

Energy, Wellbeing and Productivity in Offices and Educational Buildings

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**‘Green Buildings Pay: Design,
Productivity and Ecology’**

published in 2013 (with co-author
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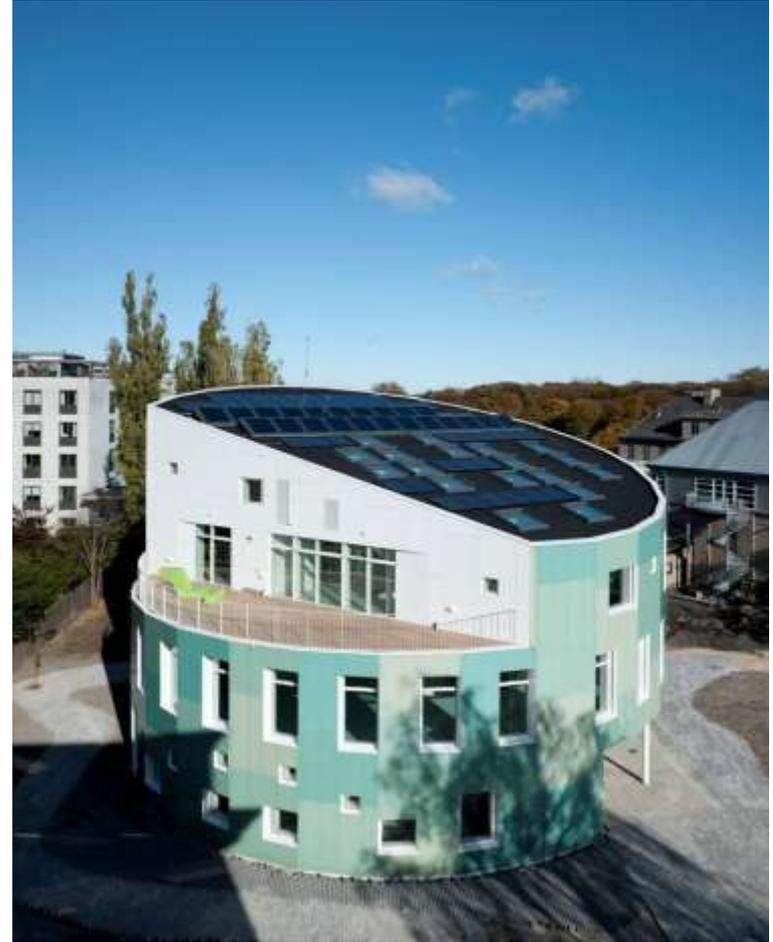
Also author of:

- ‘Rough Guide to Sustainability’
- ‘Sustainable Housing’
- ‘Sustainable Architecture’
- ‘Green Architecture’



Key Research Questions explored via 45 cases in 4 countries

- What impact does **energy design** have upon **health, wellbeing, staff productivity and company performance**
- Does **sustainability** lead to **technological** innovation, changed **client** expectation and enhanced **user** experience
- What are the emerging **green** trends in architecture and engineering
- Are working environments (offices) and learning environments (schools) similar in terms of impacts



The Research Method

- Total cases 45 (since 1997)
- 90% commercial buildings, 10% educational
- 10 cases in USA and Canada, 3 in Denmark, remainder in UK
- Primary and secondary cases employed
- Criteria for cases (high BREEAM or LEED score, architectural quality and evidence of innovation, POE, client and architect feedback)
- Triangulation of data:
Technical; Social, and Environmental



User survey

- Comfort and Control

1. Can you control the environment of the workplace
2. Are the controls understandable
3. When would you want to over-ride the BMS

- Experiential

1. What do you like about the workplace environment
2. What do you not like about it
3. What 4 key words would you use to describe the workplace

- Impact

1. Does the workplace environment give you a sense of wellbeing
2. Does it matter where you work in the building
3. Does the environment support your productivity, creativity or commitment

- Score

What score out of 10 would you give the quality of the workplace environment

Daylight or Ventilation (which matters most)

- Daylight improves productivity (not just light)
- Diversified natural light keeps brain active (creative)
- Daylight improves learning
- Daylight improves wellbeing and health
- Ventilation improves concentration
- CO2 levels are critical to mental alertness
- Indoor air quality is the main health factor
- Increasing density of workplace puts pressure on Indoor Environmental Quality (IEQ) or IAQ

Poor IEQ: What the literature says

Negatives

- Absenteeism (short term such as colds)
- Absenteeism (long term such as depression)
- Poor staff retention and morale
- Poor company image
- Poor staff recruitment

Positives

- Improvement in productivity (offices)
- More commitment and creativity
- Better staff morale
- Better company image
- Better learning (schools) and healing (hospitals)

Identifying the critical relationships and sub-questions

- Bringing energy and health together
- Determining key factors- daylight, ventilation
- Identifying critical variables: temperature, air quality, acoustic quality
- Does design matter
- Does engineering matter
- Can health and well-being be maximised through good design
- Do different types of building require different approaches
- What are best technical solutions

Two types of environment studied

Workplace (Major area)

Key factors

- Ability to focus and think
- Ability to add value to firm
- Ability to work in a team

Education (Minor area)

Key factors

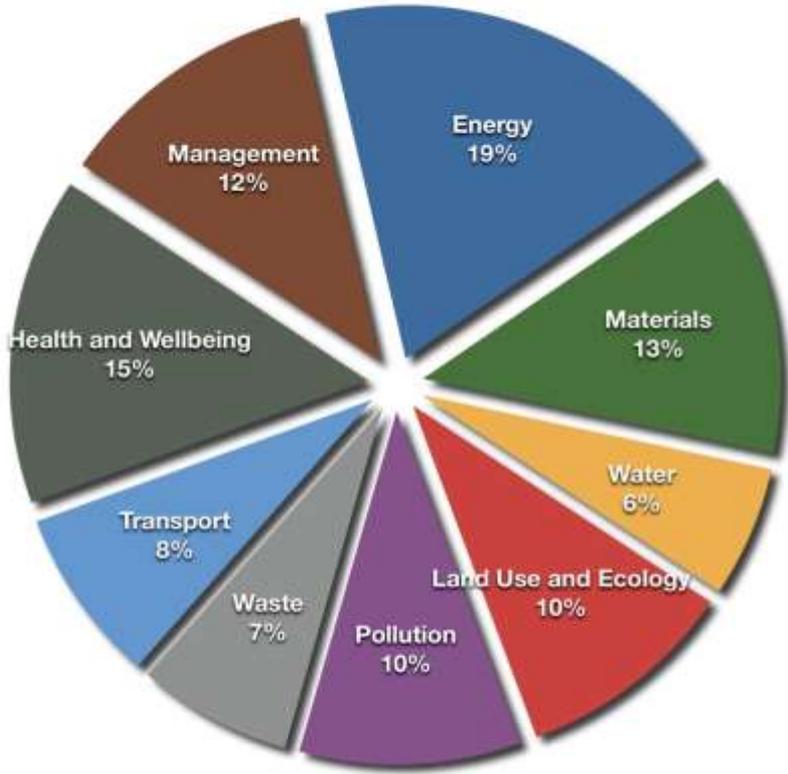
- Ability to learn
- Ability to teach
- Use of building as carrier of environmental messages to community

Testing the theory: The new cases

- Denmark – Ramboll HQ, VKR Holding HQ, Green Lighthouse
- UK- BDP offices, Wessex Water HQ, Woodlands Trust
- USA and Canada- Hearst Tower, Bank of America Tower, New York Times HQ, San Francisco Federal Building, Genzyme HQ, US Census Bureau, Kroon Hall Yale University, Manitoba Hydro

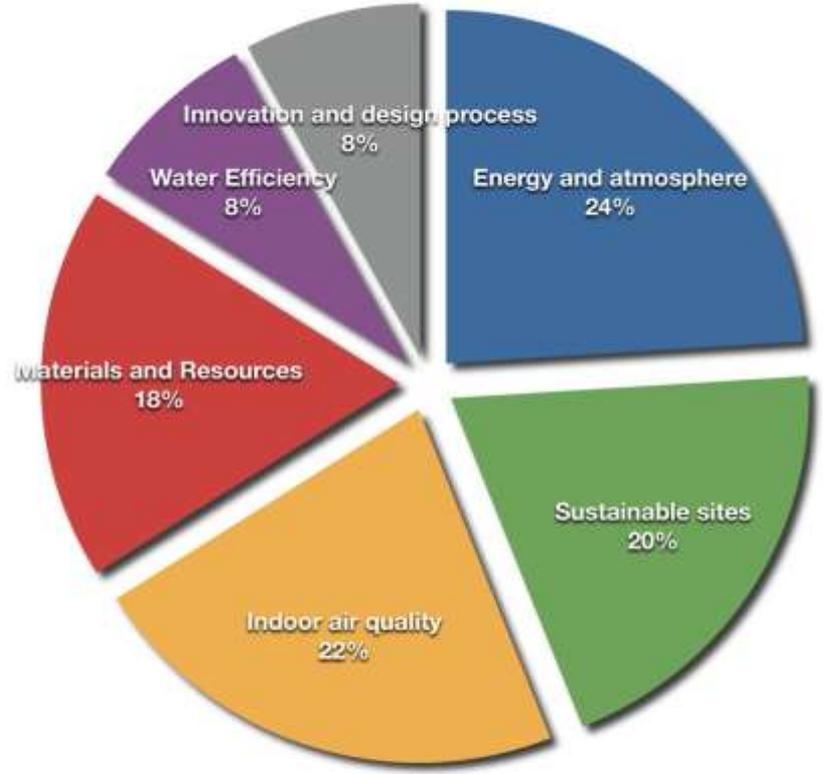


BREEAM



- Energy
- Materials
- Water
- Land Use and Ecology
- Pollution
- Waste
- Transport
- Health and Wellbeing
- Management

LEED



- Energy and atmosphere
- Sustainable sites
- Indoor air quality
- Materials and Resources
- Water Efficiency
- Innovation and design process

Developing the knowledge: clients and architects

- 5 large architectural practices interviewed (CF Muller, Foster and Partners, BDP, SOM, HOK)
- Exploration of methods and tools used in sustainable design
- Parallel interviews with building clients and developers
- Scoping study via professional and practice websites
- BREEAM and LEED database (200,000 buildings certified)



Building Case Study 1: Ramboll Head office, Copenhagen

- Energy performance 79 kWh/m²/yr (equivalent to BREEAM Excellent or LEED Gold)
- 83kWh in use
- High level of staff satisfaction (8.5 out of 10)
- Key satisfaction points were (in order) daylight levels, indoor air quality, thermal comfort and ease of controls
- Key words used in user survey- inspiring, motivating, calm, comfortable, democratic
- Features most valued- atrium, controls, views and public transport



Ramboll HQ: key design features

- Different façade designs for different orientations
- Double ventilating façade on south and west elevations
- External shading and internal solar blinds
- Large central atrium
- Personal control of workplace environment



Case study 2: BDP Office, Manchester

- High energy performance of 75kWh/m²/yr
- BREEAM Excellent
- High level of staff satisfaction 8.6 out of 10
- Annual staff turnover dropped from 21% (old building) to 11% (new building)
- Positive user comments included daylight quality, ambience of workplace environment, good air quality
- User reactions cited enhanced productivity, good image, commitment to company



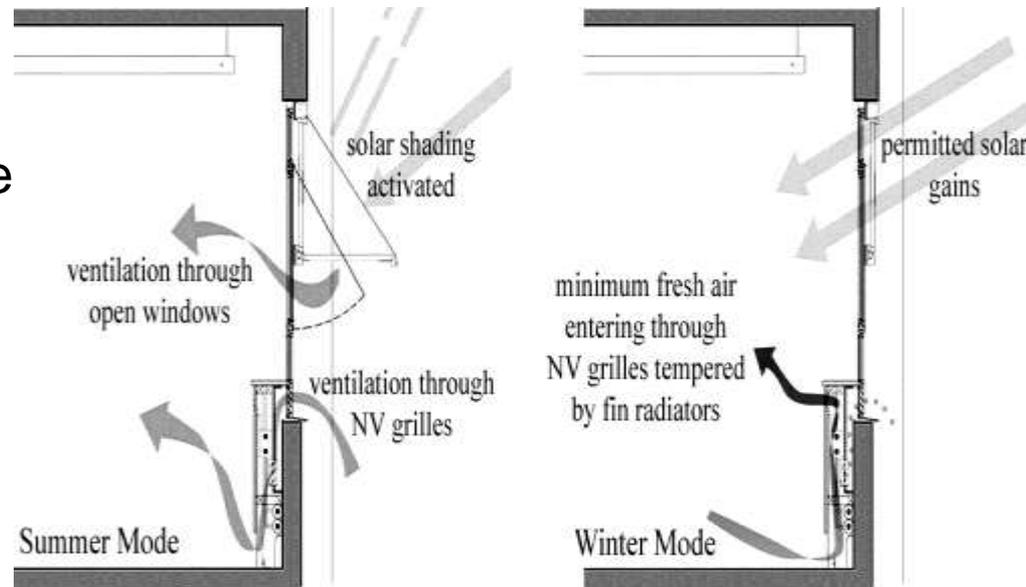
BDP office, Manchester: technical solution

- Metal clad ventilating south façade with small windows
- Fully glazed north façade
- Extensive rooflights in top floor studio.
- Exposed concrete for night time cooling
- Passive mixed mode ventilation
- planted roof with water catchment



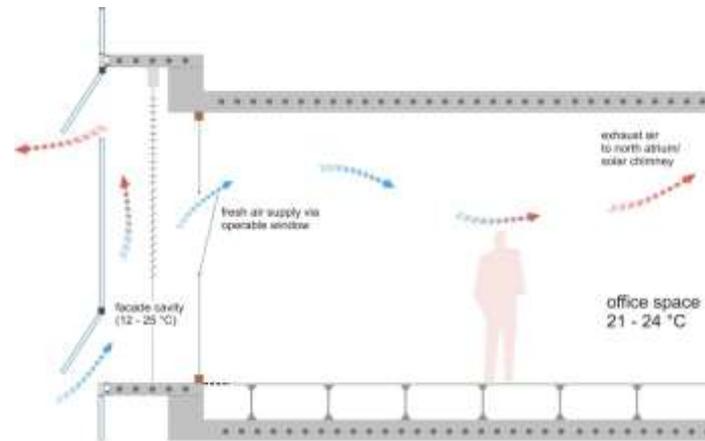
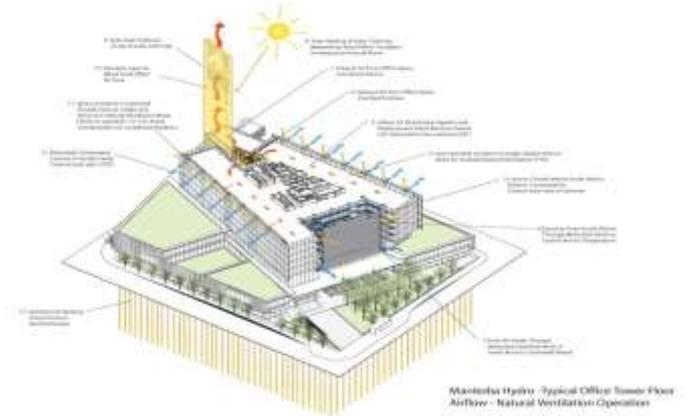
Case study 3: West End House, London

- High level of seasonal control of façade with occupant override
- Passive and active systems related to frequent sub-meters
- High level of occupant feedback citing overall **thermal comfort, ease of control of workplace environment**
- Negative point was air leakage through external grilles
- Productivity up by **9% over previous building by same company**



Case study 4: Manitoba Hydro office, Canada

- **Healthy, effective and adaptable office** for 2,000 staff (in brief)
- Building to demonstrate the company's energy expertise
- Emphasis on solar control in summer and thermal comfort in winter
- LEED Gold
- **High level staff satisfaction**



Case study 5: VKR offices, Denmark

- Demonstration building to test Velux products
- 78kWh/m²/yr
- 68% daylight and natural ventilation through year
- 40% CO₂ saving over Danish standard
- Sensors regulating internal and external blinds
- 90% satisfied or very satisfied compared to 40% in previous building
- Daylight key to satisfaction and enhanced productivity (80%)
- staff retention high



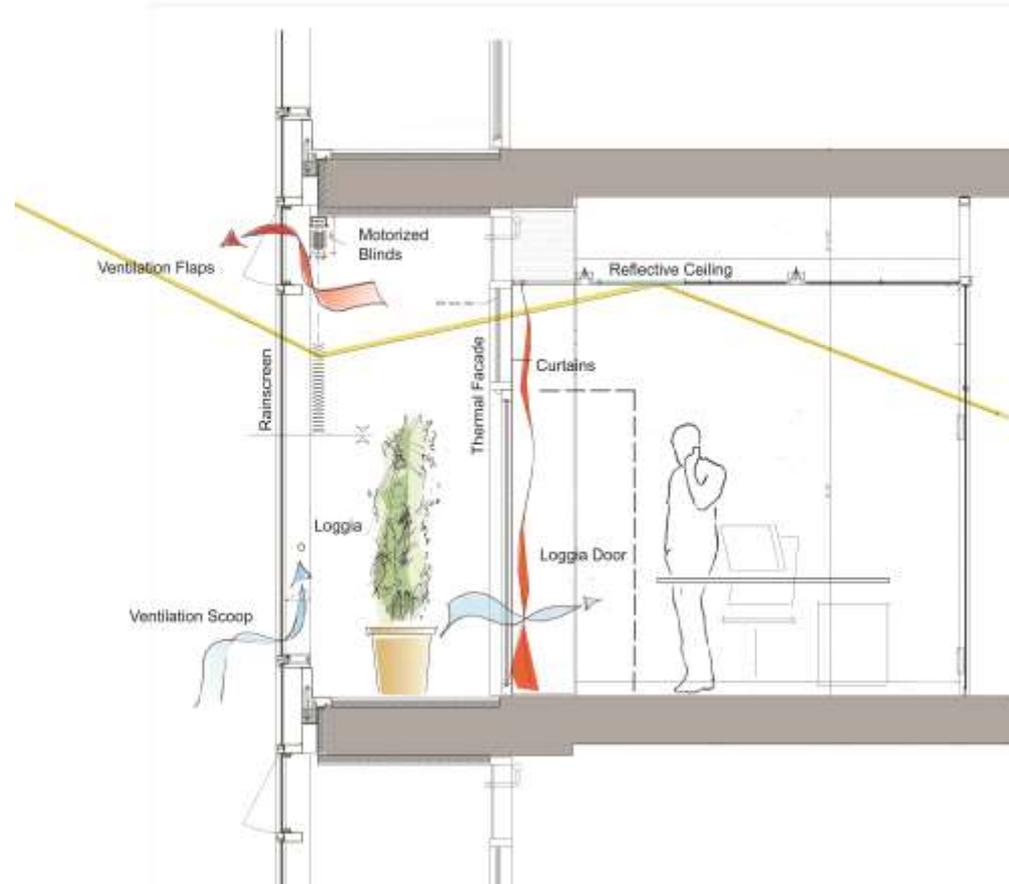
Case study 6: Genzyme HQ, Boston

- **Greenest office** building in USA when built in 2004 (87kWh/m²)
- 72% of staff reported building made them feel more **alert and productive**
- **Absenteeism down** by 4-5 %
- **Daylight in offices and sunlit atrium** key feature in satisfaction levels
- Enhanced feeling of **well-being**



Genzyme office: technical solution

- Double ventilating façade with solar shading and season variation
- Daylight shelves in offices
- Heliostat on roof to track sun for atrium
- Water used for internal cooling



Key Trends: facades

- Facades are becoming more complex technically
- Façade costs (25%) have a big impact on energy costs (40%)
- Façade design is critical to **thermal and visual comfort and sense of wellbeing**
- Façade design and control is critical factor to **productivity**
- **Solar** is biggest façade problem



Façade design



Key Trends: atria

- Atrium-based design is increasingly employed
- Both cross and stack ventilation reduces air conditioning loads and improves perception of health and wellbeing
- Sunlit atria preferred to daylight atria
- Atria are important social spaces and help with networking



Atria for comfort, energy efficiency, thermal recovery and social gains

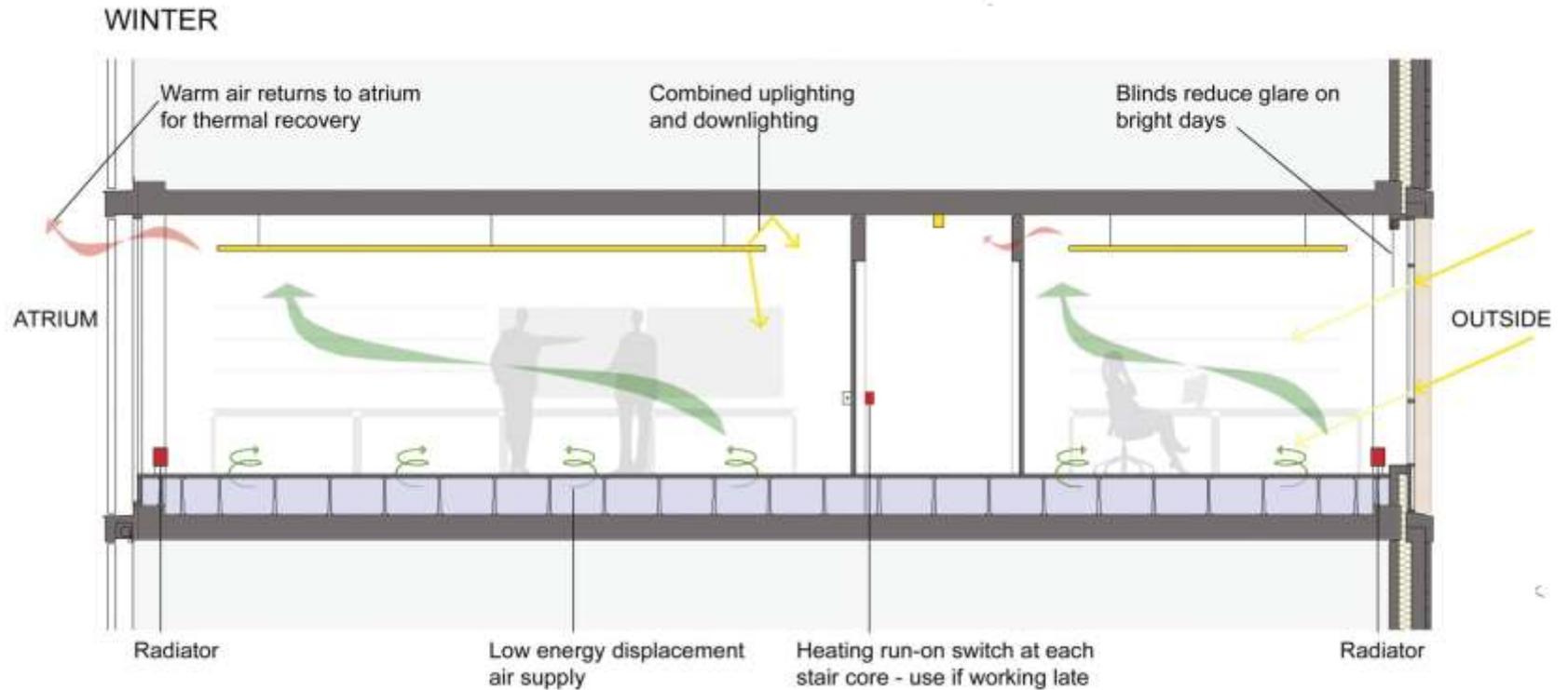


Findings: comfort and wellbeing

- Daylight and ventilation matter but natural preferred to air-con
- Maximising daylight in workplace improves **performance especially in creative industries**
- Workers prefer to control their own comfort levels
- **Wellbeing is a combination of natural light, natural ventilation and natural materials**
- **Energy efficiency does not necessarily produce wellbeing**
- Building science and management ethos must overlap



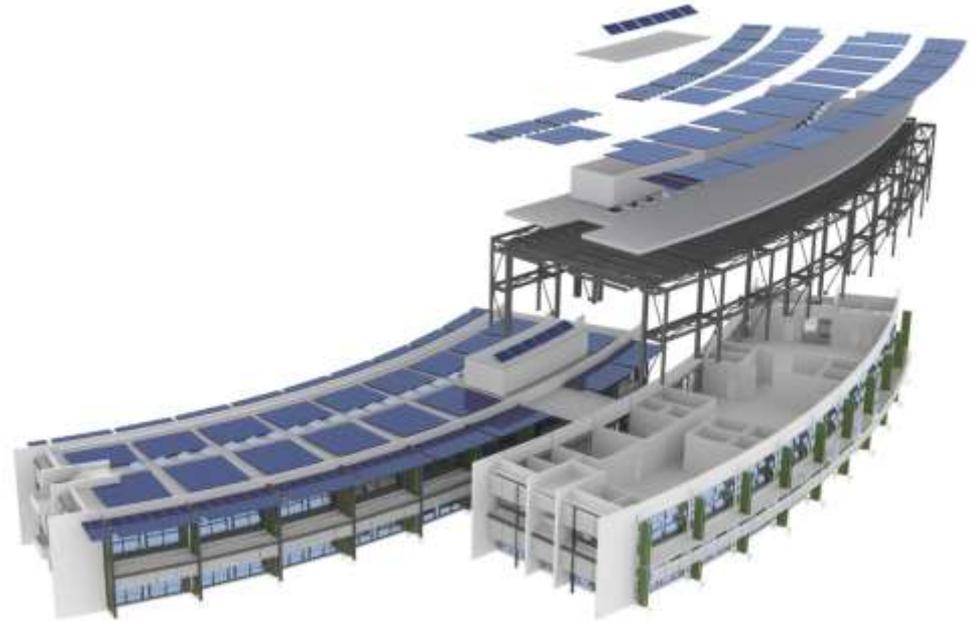
Comfort and control



Life Cycle models

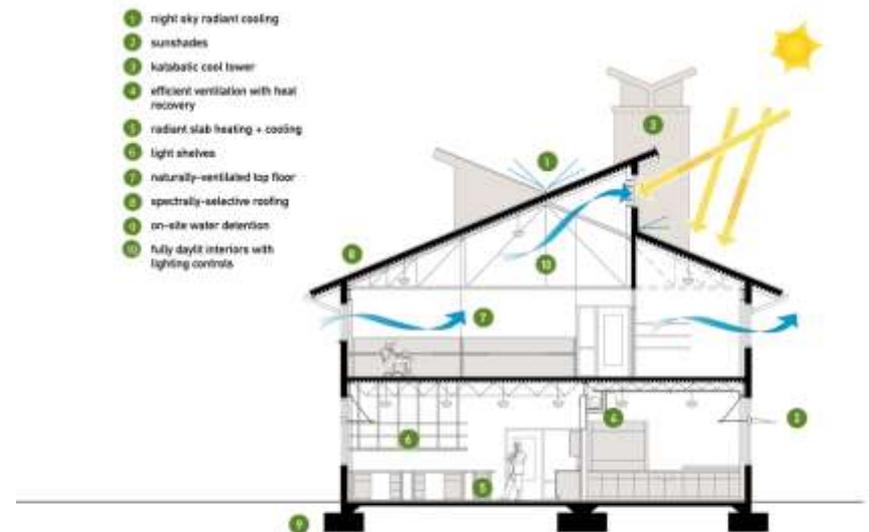
- **Business** benefits of enhanced productivity (4%) outweigh energy cost benefits by a factor of about **3 to 1** (at current energy prices)
- Image (of building) and marketing (of company) through sustainable design brings big **business benefits** (to company and community)
- Certification (BREEAM, LEED) increases the **business and user** benefits but not necessarily energy benefits
- Sustainability brings **health and wellbeing** benefits as long as design does not focus alone on energy efficiency
- Life cycle models must include **users** and their perception of **productivity, health and wellbeing**

Let geometry, orientation and façade design solve solar problems (not air-conditioning)



Final thoughts on energy efficiency in office design

- Company performance is determined by staff productivity
- Productivity is determined by perceptions of comfort (not of energy efficiency)
- Wellbeing is the consequence of good ecological design
- Solar control is the biggest design problem in many modern offices
- Ensure management ethos, design approach and building services share same values



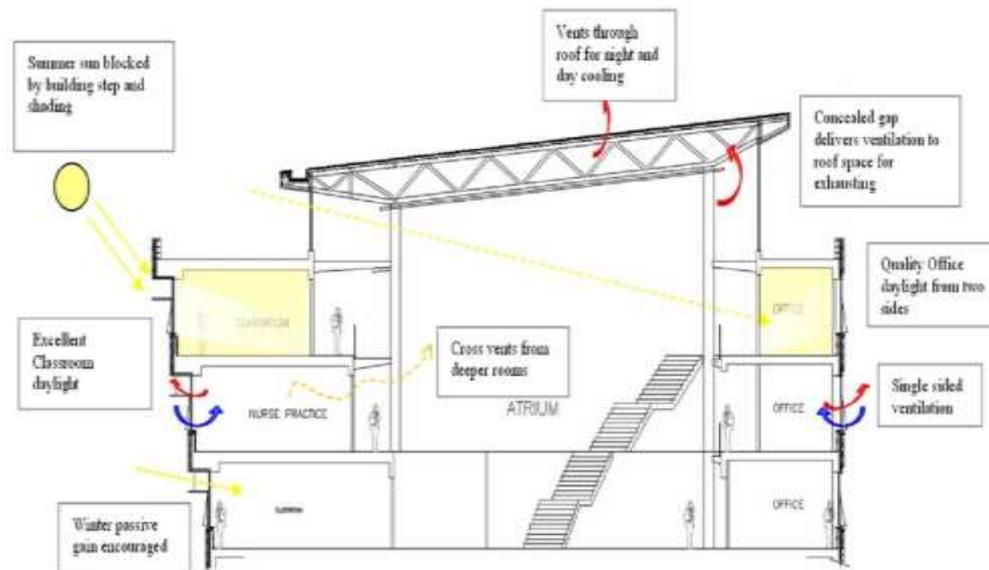
Educational buildings and Green schools

- 40 green schools and colleges surveyed over ten year period
- 2 school clusters- Hampshire and Essex (UK)
- 6 college and university buildings (4 in USA, 1 in UK, 1 in Denmark)
- Data employed included school performance tables, exam results, teacher interviews, high green certification
- Triangulation of data (eco-schools, pupil performance, teacher interviews)



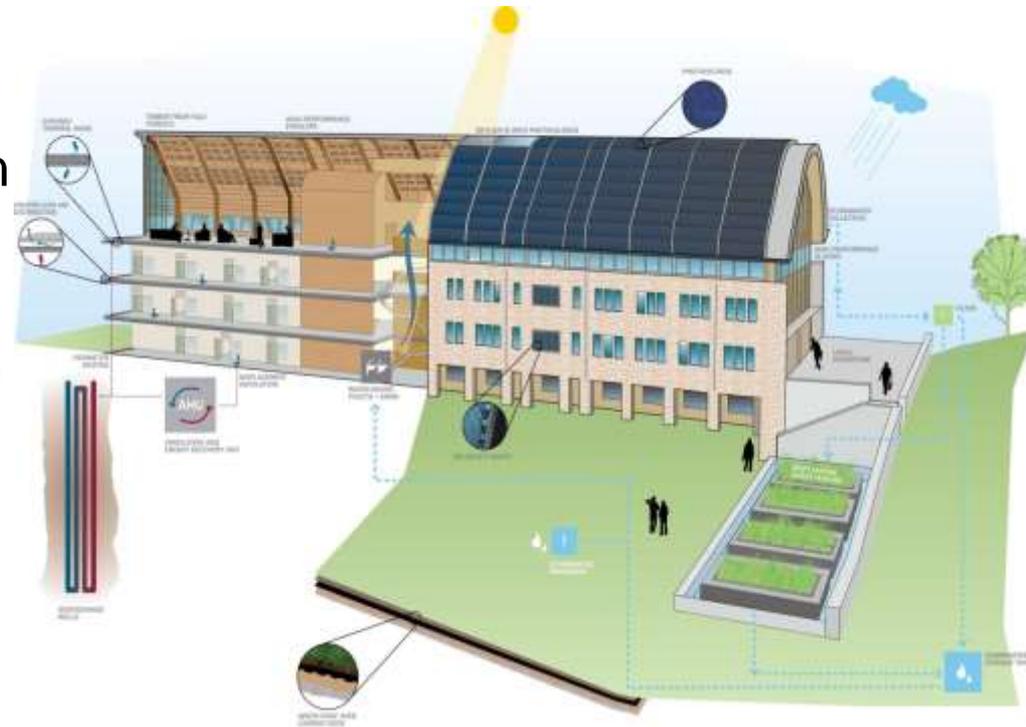
Some findings (schools)

- Learning enhanced by maximising daylight in classroom especially at early stages of child development (4% improvement)
- Solar control essential to avoid glare and overheating
- Daylight matters as much to learning as ventilation (which also matters)
- Fans disrupt teaching by masking spoken word
- Teacher satisfaction undermined by poor classroom environment
- Green schools and colleges led to better pupil learning and behaviour and better staff retention



Findings: University buildings

- Image of university enhanced by green buildings
- Sustainability can be tested on campus through building projects
- High green profiles encourage recruitment of top talent and best students, this leads to better education
- R and D begins on campus
- Green is about all resources, not just energy
- Top universities are also the greenest and leanest (Yale, Copenhagen)



$$\begin{aligned} E_n + E_c + E_v = & \langle U(c + w + h + pr) + \\ & C(i + pe + r) + \\ & B(v + lcc + le + id) \end{aligned}$$

Putting it all together

Sustainable design leads to 3 main benefits:

- Building has better life cycle costing, enhanced value over time, lower exposure
- Company has better performance, better image, better staff retention
- User is more productive, less absenteeism, better health and wellbeing