CIBSE Hong Kong Branch
One Day Seminar on “Sustainability: here and there, now and future”
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Implications of Green Roof Systems for Building Services Engineers

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1911-2011

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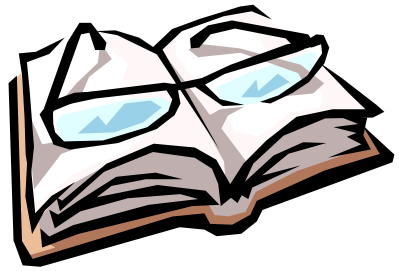
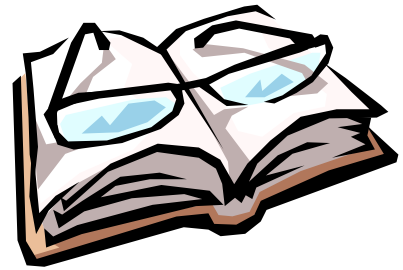
Introduction



- Problems in urban cities
  - Urban heat island (UHI)
  - Lack of greenery space
  - Large ecological footprint
- Green roofs can mitigate the adverse effects
  - Bring the nature back to urban area
  - Make better use of roof space
- To promote sustainability
  - Building Services Engineer has a role to play

Introduction



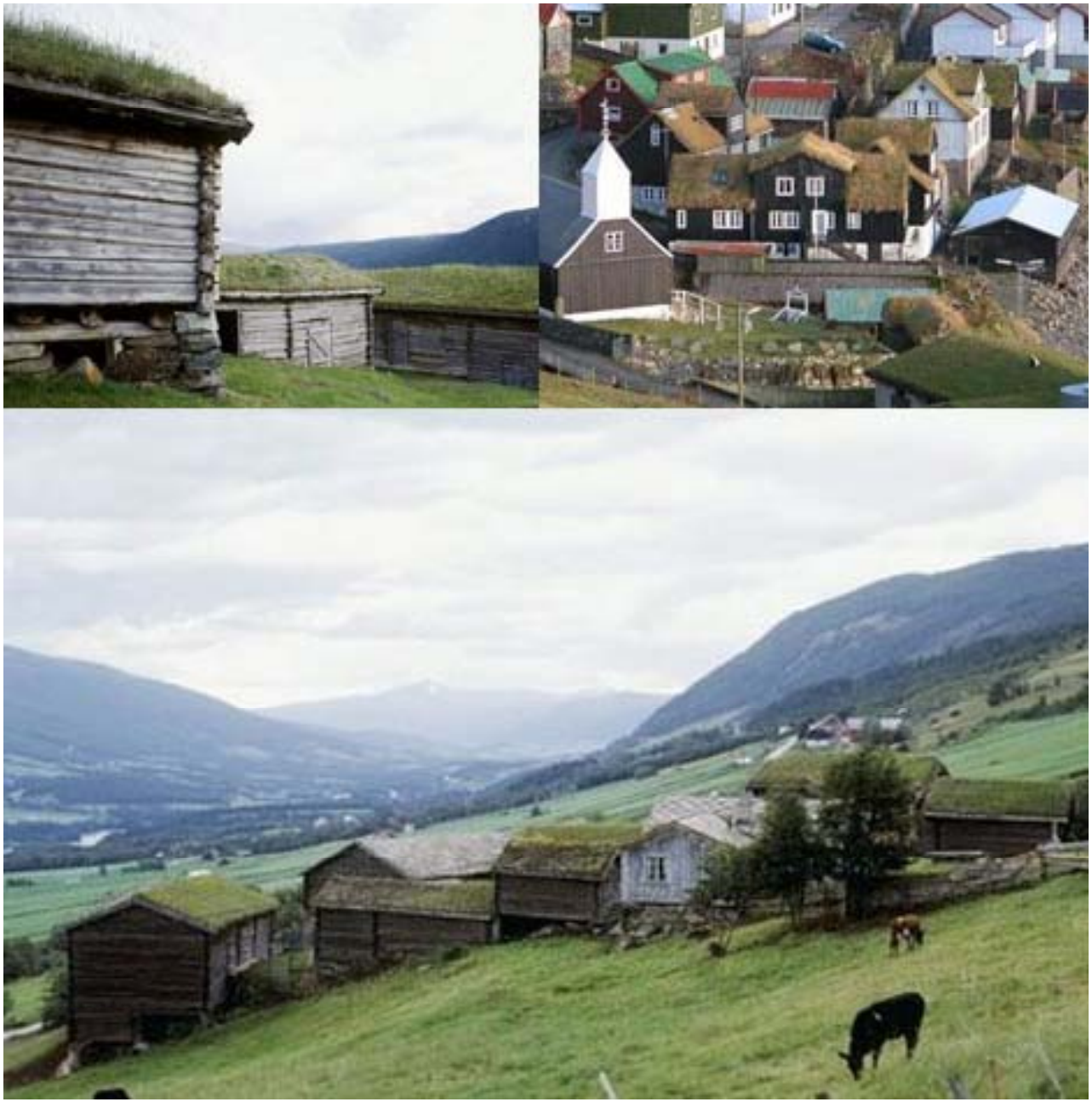
- Green roofs are not a new phenomenon
  - Hanging Gardens of Babylon (600 B.C.)
  - Traditional houses in China and Japan

  - Vikings' grass-covered green roofs on residential and farm houses in Scandinavia (1600 D.C.)
  - Terraced green roofs in Germany & Switzerland (1960's)
- Modern green roofs (came up in 1970's)
  - Multi-layered systems; various planting options

The Hanging Gardens of Babylon (an ancient wonder of the world)

(Source: http://weburbanist.com)

Simple grass-covered green roofs on residential and farm houses in Northern Europe (absorb rainfall & provide thermal protection)



(Source: http://weburbanist.com)

Goats on a green roof in Wisconsin (USA)

(Source: http://weburbanist.com)

Examples of green roofs in the world

Solar Campus Jülich, Germany (11 Jul 2001)

IBN-DLO Wageningen, the Netherlands (2 Jul 2001)

Putrajava Int. Conven. Centre, Malaysia (30 Jun 2006)

Beitou Taipei Library, Taiwan (6 Aug 2007)

(Photos taken by Dr Sam C M Hui)

Examples of green roofs in Singapore

Carpark roof of public housing (modular green roof)

Carpark roof of housing estate (built-in green roof)

Carpark roof of public housing (intensive green roof)

Lawn green roof (Nanyang Techn. Univ.)

(Photos taken by Dr Sam C M Hui, 29 May & 1 Jun 2009)

Green roof systems

- **Green Roofs**: roofs bearing vegetation – FLL
  - "Living vegetation installed on the roofs"
  - "Vegetated roof"
- **Green Roof System** – Definition
  - "A roof area of plantings/landscape installed above a waterproofed substrate at any building level that is separated from the ground beneath it by a man-made structure." – *NRCA Green Roof System Manual 2007*
- Other terms: Eco-roof, Living roof

Green roof systems

- Major types of green roofs (see Table 1)*
  - Extensive
  - Semi-intensive
  - Intensive

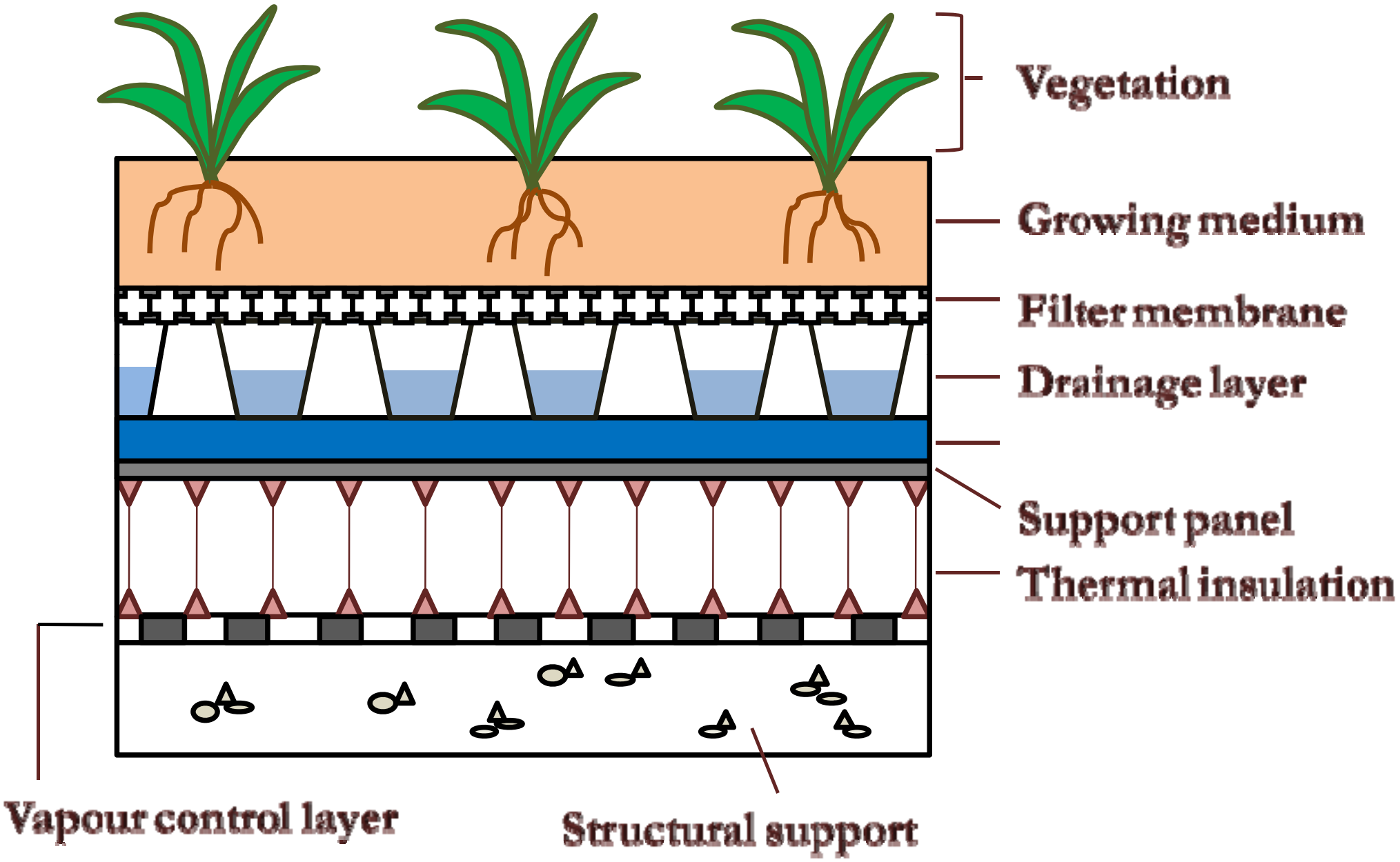
* Could also be combined as hybrid systems

- Roof gardens: usually intensive greening with other features such as potted plants, pond, etc.
  - Examples in HK: podium gardens, sky gardens
- Classify green roof systems by basic design:
  - Built-in green roofs vs Modular green roofs

Table 1. Major types of green roofs and their characteristics

Characteristics	Extensive	Semi-intensive	Intensive
Depth of material	150 mm or less	Above and below 150 mm	More than 150 mm
Accessibility	Often inaccessible	May be partially accessible	Usually accessible
Fully saturated weight	Low (70-170 kg/m^2)	Varies (170-290 kg/m^2)	High (290-970 kg/m^2)
Plant diversity	Low	Greater	Greatest
Plant communities	Moss-sedum-herbs and grasses	Grass-herbs and shrubs	Lawn or perennials, shrubs and trees
Use	Ecological protection layer	Designed green roof	Park like garden
Cost	Low	Varies	Highest
Maintenance	Minimal	Varies	Highest

Structure of extensive green roof



Green roof systems from Germany (left) and Japan (right)

Vegetated mat system (www.elteasygreen.com)

Tray system (www.liveroof.com)

Sack system (www.greenpaks.com)

Modular green roof system from Japan

G-WAVE Ecom construction distance

Gウェイブ エコム 施工の流れ 作業工程

作業工程

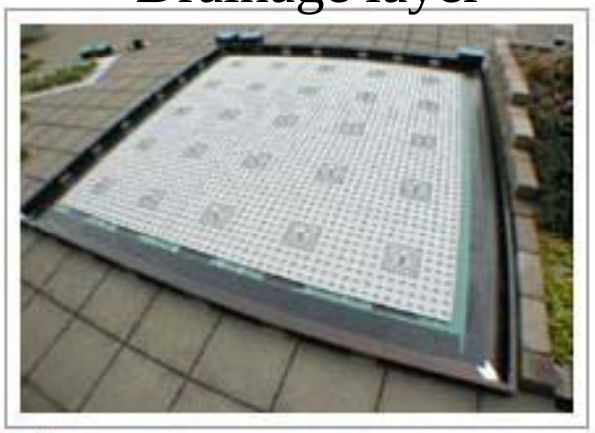
Waterproofing

1 防水層施工直後

Roof barrier layer

2 エコムテープ

Drainage layer



3 FDドレインEN FDウォール80E

Install modules

4 エコムユニット

Fix modules (if needed)

5 FDワッシャー

Completed

6 仕上がり

(Source: www.tajima-roof.jp)

Benefits of green roofs

- Green roofs provide many benefits to the society (public) and building owners (private)
  - 1. Environmental benefits
  - 2. Economic benefits
  - 3. Amenity and aesthetic benefits
- Important considerations:
  - Some benefits are common to all green roofs, but many are project design specific; some benefits will be apparent if roof greening is on a large scale

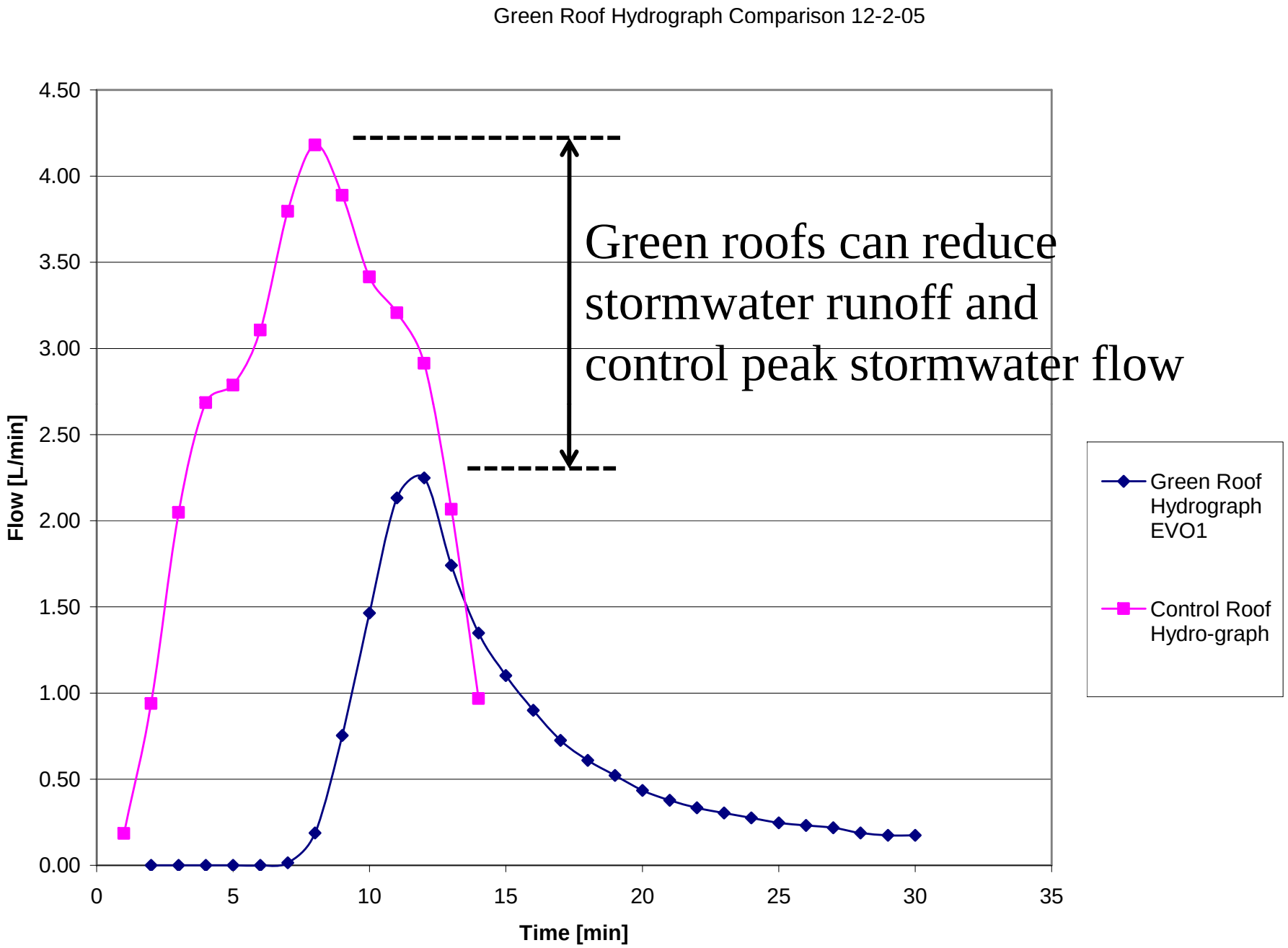
Table 2. Public and private benefits of green roof systems

Public benefits:	**Private benefits:**
- Aesthetic value - Mitigate urban heat island - Stormwater retention - Create natural habitat - Functional open space - Agricultural space - Filter dust and pollutants - Filter rainwater	- Increase roof life span - Reduce cooling loads - Contribute to green building rating credit points - Better use of space - Reduce noise levels - Reduce risk of glare for surrounding buildings

Benefits of green roofs

- 1. Environmental benefits:
  - Biodiversity and wildlife value
  - Stormwater management
  - Rainwater runoff quality
  - Air pollution mitigation
  - Carbon sinks (sequestration)
  - Mitigation of urban heat island
  - Control of noise pollution

Green roof hydrograph comparison

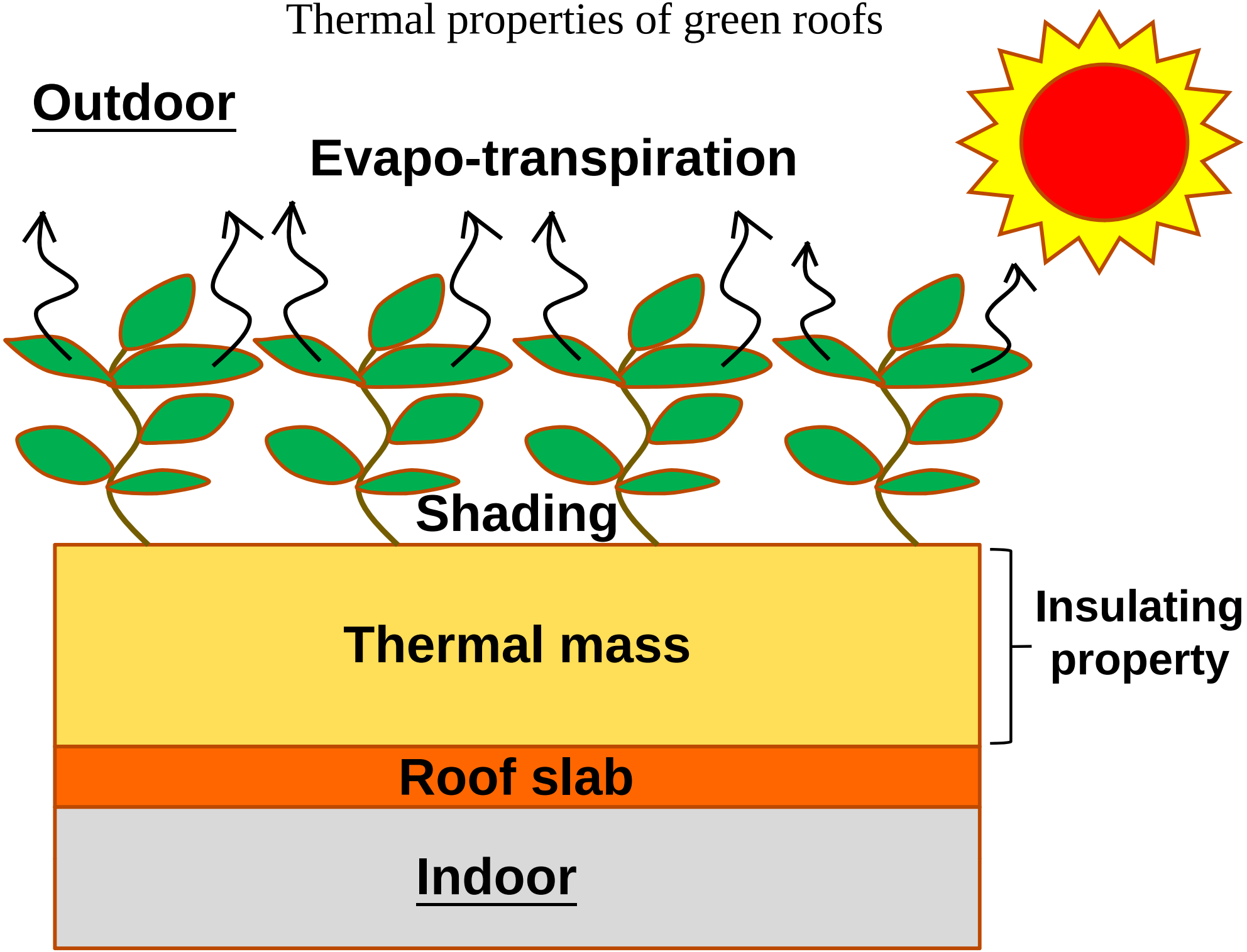


(Source: Stormwater Academy, University of Central Florida)

Benefits of green roofs

- 2. <u>Economic benefits</u>:
  - Extends roof life
  - Reduces air conditioning & heating costs (energy and maintenance)
  - Reduces capital costs for equipment and installation (air conditioner, drainage and pipes)
  - Reduces water and sewerage charges
  - Attracts buyers and tenants
  - Attracts and retains employees

Thermal properties of green roofs



Benefits of green roofs

- 3. <u>Amenity and aesthetic benefits</u>:
  - Aesthetically pleasing, useful space
    - If roof loading is sufficient, green roofs can be planned for amenity and recreational use

  - Food production (e.g. community gardens)
    - Opportunity for growing healthy food in urban areas
    - A range of marketable products (vegetable, fruit)
  - Local job creation (direct and indirect)
    - On green roof maintenance, urban agriculture, etc.
    - Useful for low-income group

Urban farming & education

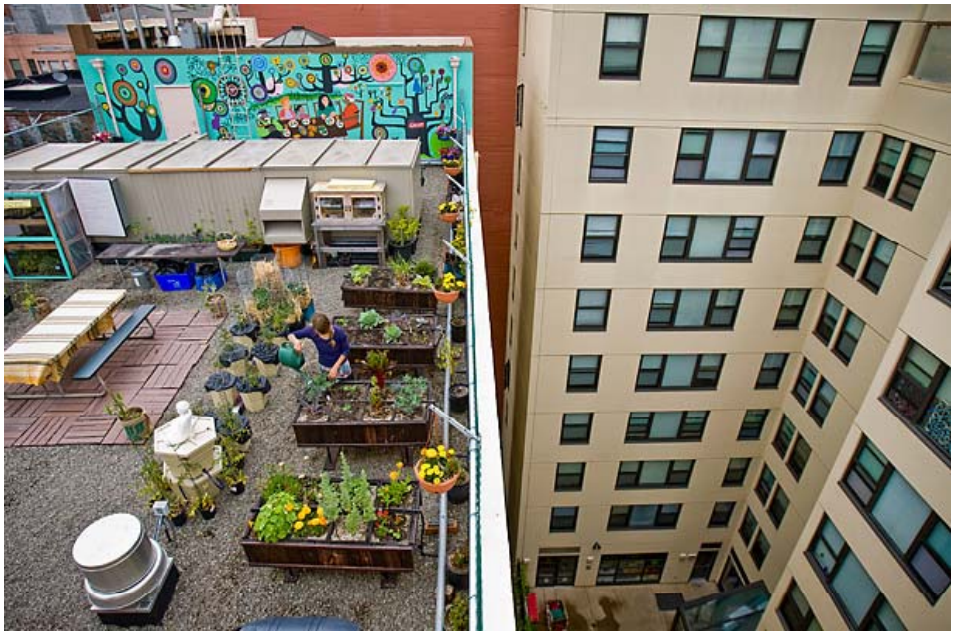
Horticultural therapy & social functions

Rooftop urban farming in the world

Bangkok, Thailand (with tree pots)

Tokyo, Japan (rooftop greenhouse)

London, UK (with bee keeping)



San Francisco, USA (for kitchen/restaurant)

(Source: www.time.com)

Hong Kong situation

- Some intensive green roofs can be found on:
  - Landscape podium roof gardens
  - “Sky gardens”
  - Public open spaces built on government structure
- Extensive green roofs and other urban greening technologies is still limited because
  - No direct government requirement or industry incentive
  - Space constraints limit greening in urban areas

A landscape podium garden in Hong Kong

(Photos taken by Dr Sam C M Hui)

Examples of green roofs in Hong Kong

Ocean Park Hong Kong

EMSD Headquarters

Parklane, Tsimshatsui

A school in San Po Kwong

(Photos taken by Dr Sam C M Hui)

Hong Kong Wetland Park Phases II
(the largest green roof in Hong Kong)

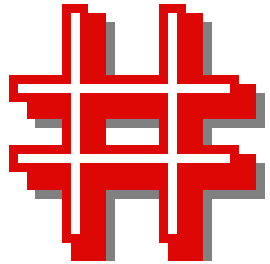
(Source: Architectural Services Department)

Table 3. Initial and maintenance costs of green roof systems

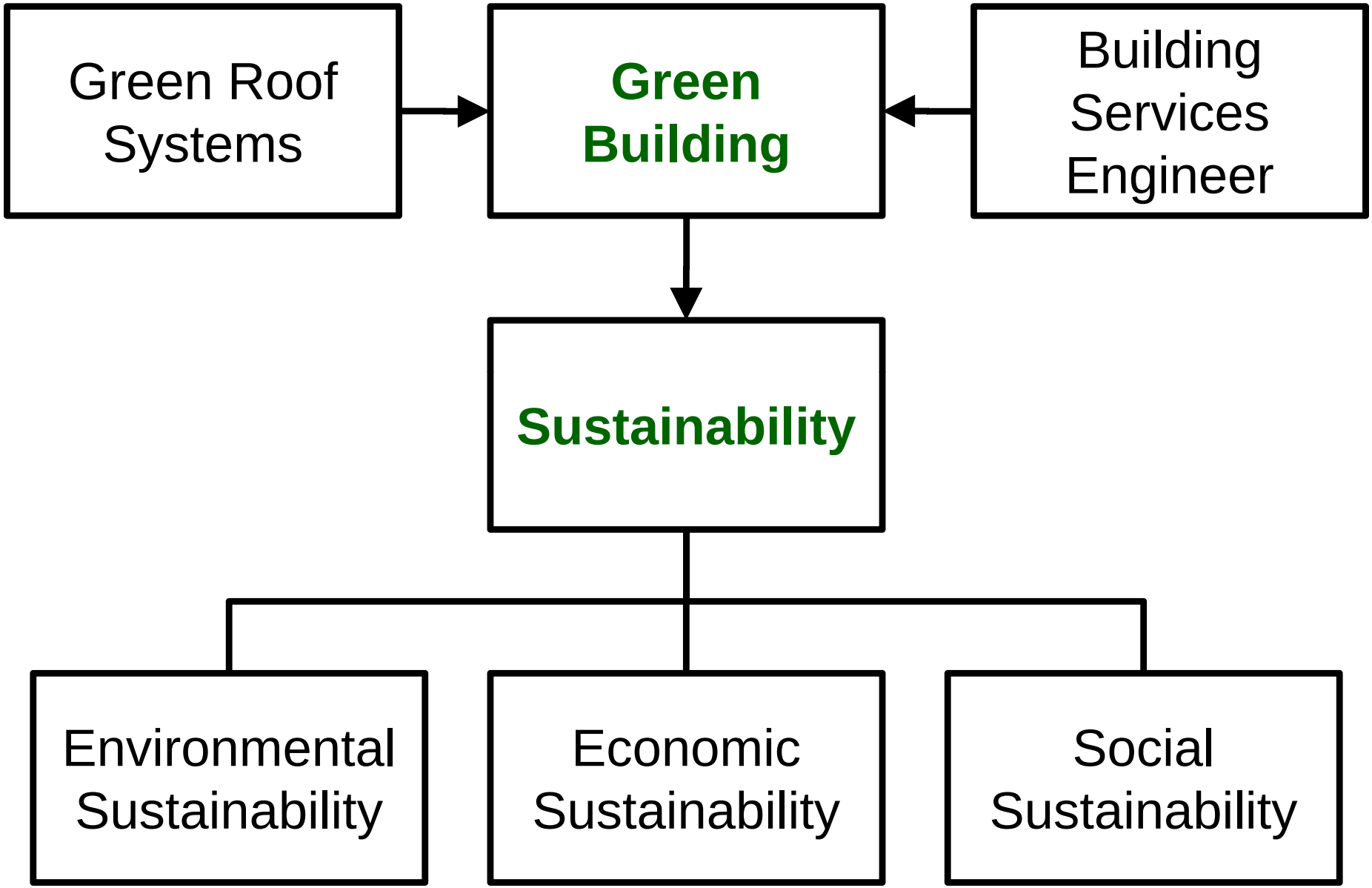
	Intensive	**Extensive**
Initial cost ($HK\$/m^2$)	1,000 to 5,000 (average: 2,000)	400 to 1,000 (average: 500)
Maintenance cost ($HK\$/m^2/yr$)	6.5 to 44 (average: 20)	0.8 to 2.25

(Source: (Urbis Limited, 2007))

Building Services Engineer



- ***Building Services Engineer (BSE)*** can help promote sustainability of green roof systems
  - Evaluate building environmental performance
    - Potential to reduce building cooling load & energy use
  - Study microclimate of green roofs
    - Effects on urban heat island & air quality
  - Design sustainable drainage
    - For stormwater management & rainwater recycling
  - Support green roof planning, design, maintenance & amenity uses


Green Roof Systems
Green Building
Building Services Engineer
Sustainability
Environmental Sustainability
Economic Sustainability
Social Sustainability

Building Services Engineer

- Green Building Assessment Methods
  - They are becoming more and more popular and important, e.g. LEED 2009 and BEAM Plus
  - In fact, greening technology has significant implications to the assessment results
- BSE can do the assessment and help people optimise the credit points from green roofs
  - Study and calculate for the energy, water and material issues

Table 4. LEED 2009 credit points of green roof systems

LEED criteria impacts:	Points
Sustainable Sites (SS)	
Credit 6.1: Stormwater design – quantity control	1
Credit 6.2: Stormwater dseign – quality control	1
Credit 7.2: Heat island effect – roof	1
Water Efficiency (WE)	
Credit 1: Water efficient landscaping	2-4
Energy and Atmosphere (EA)	
Credit 1: Optimize energy performance	1
Materials and Resources (MR)	
Credit 4: Recycled content (roof components)	1-2
Credit 5: Local/Regional materials	1-2

Secondary credit impacts:	Points
Water Efficiency (WE)	
Credit 2: Innovative waste water technologies	2
Credit 3: Water use reduction	2-4
Innovation in Design (IN)	
Credit 1: Innovation in design	1-5

Source: extracted from USGBC (2009)

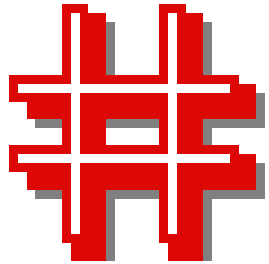
Table 5. BEAM Plus credit points of green roof systems

BEAM Plus criteria impacts:	Points
Sites Aspects (SA)	
Perequiste: Minimum landscape area	Req'd
SA 5: Ecological impact	1
SA 7: Landscaping and planters	1-3
SA 8: Microclimate around buildings (roof)	1
Materials Aspects (MA)	
MA 7: Recycled materials (roof components)	1
Credit 5: Local/Regional materials	1-2
Energy Use (EU)	
EU 1: Reduction of CO_2 emission	1-15
EU 2: Peak electricity demand reduction	1-3
Water Use (WU)	
WU 1: Water efficient irrigation	1
WU 6: Effluent discharge to foul sewers	1

Secondary credit impacts:	Points
Water Use (WU)	
WU 4: Water recycling (rainwater)	1-2
Innovations and Additions (IA)	
IA 1: Innovative techniques	1-5

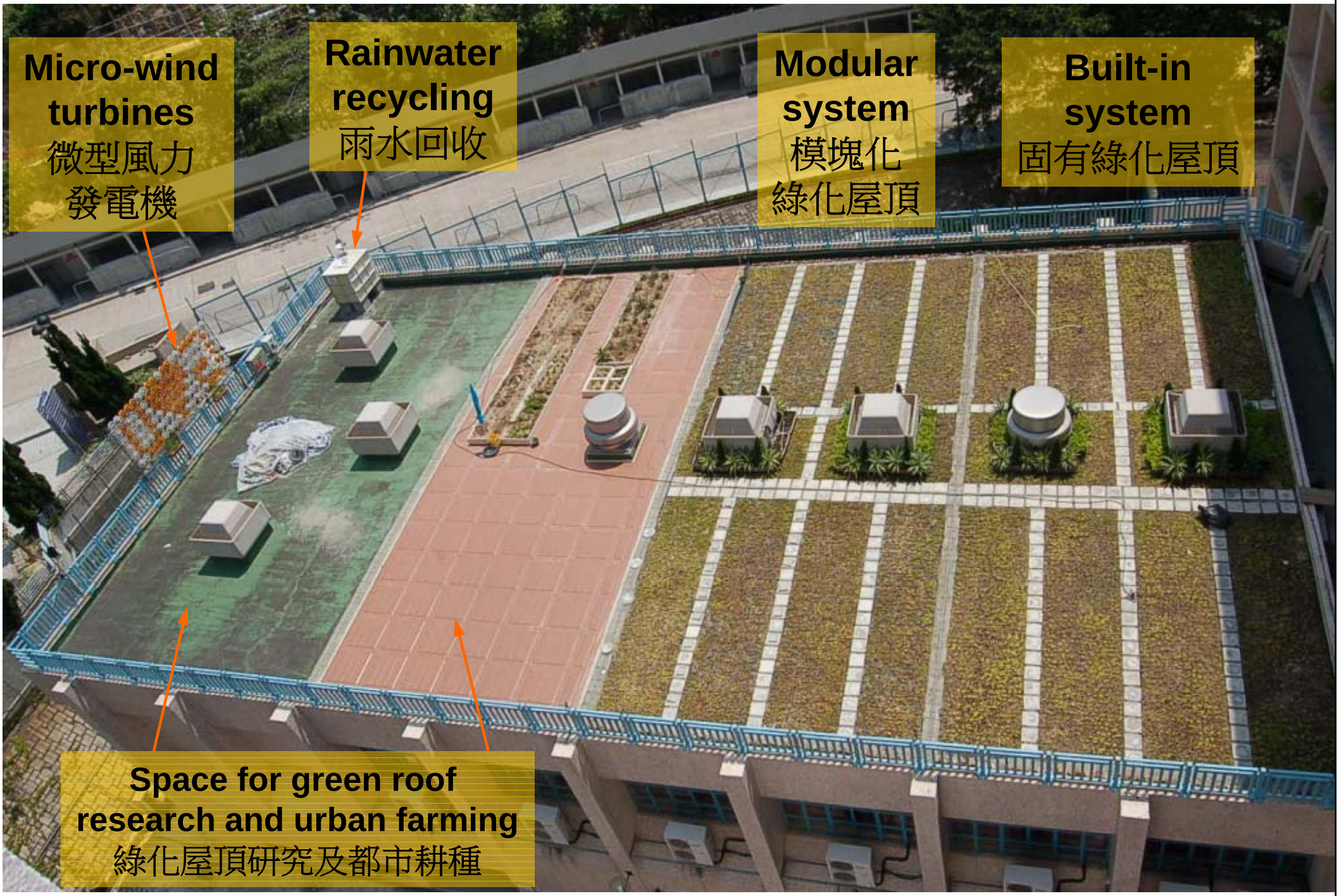
Source: extracted from BEAM Society (2009)

Building Services Engineer



- To ensure good performance and quality of green roof systems, BSE will collaborate with other professionals, e.g.
  - Architect
  - Landscape Architect/Designer
  - Structural/Civil Engineer
  - Builder/Contractor
- Integrated system design on the rooftop
  - Greening + Rainwater recycling + Renewables

A green roof project with integrated systems



Conclusions

- Green roofs can help promote sustainability in urban cities like Hong Kong
- Building Services Engineer has a role to play on the green roof movement
- More efforts are needed to set up technical guidelines and promote awareness & skills
- Need to consider the true value of green roof systems and their impacts (e.g. ecological function)

THANK YOU 謝謝 !!

BSE =
Building
Sustainability
Engineer

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