CIBSE Hong Kong Branch
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Green Roof Systems in Hong Kong

1911-2011

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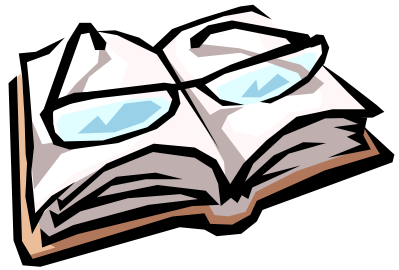
Introduction



- Problems in urban cities
  - Urban heat island (UHI)
  - Lack of greenery space
- Green roofs can mitigate the adverse effects
  - Bring the nature back to urban area
  - Make better use of roof space
- Green roof market in Hong Kong
  - Still developing and immature
  - Lack of technical guidelines & policy

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)

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)

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

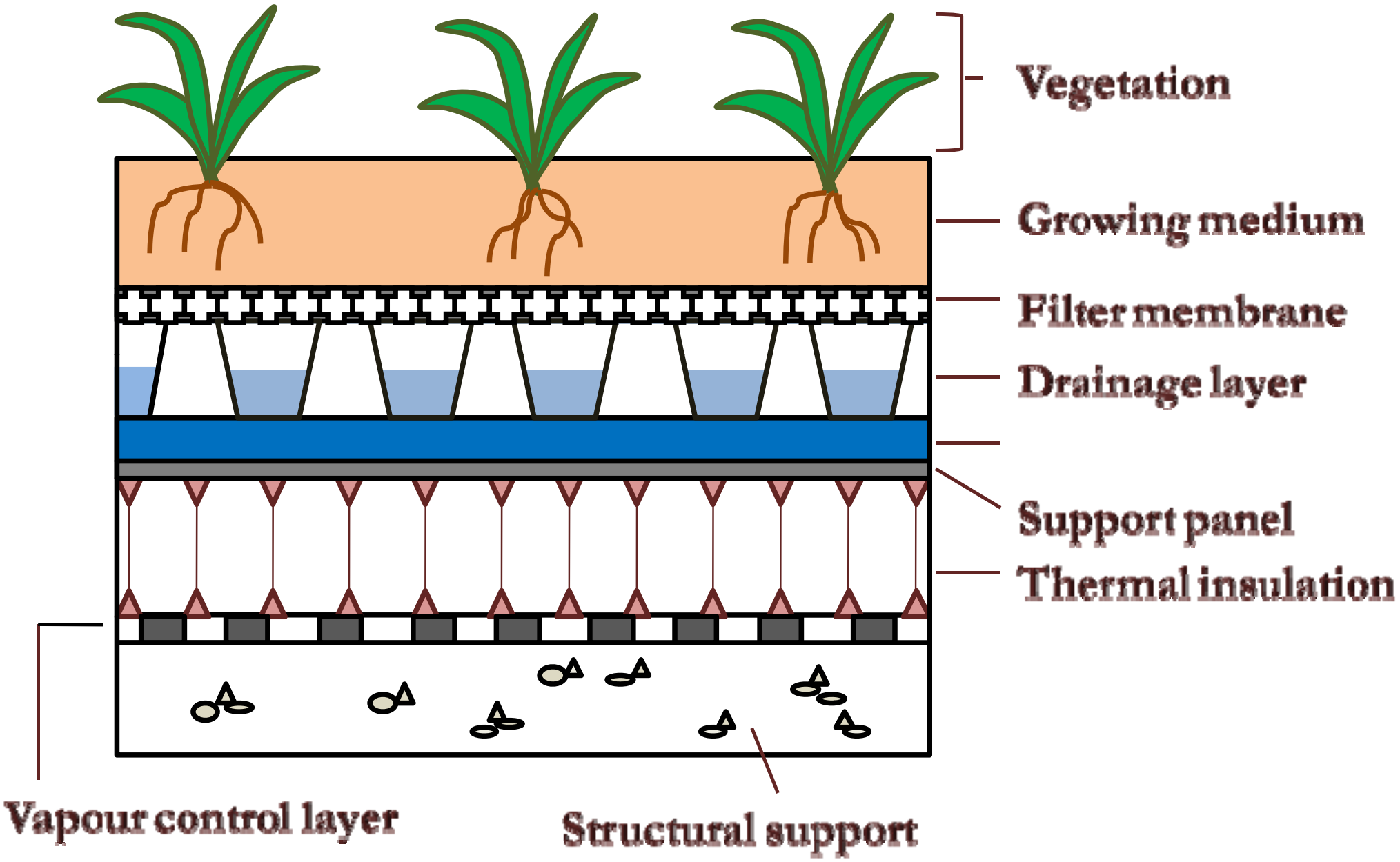
- Major types of green roofs (see Table 1)*
  - Extensive
  - Semi-intensive
  - Intensive
- Roof gardens: usually intensive greening with other features such as potted plants, pond, etc.
  - Examples in HK: podium gardens, sky gardens
- Classify green roof systems by basic design:
  - Built-in green roofs vs Modular green roofs

* Could also be combined as hybrid systems

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

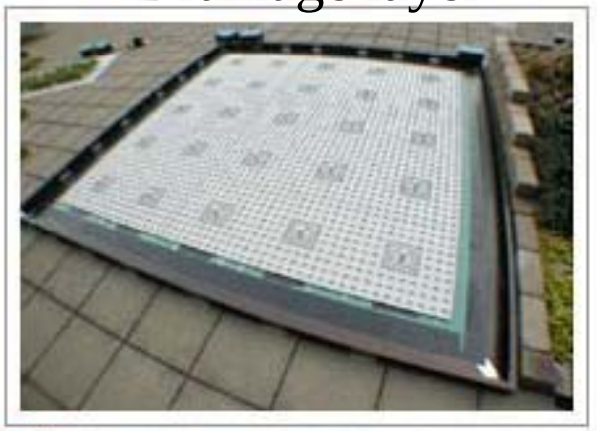
Waterproofing

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)

Table 2. 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))

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

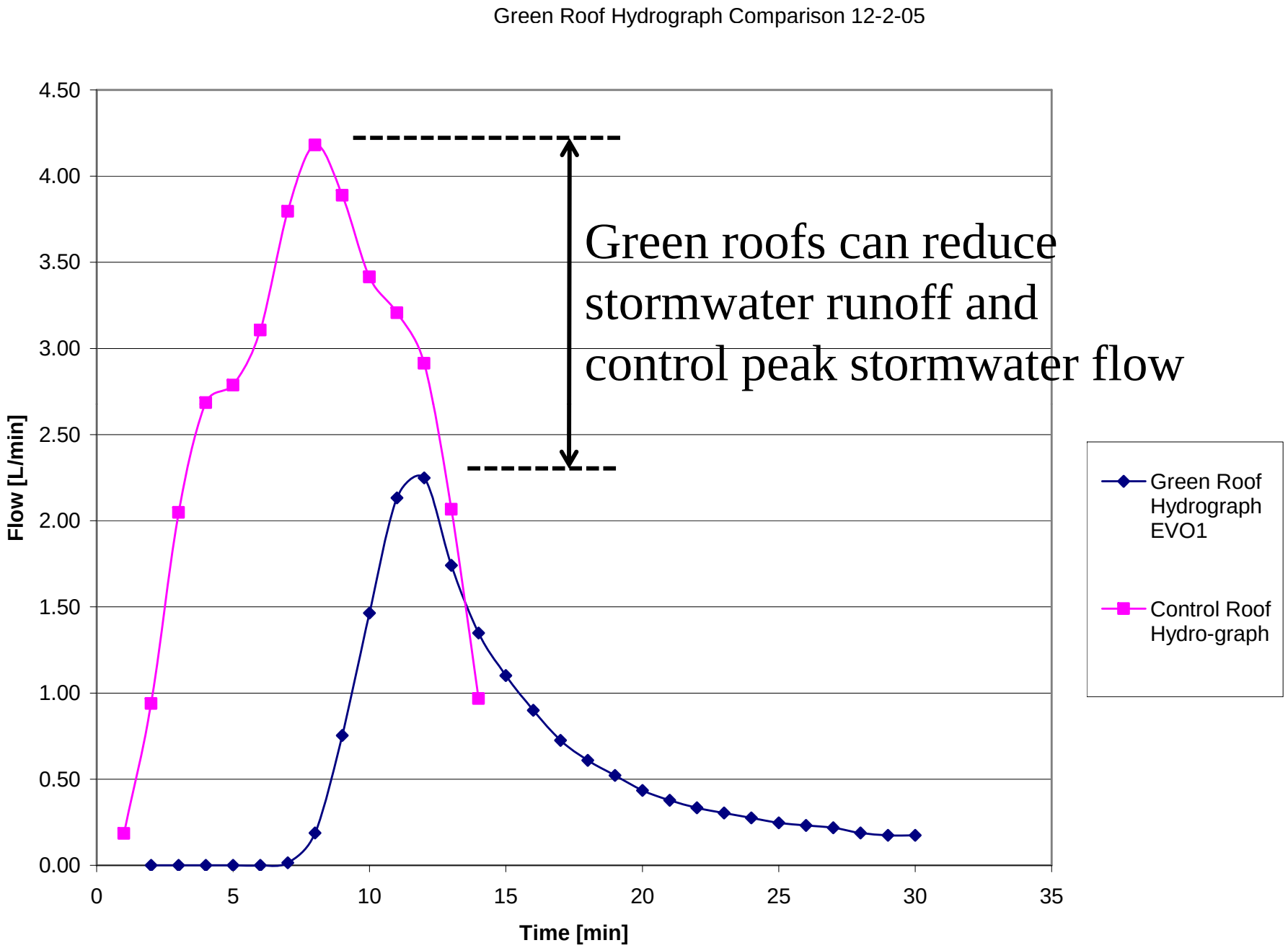
Table 3. Public and private benefits of green roof systems

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. <u>Environmental benefits</u>:
  - 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

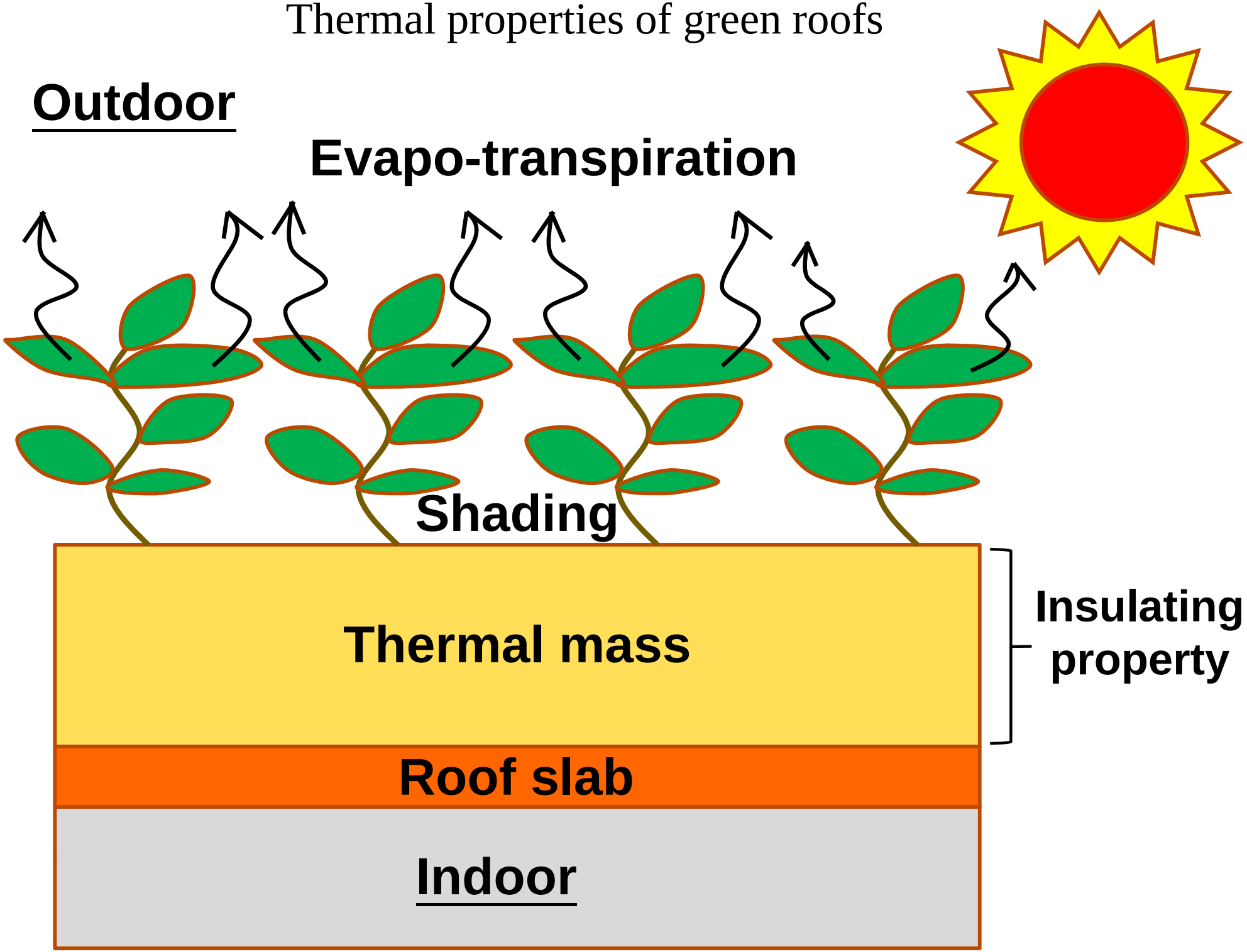


(Source: Stormwater Academy, University of Central Florida)

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

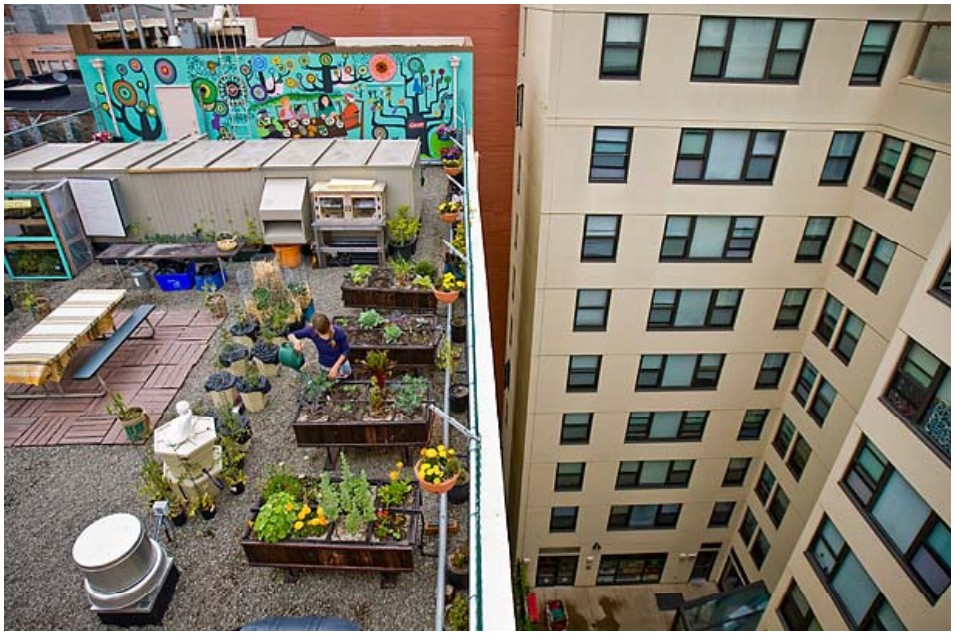
Horticultural therapy &
social functions

Rooftop urban farming in the world

Bangkok, Thailand (with rice and fruits)

Tokyo, Japan (rooftop greenhouse)

London, UK (with bee keeping)



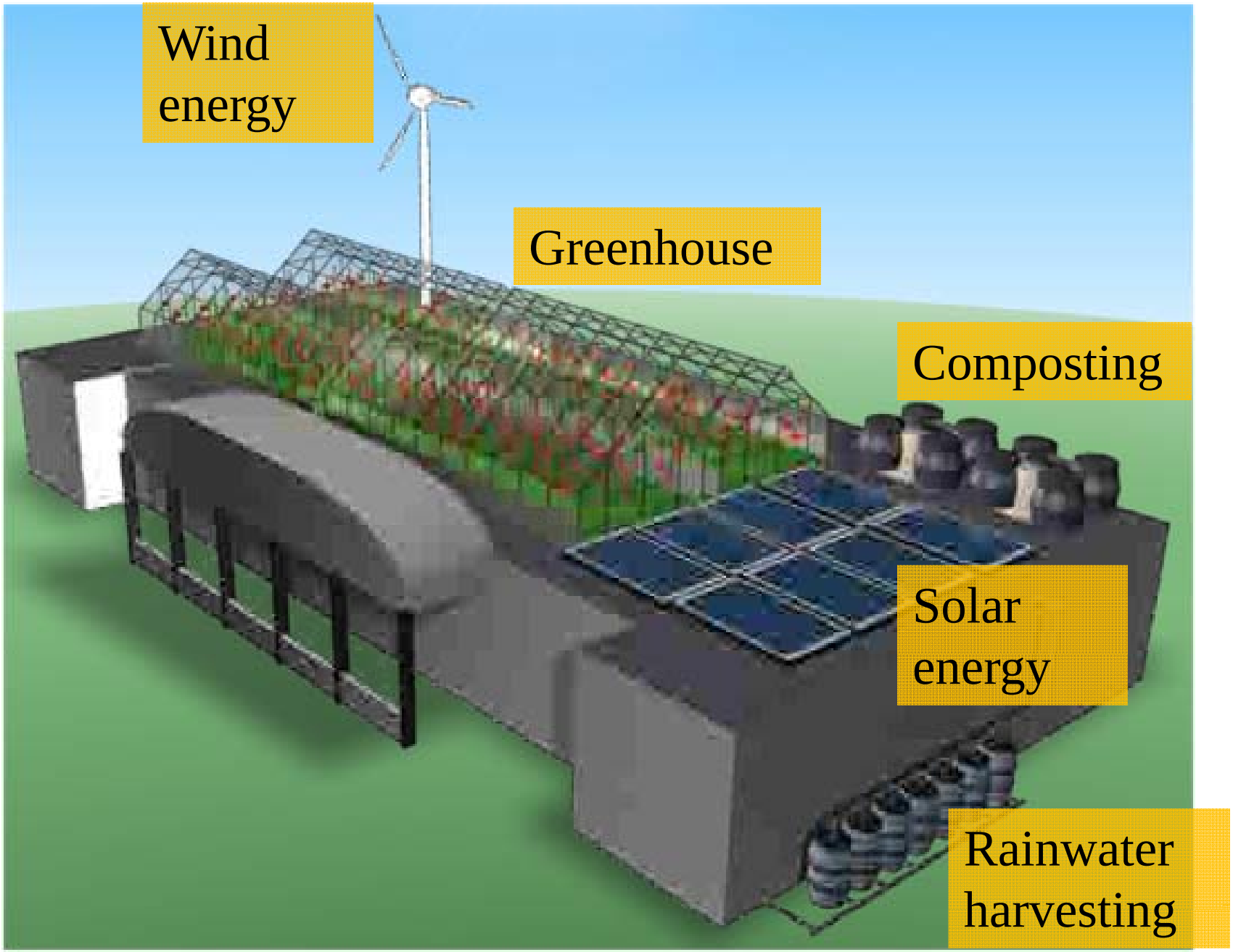
San Francisco, USA (for kitchen/restaurant)

(Source: www.time.com)

Container garden in Taiwan

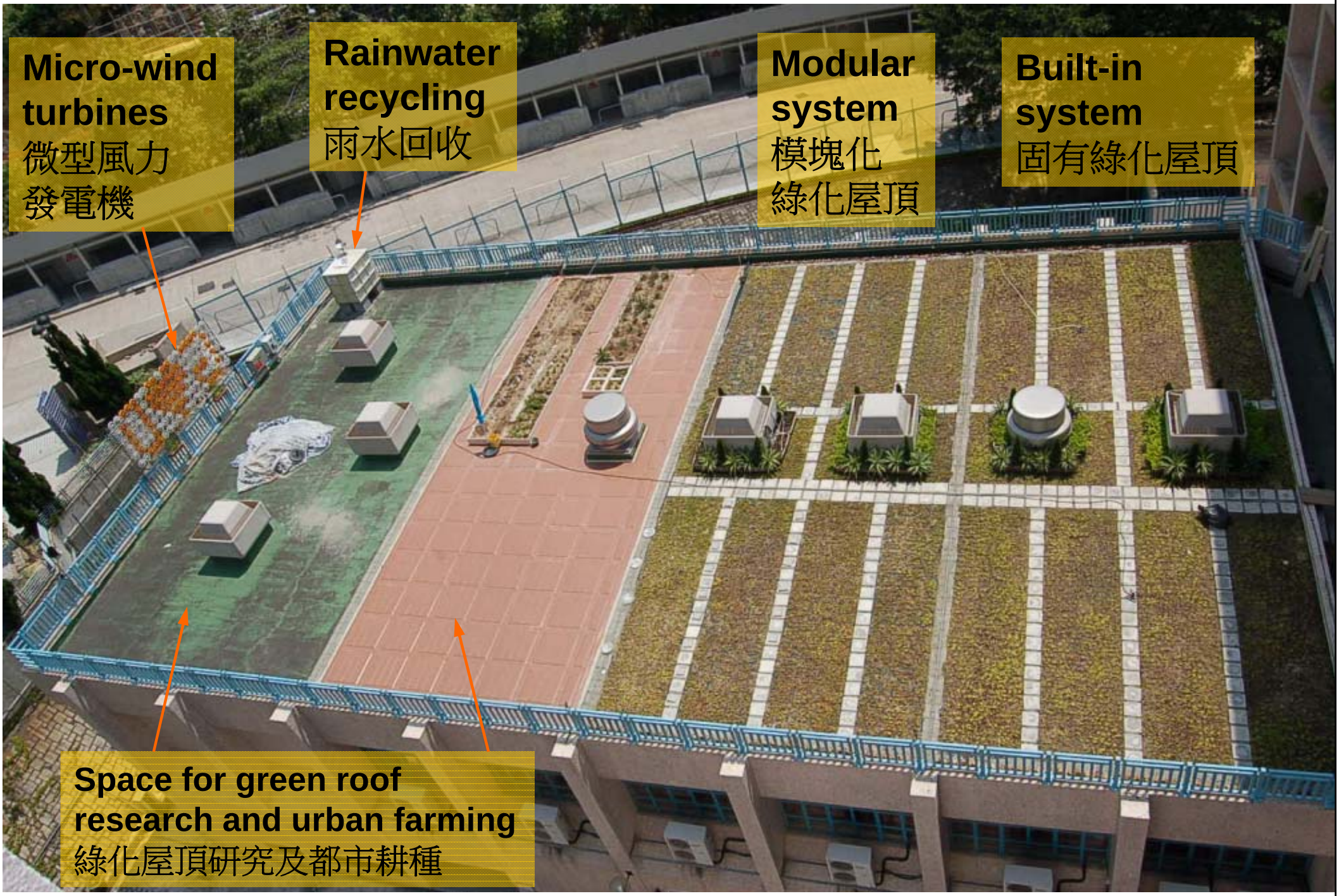
(Source: http://yiu.com.tw/green.htm)

Sustainable rooftop farming 可持續的天台農耕



(Source: www.skyvegetables.com

A green roof project with integrated systems



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
  - No government policy and requirement
  - Little incentives for private to invest on it

A landscape podium garden in North Point, Hong Kong

(Photos taken by Dr Sam C M Hui)

A landscape podium garden in Tseung Kwan O

Hong Kong situation

- Greening policy set up in recent years (www.devb.gov.hk/greening)
  - Aims to improve urban greenery and maximise greening opportunity
  - Greenery and landscaping in the planning of new towns and new development areas
- Space constraints limit greening in urban areas
  - Green roofs is a promising choice
    - However, a clear policy for green roofs is not available

Potential of promoting green roofs in urban areas

(Source: http://hk.centamap.com)

Hong Kong situation

- Government pilot projects, e.g. by:
  - Architectural Services Department (ArchSD)
  - Drainage Services Department (DSD)
  - Housing Authority (HA)
- But, the technical requirements and actual performance of the green roofs are not well defined and understood
  - This will hinder development of the local green roof or greenery market and technology

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

(Source: Architectural Services Department)

Green roof on a water treatment plant in Hong Kong

(Source: Drainage Services Department)

Hong Kong situation

- Green roof research
  - In 2006-07, the Government commissioned a consultancy study on “Green Roof Application in Hong Kong” (Urbis Limited, 2007)
  - In the past few years some research projects on green roof are developed; but most of them focuses on field experiments and measurements
  - A lack of research on practical design issues and technical codes (c.f. FLL in Germany & CUGE in Singapore)

Worldwide experience

- Germany and Japan are more advanced
- Germany: FLL guidelines (FLL, 2008)
  - By Research Society for Landscape Development and Landscape Design (**F**orschungsgesellschaft **L**andschaftsentwicklung **L**and-schaftsbau e.V.) (www.fll.de)
  - Set quality standards for green roof systems
  - Complement the construction regulations in Germany and the DIN standards of landscape contractors

Worldwide experience

- Japan guidelines on rooftop & wall greening
  - Started in 1990 by the Organization for Landscape and Urban Green Technology Development (www.greentech.or.jp)
    - Organise annual competition on greening technology since 2002
    - Coordinate R&D work, conferences and incentive schemes on urban greening
  - Local provincial governments also developed their requirements and standards

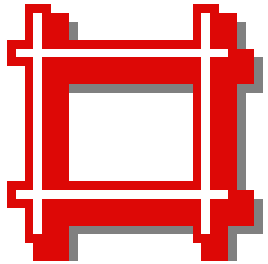
Worldwide experience

- Other places which have developed guidelines and codes for roof greening:
  - UK: GRO Green Roof Code 2011
  - Canada
  - Australia
  - China (Beijing, Guangzhou, Shenzhen)
  - Singapore
  - UAE
  - USA

Worldwide experience

- Some countries have also developed technical standards, e.g.
  - ASTM standards
  - SPRI standards (on wind and external fire)
  - Singapore standards (on design loads and safety)
  - Toronto Green Roof Construction Standard 2010

Developing techn. guidelines



- A research project sponsored by CIBSE Hong Kong Branch
  - Prepare technical guidelines for green roof systems in Hong Kong
  - Learn from experience of other countries/cities
  - Will also consider and adapt the local conditions of Hong Kong
- Project duration:
  - September 2010 to March 2011 (~ 6 months)

Table 4. Proposed contents of the guidelines

Part 1	1. Introduction 2. Scope 3. Definitions
Part 2	4. Planning Requirements 5. Design Considerations 6. Construction 7. Maintenance 8. Project Management
Part 3	References Appendices (with case studies)

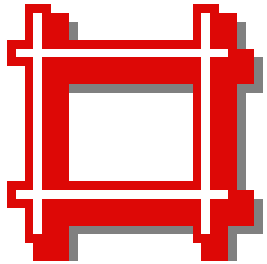
Table 5. Major factors to consider

Planning Requirements	- Functions and effects - Structural loading - Accessibility - Site conditions (wind, shade) - Water proofing condition - Green building credits
Design Considerations	- Landscape design - Irrigation & water supply - Stormwater drainage - Plant species - Wind design (e.g. typhoons) - Sustainable technologies (e.g. solar) - Food production (farming) - Rainwater recycling - Roof slope
Construction	- Safety issues (preventing falls) - Vegetation planting method - Testing & monitoring
Maintenance	- Maintenance requirements - Warranties - External fire hazard - Safety issues
Project Management	- Green building assessment - Financial incentives - Regulatory measures - Contractual matters

Developing techn. guidelines

- Considerations for Hong Kong:
  - High-density urban areas
    - Very limited roof area
    - More effective to apply green roofs to podiums and medium- or low-rise buildings/structures
  - Green roof on existing buildings
    - Limited by loading capacity
    - Guidance to help people select a suitable green roof system (usually light-weight)
  - Typhoon and stormwater

Developing techn. guidelines



- Green Building Assessment Methods
  - Such as LEED 2009 and BEAM Plus
  - They are becoming more and more popular and important
  - In fact, greening technology has significant implications to the assessment results
  - Our guidelines will include information to help people optimise the credit points from green roofs

Table 6. 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)

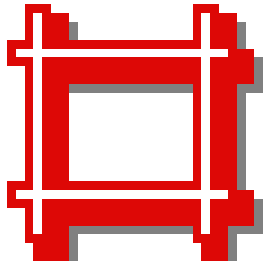
Table 7. BEAM Plus credit points of green roof systems

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)

Developing techn. guidelines



- Green roof performance and quality
  - Avoid poorly designed/constructed green roofs
  - Consider the true value of green roof systems and their impacts
  - Types of performance
    - Thermal and energy performance
    - Hydrologic or stormwater management performance
    - Air quality/ pollution control
  - Ecological function is also important

Green roof inspection report – Checklist

Testing:

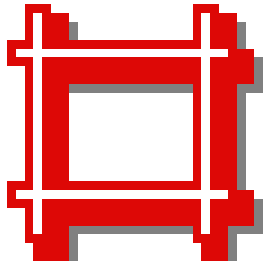
Flood test	Electrical field vector mapping
Impedance test	Infrared (IR) thermal imaging
Low voltage test	Moisture sensors

Inspection:

A. Green roof size and location	H. Waterproofing
B. Gravity loads	I. Drainage
C. Slope stability	J. Water retention
D. Parapet height and/or overflow scupper	K. Vegetation performance
E. Wind uplift	L. Plant selection
F. Fire safety	M. Irrigation
G. Occupancy and safety	N. Maintenance plan

(Extracted from Toronto Green Roof Construction Standard, www.toronto.ca/greenroofs)

Developing techn. guidelines



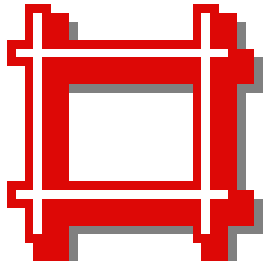
- In Germany, FLL has developed a performance rating system for green roofs based on the desired ecological functions:
  - Water retention capacity of the growing medium
  - Water retention capacity of the drainage layer
  - Number of plant species for extensive green roofs
  - Plant biomass or volume for intensive green roofs
- It also help to judge whether a project is suitable for ecological compensation

Table 8. FLL's qual. parameters for assessing green roof performance

Category:	Description:
Soil	Quality of soil
Water	Improvement in surface water quality Reduction in load of the sewer system Improvement in groundwater recharge Purification of stormwater
Air & temperature	Filtering of air Contribution to oxygen production Contribution to urban temperature levelling
Habitat	Contribution to establishment of flora and fauna habitat
Landscape	Contribution to landscape and urban scenery
Amenity	Contribution to amenity for people / leisure / healing

Note: * Each parameter is deemed "possible to fulfill completely", "possible to fulfill partially", or "slightly or not possible to fulfill."

Developing techn. guidelines



- Example: “Karlsruhe Performance Rating System” for green roofs, according to five natural functions:
  - Type and depth of soil used (Soil) – 15%
  - Impact on climate due to evapotranspiration (Climate) – 15%
  - Type and variety of vegetation (Flora) – 30%
  - Impact on zoological biodiversity (Fauna) – 30%
  - Average annual stormwater retention (Water Balance) – 10%

Conclusions

- Urban cities like Hong Kong can benefit from green roofs and walls
- There is a need to develop local technical guidelines for planning, designing and commissioning green roof systems in HK
- To achieve a sustainable urban environment
  - Financial incentives & public awareness
  - Promote roof and multi-level greening
- Green roof movement in HK has just begun!

THANK YOU 謝謝 !!

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