Design of High Performance Green Buildings: Opportunities and Challenges

高效能綠色建築設計: 機遇與挑戰

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Acknowledgments

- ASHRAE Headquarters

- Mr. Kent W. Peterson
  - Past Chairman of ASHRAE Standard Project Committee 189.1 (SPC 189.1)
  - ASHRAE Past President
“What is green building?”
An example of green building in Hong Kong ?!

(Photo taken by Dr Sam C M Hui)
Green building is NOT just adding a green outlook

(Photo taken by Dr Sam C M Hui)
What is green building?

- It is a structure that is **environmentally responsible** and **resource-efficient** throughout its **life-cycle**.
- Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:
  - Efficient use of energy, water, and other resources
  - Protecting occupant health and improving employee productivity
  - Reducing waste, pollution and environment degradation
Resource and material flow in the building ecosystem

**Upstream**
- Bldg. materials
- Energy/fuels
- Fresh water
- Consumer goods
- Solar radiation
- Wind
- Rain

**Downstream**
- Used materials
- Combustion by-product
- Waste water
- Garbage
- Heat
- Polluted air
- Ground water
Construction process and building life cycle (cradle-to-grave)
What is green building?

• Green buildings are
  • Energy and resource efficient
  • Non-wasteful and non-polluting
    • Sustainable design that helps minimise broad environmental impacts (e.g. ozone depletion)
  • Highly flexible and adaptable for long-term functionality
  • Easy to operate and maintain (lower running costs)
  • Supportive of the productivity and well-being of the occupants
"It's not easy being green." -- Kermit the Frog, 1972.

Why going green?
Why going green?

- Survival of our planet: environmental crisis
  - Air (destruction of Earth’s atmosphere)
    - Global warming, climate change
  - Water (an undervalued resource)
    - Shortage and pollution
  - Fire (the problem of fuels)
    - Fossil fuel burning (coal, oil)
  - Earth (resources and materials)
    - Resources depletion
SUSTAINABLE DEVELOPMENT
If all countries have ecological footprints same as current industrialized ones, we need four earth planets to support the living.
Why going green?

- Green buildings pay
  - Direct benefits (e.g. energy/cost savings)
  - Indirect benefits (e.g. healthier conditions)
  - Wider global benefits (e.g. reduced CO₂ emission)
- Life-cycle benefits
  - Total economic and environmental performance
  - Long-term “sustainability”
Why going green?

- Green building incentives, such as, in Hong Kong, exemptions of gross floor area (GFA) and site coverage (SC)
  - Joint Practice Notes No. 1 & 2: Green and Innovative Buildings
  - Practice Note APP-151, Building Design to Foster a Quality and Sustainable Built Environment
  - Practice Note APP-152, Sustainable Building Design Guidelines
Why going green?

- Promoted by building energy efficiency codes and guidelines, such as
  - In Hong Kong: the Building Energy Codes under the Buildings Energy Efficiency Ordinance
  - In Macau: the Macau Building Energy Optimisation Technical Guidelines (澳門建築物能耗優化技術指引)
Why going green?

- What happens when Green becomes code?
  - Overseas experience: mandatory codes

CALGreen 2010 Green Building Standards Code

International Green Construction Code (IgCC)
ASHRAE Standard 189.1

• What is Standard 189.1?
  • A standard developed in model code language
  • Provides minimum requirements for high-performance, green buildings
  • Applies to all buildings except low-rise residential buildings (same as ASHRAE Standard 90.1)
  • Optional compliance path to the International Green Construction Code (IgCC)
  • Not a design guide, not a rating system
ASHRAE Standard 189.1

- It is jointly developed by:
  - ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers)
  - USGBC (U.S. Green Building Council)
  - IESNA (Illuminating Engineering Society of North America)
- It is also approved by American National Standards Institute (ANSI)
ASHRAE Standard 189.1

• Goals for Standard 189.1
  • Establish mandatory criteria in all topic areas
    • One “challenge” is existing green building rating systems contain few mandatory provisions
  • Provide simple prescriptive compliance options
  • Provide flexible performance compliance options
  • Complement green building rating programs
    • Standard is not intended to compete with green building rating programs (e.g. LEED)
Standard 189.1 building blocks

(Source: Mr. Kent W. Peterson)
Compliance paths of Standard 189.1

Mandatory + Prescriptive Path
(simple option, very few calculations)

Mandatory + Performance Path
(more options, but more effort)

(Source: Mr. Kent W. Peterson)
ASHRAE Standard 189.1

- Standard 189.1 topic areas:
  - SS  Sustainable Sites
  - WE  Water Use Efficiency
  - EE  Energy Efficiency
  - IEQ Indoor Environmental Quality
  - MR Building’s Impact on the Atmosphere, Materials & Resources
  - CO Construction and Operations Plans
ASHRAE Standard 189.1

- Sustainable Sites Highlights
  - Site selection
    - Allowable sites (e.g. brownfield)
    - Prohibited development activity
  - Reduce heat island effect
    - Site hardscape
    - Wall and roof
  - Reduce light pollution
    - Outdoor lighting
    - Light trespass limits
ASHRAE Standard 189.1

- **Water Use Efficiency Highlights**
  - Site water use
    - Bio-diverse plantings, hydrozoning, and smart irrigation controllers
  - Building water use
    - Plumbing fixtures & fittings, appliances, HVAC systems & equipment
    - Cooling tower maximum cycles of concentration
  - Water measurement for building and subsystems
Building Energy Codes (e.g. ASHRAE 90.1)

(Source: Mr. Kent W. Peterson)
ASHRAE Standard 189.1

- Energy Efficiency Highlights
  - More stringent than Standard 90.1-2007
    - Equipment efficiency compliance
  - Includes plug/process loads
  - Electric peak load reduction
  - Renewable energy provisions
    - On-site renewable energy systems
  - Energy measurement for verification
ASHRAE Standard 189.1

- Indoor Environmental Quality Highlights
  - Indoor air quality
    - Ventilation rates per ASHRAE Standard 62.1
    - Outdoor air flow rate monitoring of min. outside air
    - MERV 8 filter (MERV 13 in PM2.5 non-attainment areas)
    - No smoking inside building
    - Source contaminant control
  - Daylighting
  - Acoustical control
ASHRAE Standard 189.1

- The Building’s Impact on the Atmosphere
  
  **Highlights**

  - Construction waste management
  - Reduced impact materials
  - Wood products
  - Refrigerants
  - Storage and collection of recyclables and discarded goods
ASHRAE Standard 189.1

- Construction and Operation Highlights
  - Acceptance testing / commissioning
  - IAQ construction management plan
- Plans for Operation
  - High-performance building operation
  - Maintenance
  - Service life
  - Transportation management
Opportunities

• Global trends – green building: there are significant and growing opportunities
  • Such as green building services and products
• Green building is being adopted at dramatic rates in every region of the world, e.g. China, India and Middle East
• A priority for Mainland China is to encourage green building and energy efficiency
LEED registered projects in international market

<table>
<thead>
<tr>
<th>Country</th>
<th># Projects</th>
<th>Floor area (ft²)</th>
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</thead>
<tbody>
<tr>
<td>India (Includes IGBC data on LEED India)</td>
<td>1554</td>
<td>964,673,465</td>
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<tr>
<td>Canada (Includes CaGBC data on LEED Canada)</td>
<td>3768</td>
<td>766,416,439</td>
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<td>China (incl. HK, Macau, and Taiwan)</td>
<td>690</td>
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<td>UAE</td>
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<td>Korea</td>
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<td>Saudi Arabia</td>
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<td>Brazil</td>
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<td>Mexico</td>
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<td>Qatar</td>
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</table>

Opportunities

• Market sectors
  • Residential buildings
  • Commercial buildings
  • Public sector buildings
  • Industrial buildings

• Market drivers
  • The issue of climate change, energy efficiency, carbon emission reduction, energy price, government policies and legislation
Opportunities

• Major technology demand
  • Energy efficient lighting, HVAC systems, building controls & energy management, solar energy systems (e.g. PV), green building materials, water efficiency systems

• Green building services
  • Architectural and engineering services, urban planning & design, specialised green building consultancies, energy efficiency consultancies
Opportunities

- Key areas for green specialist advices
  - Building structure
  - Envelope design
  - Lighting services
  - Electrical power
  - Cooling and heating engineering
  - Water services
  - Ventilation
  - Cost estimating
  - Landscaping
Opportunities

• Growing importance of green building assessment/rating and certification, such as:
  • LEED (USA)
  • BEAM Plus (HK)
  • China 3-star Standard (China)
  • BREEAM (UK)
  • CASBEE (Japan)
  • BCA Green Mark (Singapore)
  • Green Building Label (Taiwan)
Green building assessment and certification
Opportunities

- LEED Green Building Rating System
  - Leadership in Energy & Environmental Design
  - By US Green Building Council
  - Current LEED systems:
    - New construction & major renovation (LEED-NC)
    - Existing building operations (LEED-EB)
    - Commercial interiors projects (LEED-CI)
    - Core and shell projects (LEED-CS)
    - Schools, Retail, Healthcare, Homes
    - Neighborhood development (LEED-ND)
Opportunities

- LEED Green Building Rating System
  - Evaluates and recognizes performance in accepted green design categories, including:
    - Sustainable sites
    - Water efficiency
    - Energy and atmosphere
    - Materials and resources
    - Indoor environmental quality
    - Innovation credits
  - Website: www.leedbuilding.org
<table>
<thead>
<tr>
<th>Category</th>
<th>Possible Points</th>
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<tr>
<td>Sustainable Sites</td>
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<tr>
<td>Water Efficiency</td>
<td>10</td>
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<tr>
<td>Energy &amp; Atmosphere</td>
<td>35</td>
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<tr>
<td>Materials &amp; Resources</td>
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<tr>
<td>Indoor Environmental Quality</td>
<td>15</td>
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<tr>
<td>Innovation in Design</td>
<td>6</td>
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<tr>
<td>Regional Priority</td>
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</table>

For LEED version 3

(Source: USGBC)

Total Possible Points: **110**

* Out of a possible 100 points + 10 bonus points

**Certified 40+ points, Silver 50+ points, Gold 60+ points, Platinum 80+ points**
Opportunities

• BEAM Plus (launched 2009)
  • Version 2009: (start 1 Apr 2010)
    • BEAM Plus for New Buildings
    • BEAM Plus for Existing Buildings
  • Criteria [weighting]
    • Site aspects (SA) [25%]
    • Materials aspects (MA) [8%]
    • Energy use (EU) [35%]
    • Water use (WU) [12%]
    • Indoor environmental quality (IEQ) [20%]
    • Innovations & additions (IA) [credits 0-3]
Opportunities

- **BEAM Plus** (launched 2009)
  - **Overall grade**: (with min. for SA, EU and IEQ)

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<tr>
<th></th>
<th>Overall</th>
<th>Site Aspects</th>
<th>Energy Use</th>
<th>IEQ</th>
<th>Innov. &amp; Addn.</th>
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<tr>
<td><strong>Platinum</strong></td>
<td>75%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
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<tr>
<td><strong>Gold</strong></td>
<td>65%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>2 credits</td>
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<tr>
<td><strong>Silver</strong></td>
<td>55%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>1 credit</td>
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<tr>
<td><strong>Bronze</strong></td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
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</table>
Note: CEPAS = Comprehensive Environmental Performance Assessment Scheme

(Source: Buildings Department, HK)
Challenges

• Main market barriers
  • High initial installation costs
  • No proper definition for green building concept
  • Separated interests of developers & building users
  • Short investment horizon & payback periods
  • Lack of reliable information & support
  • Slow progress in renewable energy sources
  • Uncertainty about green building performance
The complex value chain in the building sector

Challenges

- Green building design involves
  - Holistic approach (whole systems thinking)
    - Each aspect is considered in relation to all others
  - Interdisciplinary efforts
    - Understanding & contribution from all involved
  - Understanding of building performance
    - Assessment & evaluation of performance
  - Caring for people
    - Well being of the occupants and users
Green Building 綠色建築
Challenges

• Major concerns
  • Conserve non-renewable energy & scarce materials
  • Minimise life-cycle ecological impact
  • Use renewable energy and materials that are sustainably harvested
  • Protect & restore local air, water, soils, flora and fauna
  • Support pedestrians, bicycles and mass transit
  • Reduce human exposure to noxious materials
Building life cycle and sustainable construction

Design

Construction

Operation & maintenance

Demolition/Disposal

Energy issues
- Efficiency
- Renewable

Water conservation
- Reduce
- Recycle

Designers

Contractors

Users

Materials and systems
- Reduce
- Select

Waste management
- Recycle
- Reuse
Challenges

• How to achieve Green Building?
  • 1. Planning and design
  • 2. Energy efficiency
  • 3. Water efficiency and conservation
  • 4. Material conservation and resource efficiency
  • 5. Environmental quality
Challenges

- Green building design strategies
  - Urban and site design
  - Energy efficiency
  - Renewable energy
  - Building materials
  - Water issues
  - Indoor environment
  - Integrated building design
Site analysis and understanding of the environmental factors is important.
Advanced Energy Design Guides
www.ashrae.org/freeaedg

Now Available for Free Download from ASHRAE
Major factors contributing to indoor air quality (IAQ)

- Particulates
- Biological contaminants
- Volatile organic compounds

Construction materials
Building envelope
Furnishings
Equipment
Ventilation systems
Maintenance
Occupants
Electro-magnetic fields
Site

Challenges

- WBDG - The Whole Building Design Guide
  - www.wbdg.org
- Two components of whole building design:
  - Integrated design approach
  - Integrated team process
- A holistic design philosophy
  - Holism + Interconnectedness + Synergy
  - “The whole is greater than the sum of its parts”
Elements of Integrated Design

- Emphasize the integrated process
- Ensure requirements and goals are met (via Building Commissioning, etc.)
- Evaluate solutions
- Think of the building as a whole
- Develop tailored solutions that yield multiple benefits while meeting requirements & goals
- Focus on life cycle design
- Work together as a team from the beginning
- Conduct assessments (e.g., Threat/Vulnerability Assessments & Risk Analysis) to help identify requirements & set goals

(Source: www.wbdg.org)
Integrated Design Process

(Source: International Initiative for a Sustainable Built Environment (iiSBE), www.iisbe.org)
LCA: a methodology for assessing the life cycle environmental performance of products and processes

(Source: Athena Institute, www.athenasmi.org)
Conclusions

• Green building movement is critical to every society including Hong Kong and Macau
• There are good opportunities for building and construction professionals to contribute
• More efforts are needed to develop policies, technologies, research studies and design collaboration to overcome the market barriers
• It is also important to educate GREEN people!
THANK YOU 謝謝

(More information: www.hku.hk/bse/sbs/)