fossil fuel boilers or electric heating, making them the most effective way of reducing the impact on both the environment and domestic fuel costs.

Ground Source Heat Pumps

Solar heat is stored in the surface layer of the soil. Using that energy for heating is a practical approach for houses with a large plot.

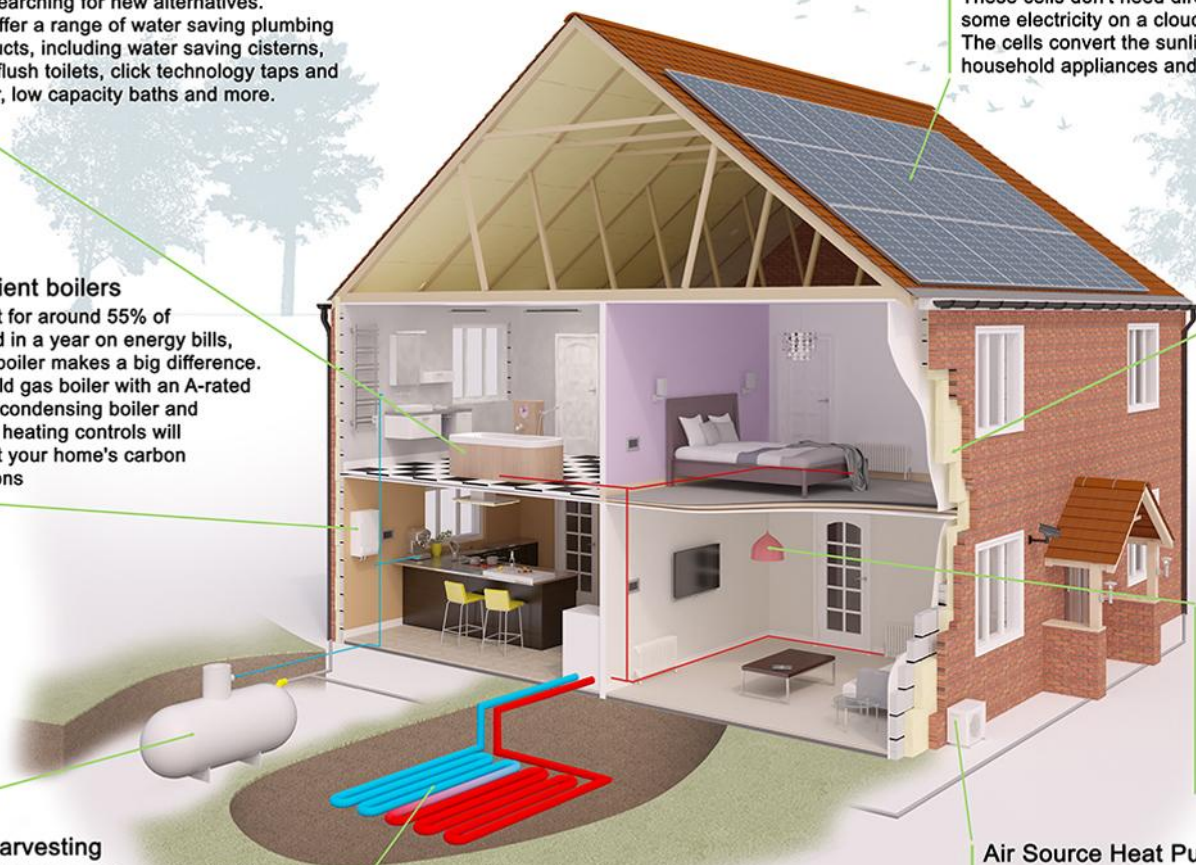
The heat is extracted from the soil by means of buried plastic tubing.

An environment-friendly non-freezing liquid circulates in the tubing and delivers the collected heat to the heat pump. In the heat pump the heat is converted into high-grade heat for space heating and to produce hot water.

Rainwater Harvesting

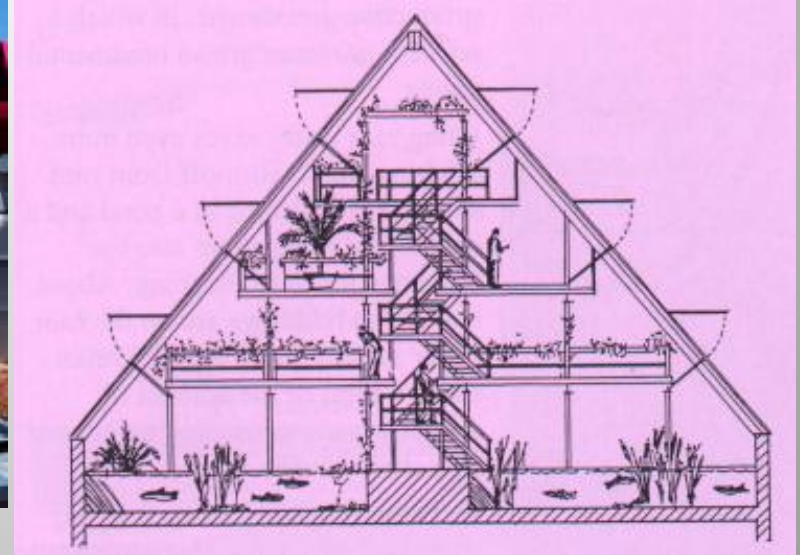
Changes in lifestyle mean we are using 55% more water now than we did 25 years ago. Rainwater harvesting is not just sensible, it also has ecological and economic advantages. It enables the provision of ground water supplies whilst reducing costs for water treatment and transport.

With water costs increasing, utilising rain water is becoming extremely common.



Can construction be sustainable?

- Passive design
- Native landscape
- Attention to power
- Water conservation
- Reduction of emissions
- Design for operation and maintenance
- Materials efficiency
- Design for recycling



Can we measure sustainability?

UK – BREEAM, uses 10 criteria
To award points / credits of
performance:

Energy

Health and Wellbeing

Innovation

Land Use

Materials

Management

Pollution

Transport

Waste

Water



Can we measure sustainability?

Other countries

America – LEED – Leadership in
Energy and Environmental design

Performance goals:

Integrative

Location and transportation

Sustainable sites

Water

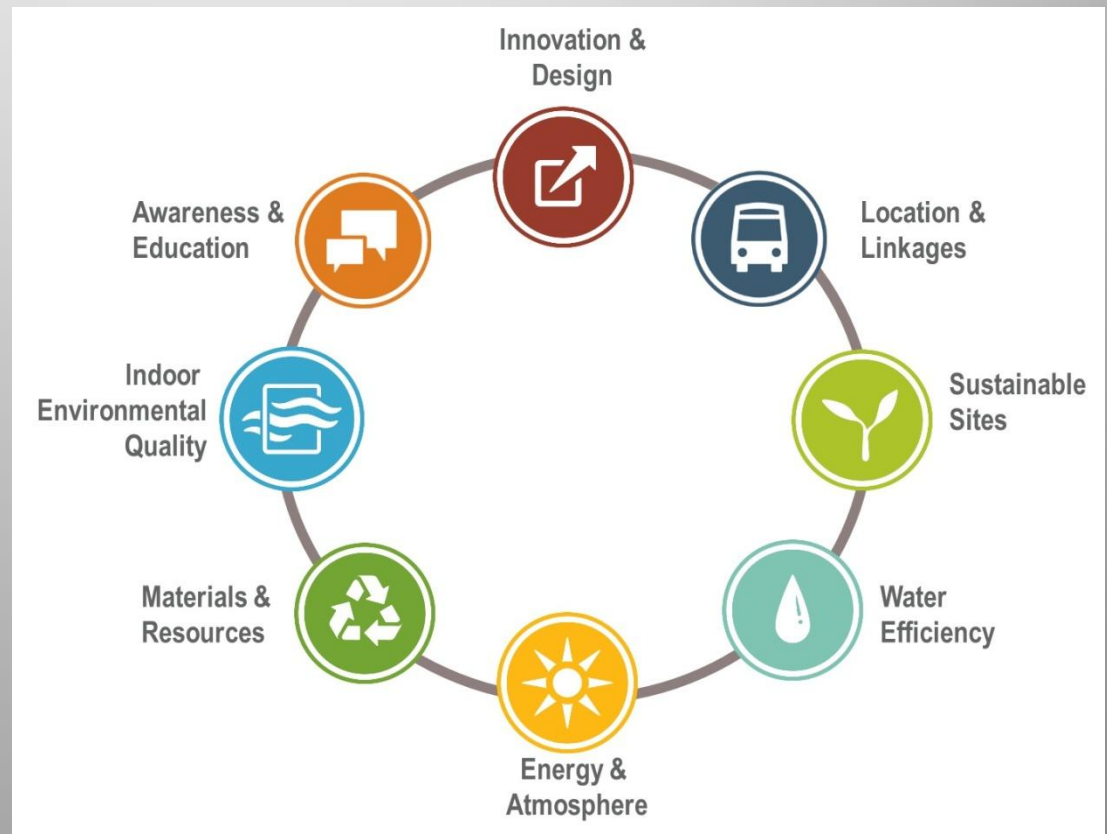
Energy and atmosphere

Materials and resources

Indoor environment quality

Innovation

Regional priority



Green Building

... a building that is responsive to the environmental needs of itself and its environments. It is one that demonstrates environmental friendliness and is designed, constructed and operated with minimum impact to the natural environment.



Green Building

- Factors that need to be considered
 - Design and construction costs
 - Asset value
 - Operating costs
 - Workplace environment
 - Risk mitigation
 - Economics



Green Cities

Chicago's smog-eating concrete

- Paving material
- Reduces < 70% of common air pollutants
- Breaks down nitrogen oxides expelled by vehicles
- Can be cost effective



Green Cities

London's electricity-generating pavements

- hybrid technology
- converts kinetic energy into electricity



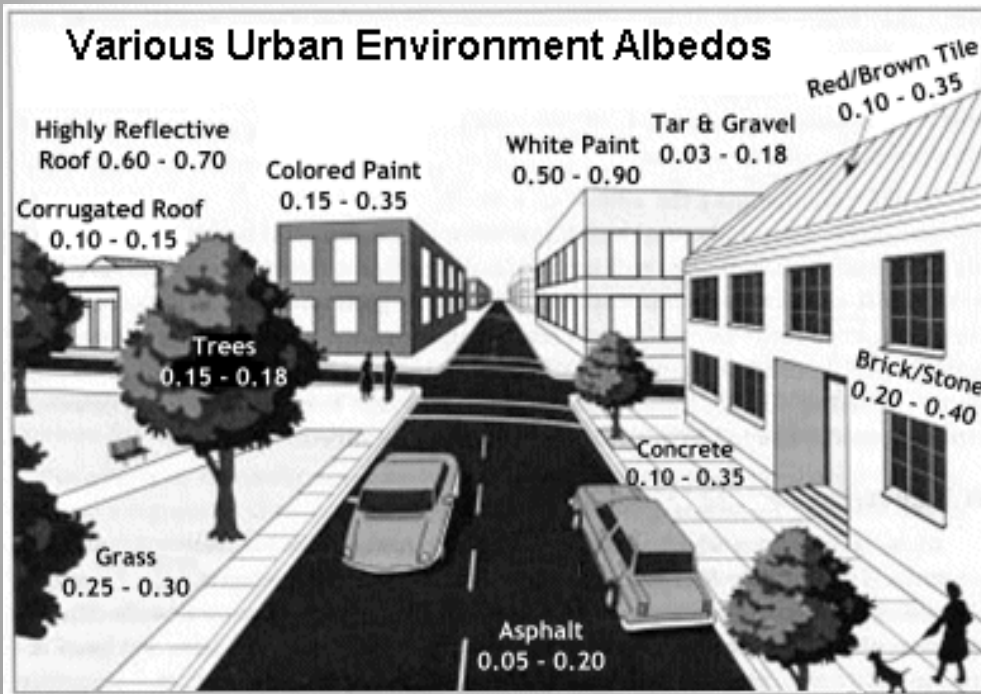


The electric Volt

Pedestrianised streets



Various Urban Environment Albedos

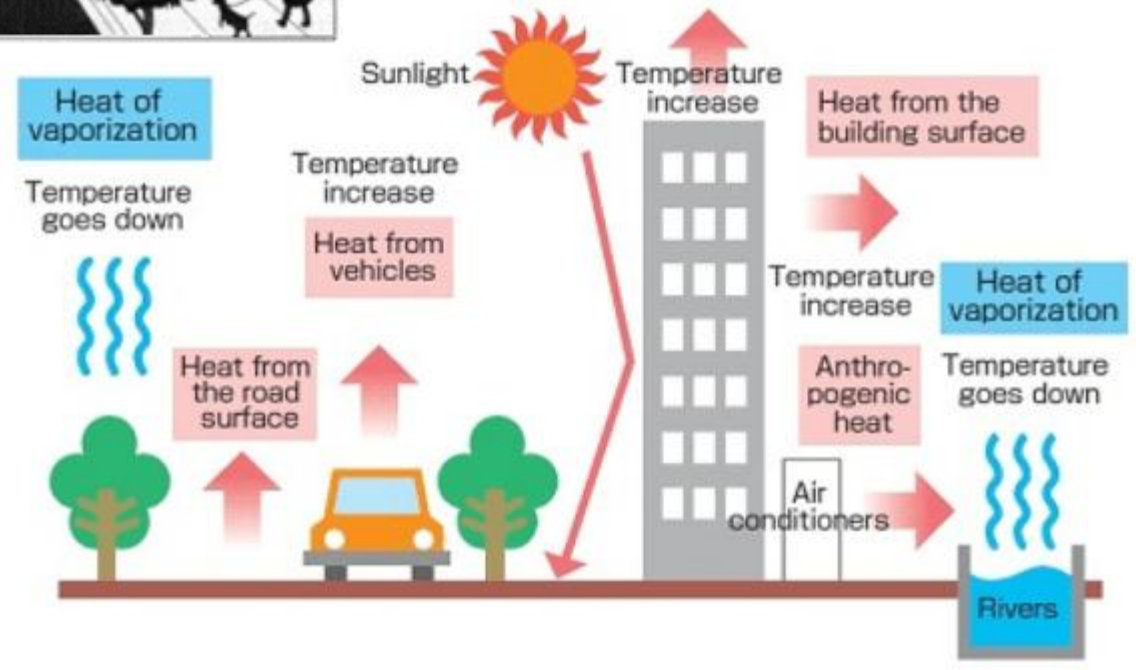


Albedo of various materials used in the built environment

0 = perfectly absorptive

1 = perfectly reflective

High-albedo surfaces (reflective areas) reduce heat gain by reflecting solar energy rather than absorbing it!





www.alamy.com - A72TWK

Future Proofing

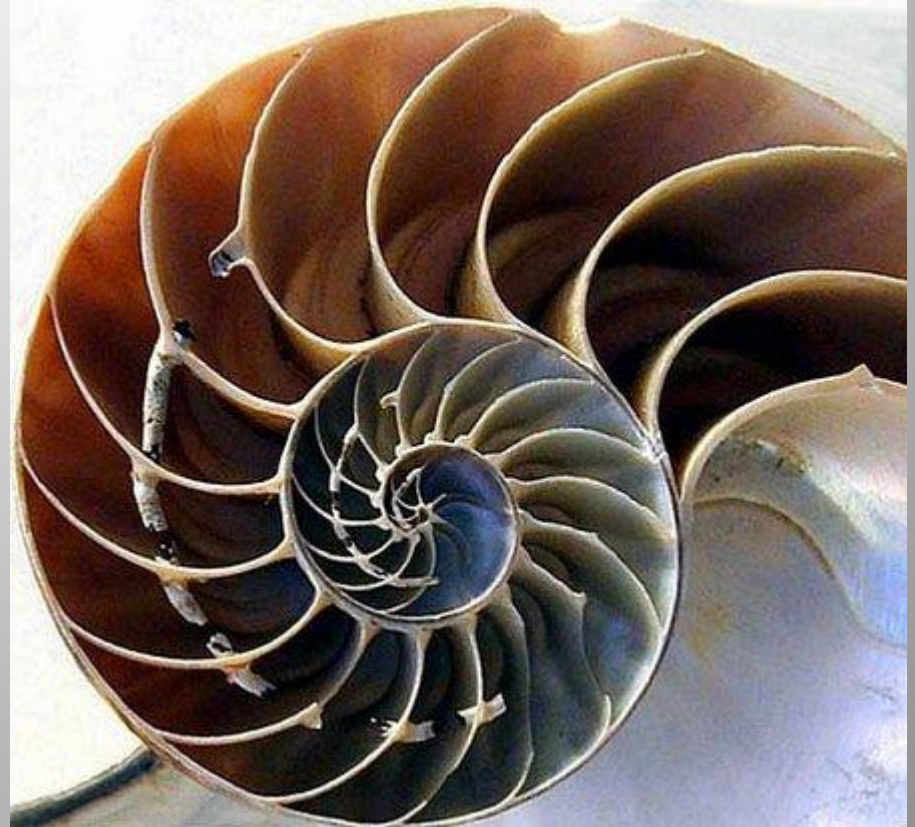
Availability of resources

Learning from the past

New College Oxford

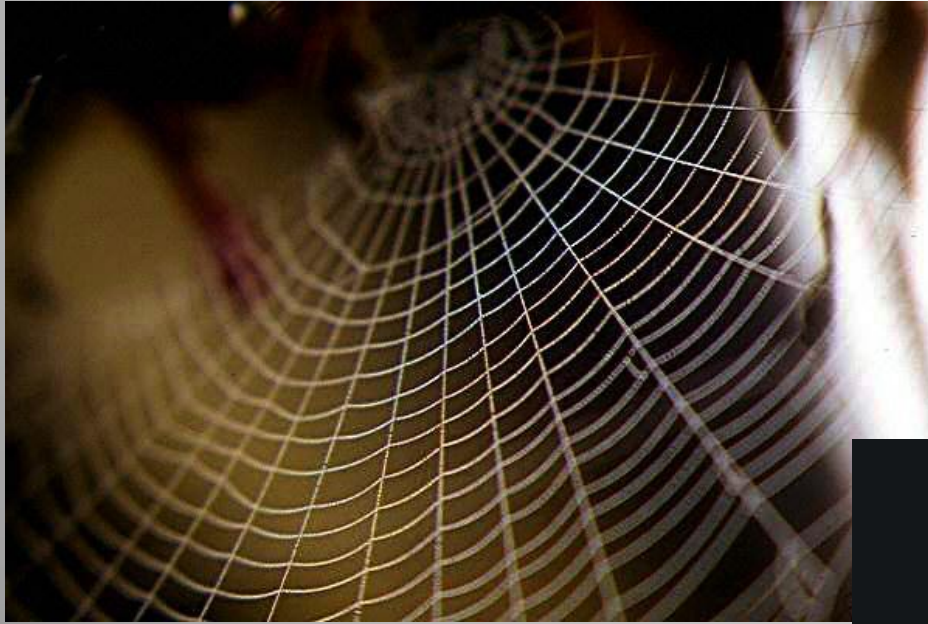
Sustainable construction?

- Design for minimum waste
- Lean construction & minimise waste
- Minimise energy in construction & use
- Do not pollute
- Preserve & enhance biodiversity
- Conserve water resources
- Respect people & local environment
- Monitor & report, (ie use benchmarks)



Sustainability and the Revolution in Design ...

Sustainable design



From this



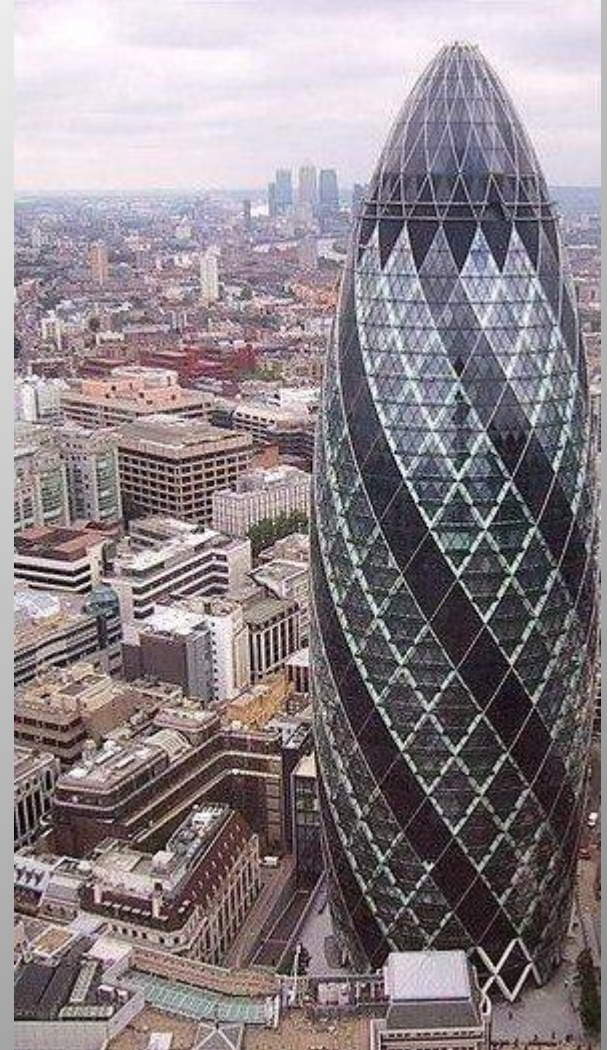
To this

Sustainable design

this



to this





and, from this

..to this



Sustainable Development

The current model is not working!

Economics

- Non-renewable resources
- Waste
- Pollution
- Eco-system
- Growth



Source: Guardian, Beijing's waste

Sustainable Development

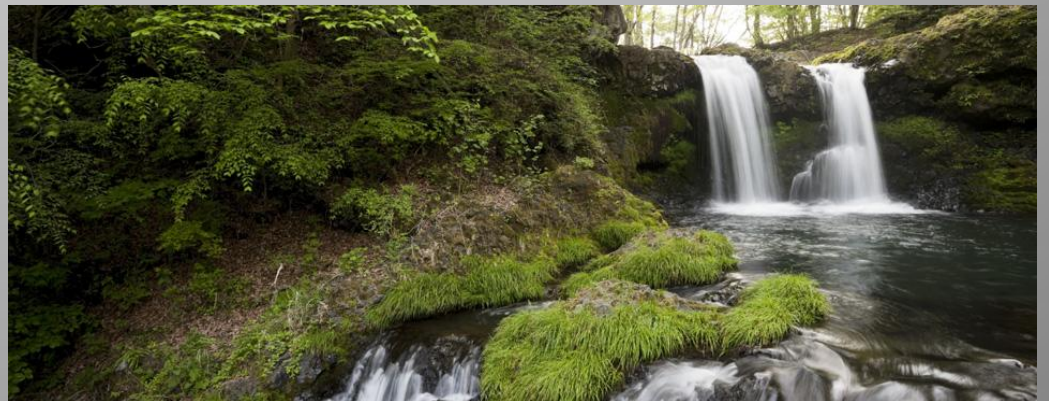
A way forward!

- Renewable resources
- Less waste
- Cleaner technologies
- Design with nature in mind
- Efficient use of resources
- Leadership



Linking sustainable construction to SD

- The five capitals model
 - Natural capital
 - Human capital
 - Social capital
 - Manufactured capital
 - Financial capital



Defining Sustainable Development



- Triple-bottom line
- Forum for the future
- Natural step

Sustainable Construction

- Success will depend on...
- Effectiveness
 - The ability to do the right thing!

and
- Efficiency
 - The ability to do the right thing, right!



Construction 2025 – A Vision!

People: An industry that is known for its talented and diverse workforce

Smart: An industry that is efficient and technologically advanced

Sustainable: An industry that leads the world in low-carbon and green construction exports



M&S Cheshire Oaks is designed to be the most carbon efficient store of its type.



Runcorn bridge uses an innovative cathodic protection system, with remote monitoring, to stop corrosion and simplify future maintenance and inspection.

Growth: An industry that drives growth across the entire economy

Leadership: An industry with clear leadership from a Construction Leadership Council

Balancing the natural with the built!



Now, we did
say sustainable,
didn't we?

Sources of information

<https://www.ons.gov.uk/>

<http://www.designcurial.com/news/biophilic-design-and-architecture---10-of-the-best-biophilic-buildings-4527750/5>

<https://www.forumforthefuture.org/>

<https://thenaturalstep.org/>

<http://www.rockymountainsustainabilitycenter.org/>

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Biffa

Freight Transport Association

BRE

<https://vimeo.com/ondemand/biophilicdesign>

<https://vimeo.com/74294955>