Green Building Pay: Design. Productivity and Ecology

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‘Green Buildings Pay: Design, Productivity and Ecology’
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Also author of 20 other books including:
• ‘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
• Criteria for cases (high BREEAM or LEED score, architectural quality and evidence of innovation in design and engineering, client and architect feedback)
• Triangulation of data: Technical (design and engineering); Social (business and user), and Environmental (energy and ecology)
User survey

• **Comfort and Control**
  1. Can you control the environment of the workplace
  2. Are the controls understandable and do you have the knowledge
  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
The debate: **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 and smart engineering
- What are the 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
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
Context and Issues
• Growth in environmental assessment and certification schemes
• BREEAM (1990), LEED (1998), DGNB (2008)
• Increasing dominance of LEED and relative importance of energy credits
• Added value of ‘green’ certification - are there real or imagined benefits
• 200,000 BREEAM buildings, 40,000 LEED
Developing the knowledge: clients and architects

- 5 large architectural practices interviewed (CF Muller, Foster and Partners, BDP, SOM, HOK)
- Exploration of methods and simulation tools used in sustainable design and engineering
- Parallel interviews with building clients
- 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 screens and internal blinds for thermal and acoustic control
- Large central atrium for stack ventilation and MVHR
- Integrated design
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 double 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 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
- Building to demonstrate the company’s energy expertise
- Emphasis on solar control in summer and thermal comfort in winter via double facade
- 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 building standards
- 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
- Ecology and engineering design integration
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
- Planting used for noise and air quality improvement
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, acoustic and visual comfort and sense of wellbeing
- Façade design and control is critical factor to productivity
- Solar is biggest façade problem
- New engineering solutions are changing the architecture of commercial buildings
Changing façade design in UK, Denmark and USA
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 day-lit atria
- Atria are important social spaces which help with networking
- Atria are the ecological heart of big buildings
Atria for comfort, energy efficiency, thermal recovery and social gains
Ecology and nature

- Energy, health and ecology need integration
- Nature inside and out
- Biomorphism inspiring architecture and engineering
Key trends: Roofs

• Roofs are becoming more active architecturally
• Water, ecology and cooling are reshaping the engineering of roofs
• Roof design is key to energy efficiency
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
Example of good comfort and control

- Warm air returns to atrium for thermal recovery
- Combined uplighting and downlighting
- Blinds reduce glare on bright days
- Radiator
- Low energy displacement air supply
- Heating run-on switch at each stair core - use if working late
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** (staff costs 60% of company total costs)
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 engineering share same values
Let geometry, orientation and façade design solve solar problems (not air-conditioning)
LEED and BREEAM have changed design approach
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)
Putting it all together

Sustainable design leads to 3 main benefits:

• **Building** has better life cycle costing, enhanced value over time, lower exposure to changing environmental legislation

• **Company** has better performance, better image, better staff retention

• **User** is more productive with less absenteeism, better health and wellbeing
The Equation: **Green Buildings Pay when:**

\[ \text{En} + \text{Ec} + \text{Ev} = \text{Users (c+ w+ h+ pr)} + \text{Company (i+ pe+ r)} + \text{Building (v+ lcc+ le+ id)} \]

Where

- **En** (energy)
- **Ec** (ecology)
- **Ev** (environment)
Future thoughts

• Buildings of tomorrow will generate their own power and export the surplus
• Carbon neutral architecture depends on teamwork across professions.
• Growing urban densities will push buildings high-tall is the new challenge
• Innovation today is the key to solving tomorrow’s problems