AIIB Seminar: The Headway of Consideration for Green Roofing Systems in Hong Kong
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Prospects of building greening in Hong Kong

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(More information: http://ibse.hk/greenroof/)

Contents

- Introduction
- Green roofs
- Vertical greening
- Potential benefits
- Sustainable technologies

Introduction

- Skyrise greenery 天際綠化
  - Greening at the buildings or other structures beyond the ground level, such as
    - Roof greening (horizontal or inclined)
    - Vertical greening
    - Sky gardens, podium gardens
    - Terrace and balcony planting
    - Edge greenery
  - Multi-level greening
  - History
    - Hanging gardens of Babylon (600 B.C.)

(Ref: Skyrise Greenery http://www.greening.gov.hk/en/green_technologies/skyrise.html)

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

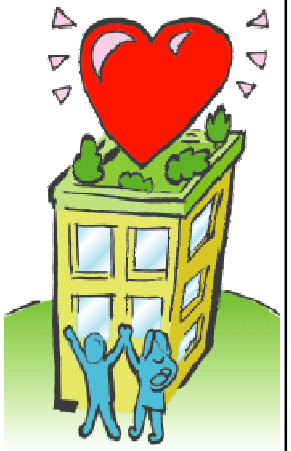
(Video: Gift for a Queen - Hanging Gardens of Babylon (2:44) http://youtu.be/Kfg1YE-BqTc)

(Source: http://weburbanist.com; see also http://en.wikipedia.org/wiki/Hanging_Gardens_of_Babylon)

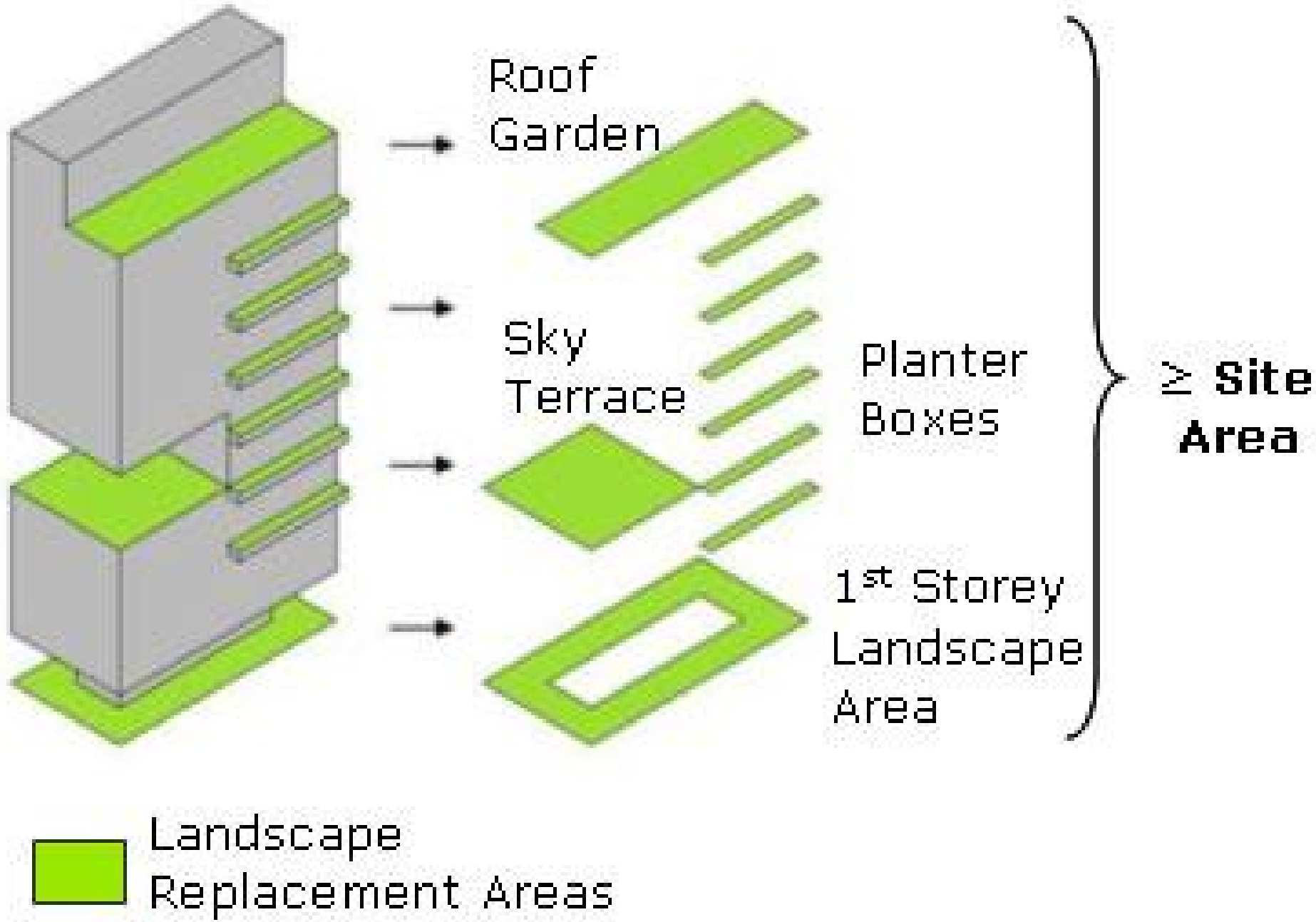
Introduction

- Skyrise greenery in modern world
  - High-density urban cities
  - Highrise buildings and concrete jungle
  - Limited space for greening & relaxing

- Greenery in urban landscape
  - Make good use of existing spaces in urban areas
  - Integrate nature into our urban development
  - Create urbanscapes that are dynamic in more environmental and sustainable ways



Types of landscape areas from skyrise greenery



(Source: Urban Redevelopment Authority, Singapore, http://www.ura.gov.sg/uol/circulars/2009/apr/dc09-09)

Green roofs

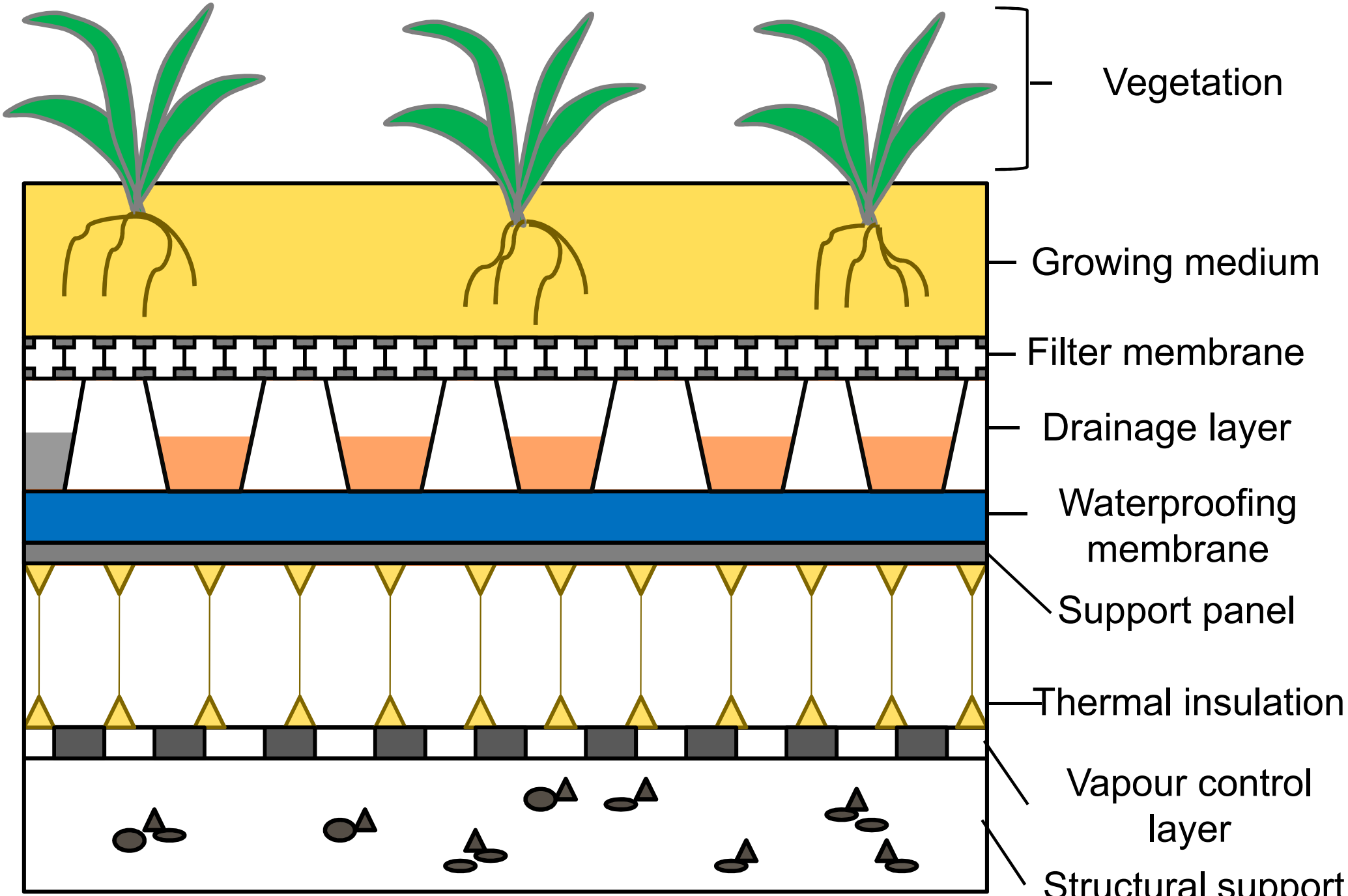
- **Green Roofs**: roofs bearing vegetation –FLL*
  - "Living vegetation installed on the roofs"
  - "Vegetated roof" 植被屋頂
- **Green Roof System** – Definition 屋頂綠化系統
  - "A roof area of plantings/landscape installed above a waterproofed substrate at any building level that is separated from the ground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

* FLL = Research Society for Landscape Development and Landscape Design (Forschungsgesellschaft Landschaftsentwicklung Land-schaftsbau e.V.) (www.fll.de)

Table 1. Major types of green roofs and their characteristics

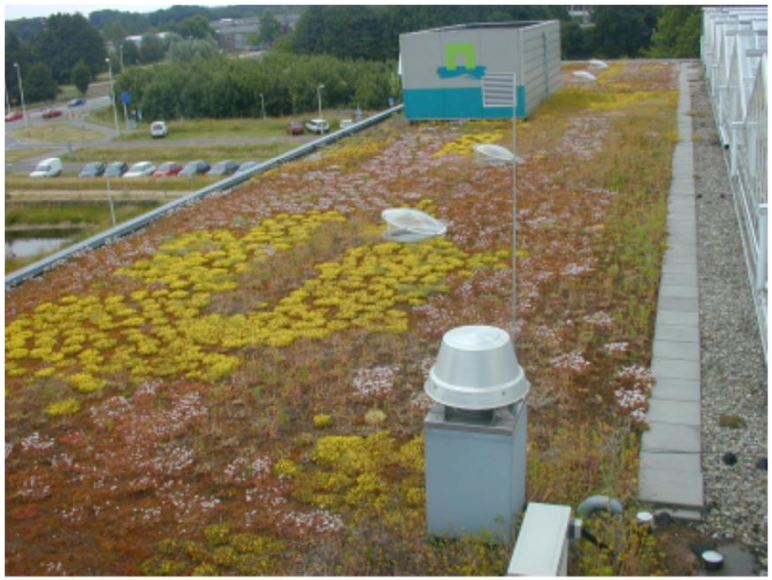
Characteristics	Extensive	Semi-intensive	Intensive
Depth of material	150 mm or less	Above and below 150 mm	More than 150 mm
Accessibility	Often inaccessible	May be partially accessible	Usually accessible
Fully saturated weight	Low (70-170 kg/m^2)	Varies (170-290 kg/m^2)	High (290-970 kg/m^2)
Plant diversity	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

Typical structure of extensive green roof



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 Hong Kong

Ocean Park

EMSD Headquarters

Parklane, TST

HK Wetland Park

(Photos taken by Dr Sam C M Hui)

Collapse of green roof in Hong Kong (20 May 2016)

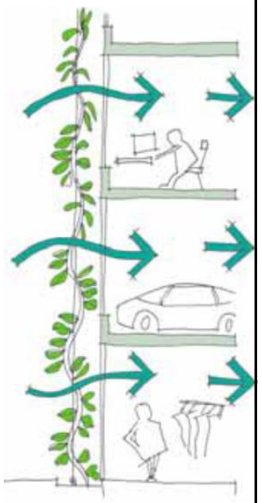
Overloading due to:
1. Thickening of screeding
2. Green cover layers
3. Localised water ponding (rainwater and poor drainage)

(Image source: http://hk.apple.nextmedia.com/)

Another type of green roof in Hong Kong

Vertical greening

- ***Vertical greening*** – descriptive terms
  - Green walls, living walls, bio-walls, living wall/ cladding, green facades, vertical green, vertical gardens, vegetated wall surfaces
- Possible applications:
  - 1. Building façades or outdoor vertical surfaces
  - 2. Interior walls or indoor vertical surfaces
  - 3. Noise barriers (e.g. along the roads)
  - 4. Slopes and site hoarding boards



An example of outdoor vertical greening

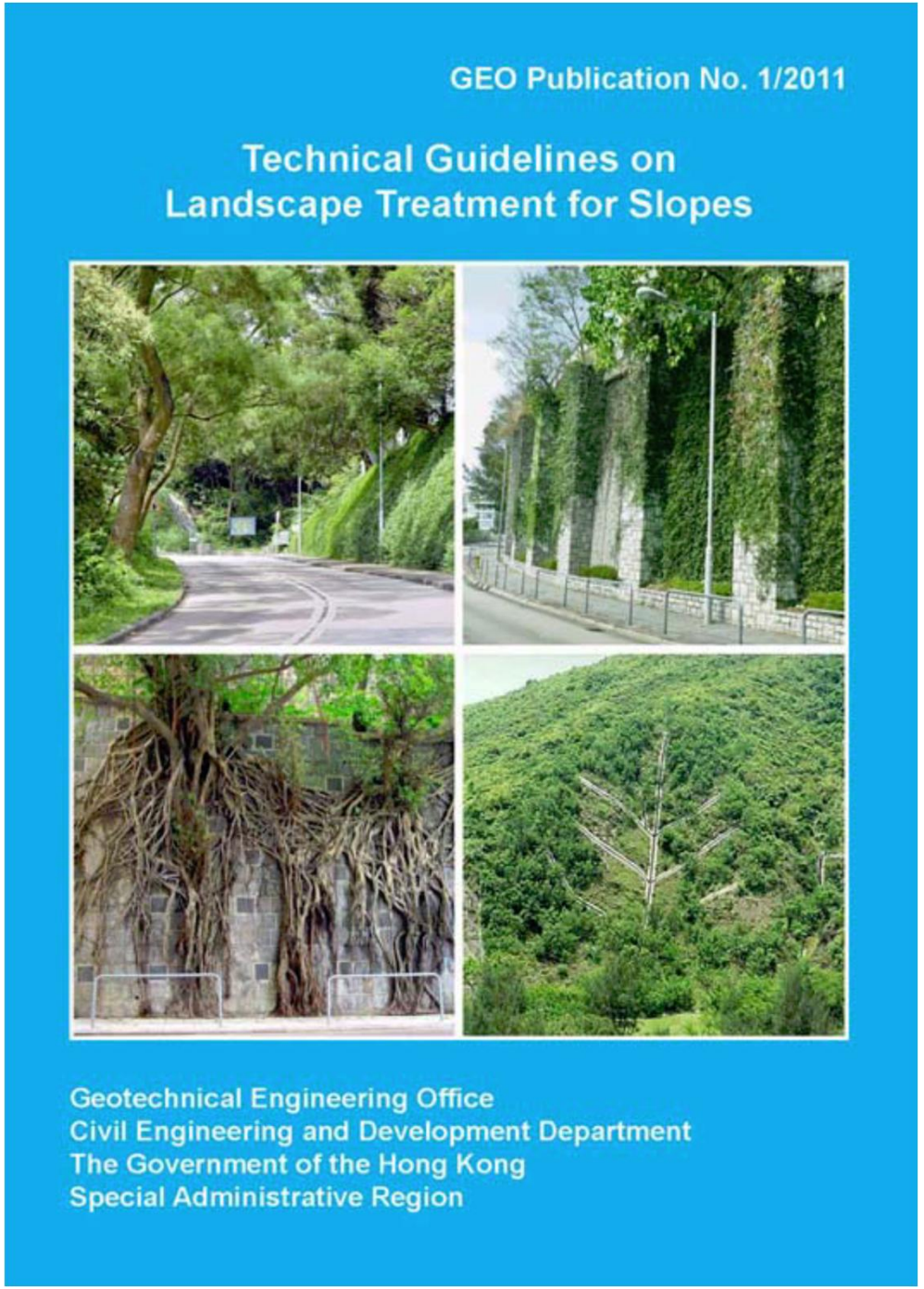
(Source: CityWalk, Tsuen Wan, 荃灣荃新天地, www.citywalk.com.hk)

Indoor green walls

Green noise barriers

(Source: Highway Department, HK)

Greening on slopes



(Source: Civil Engineering and Development Department, HK)

Vertical greening

- Common reasons for vertical greening:
  - Aesthetic (how it looks)
  - Cognitive (meaning)
  - Experiential (trial use)
  - Planning and financial gains ($)
  - Pollution absorption (air)
  - Ecology (habitats)
  - Fashionable

Green wall example in Taichung, Taiwan

(Source: Dr. Sam C. M. Hui)

Greening on site hoarding boards (Taiwan) 綠化圍板（台灣）

(Photo taken by Dr. Sam C. M. Hui)

Indoor green wall in a subway station (Taipei)

(Source: Mr. Eddie Tse)

Potential benefits

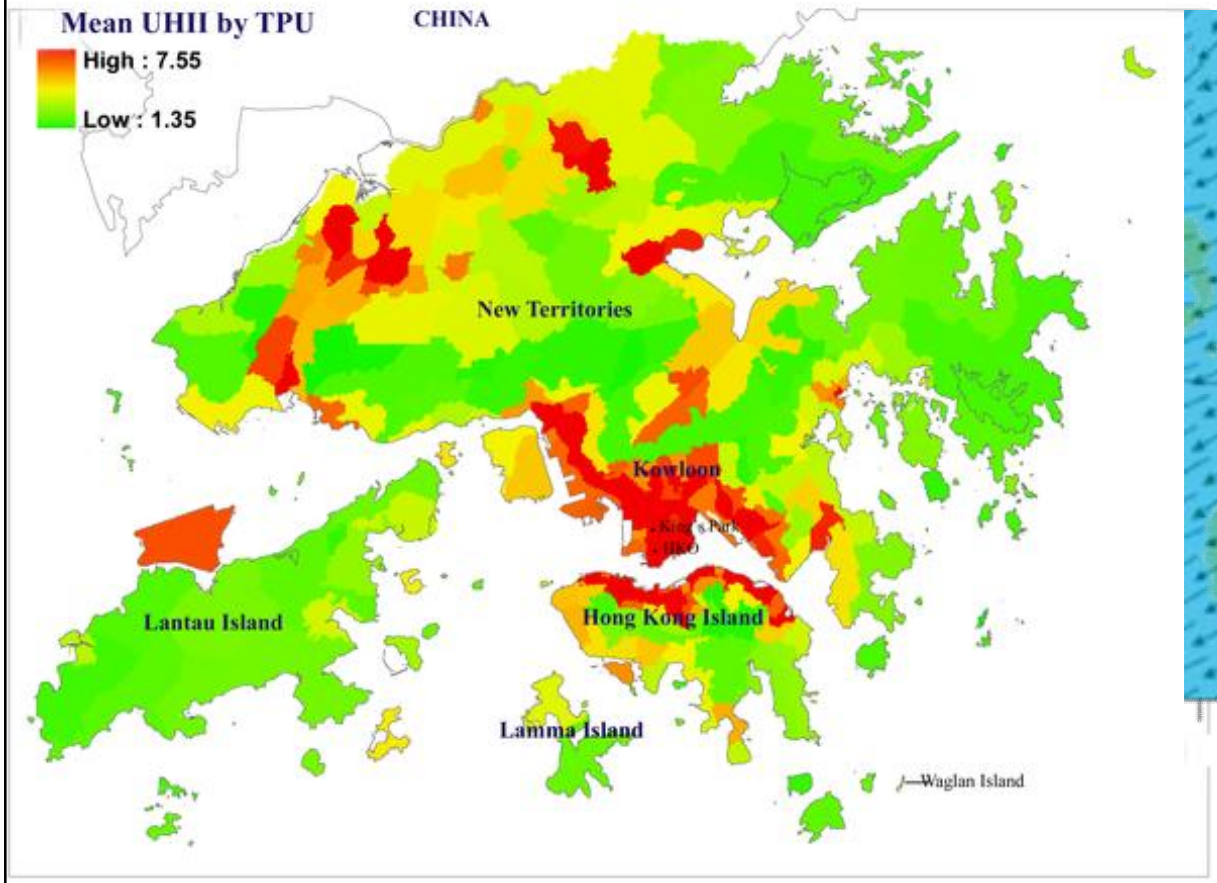
- Green roofs & vertical greening
  - Building integrated vegetation
  - Urban cityscape
  - Green infrastructure

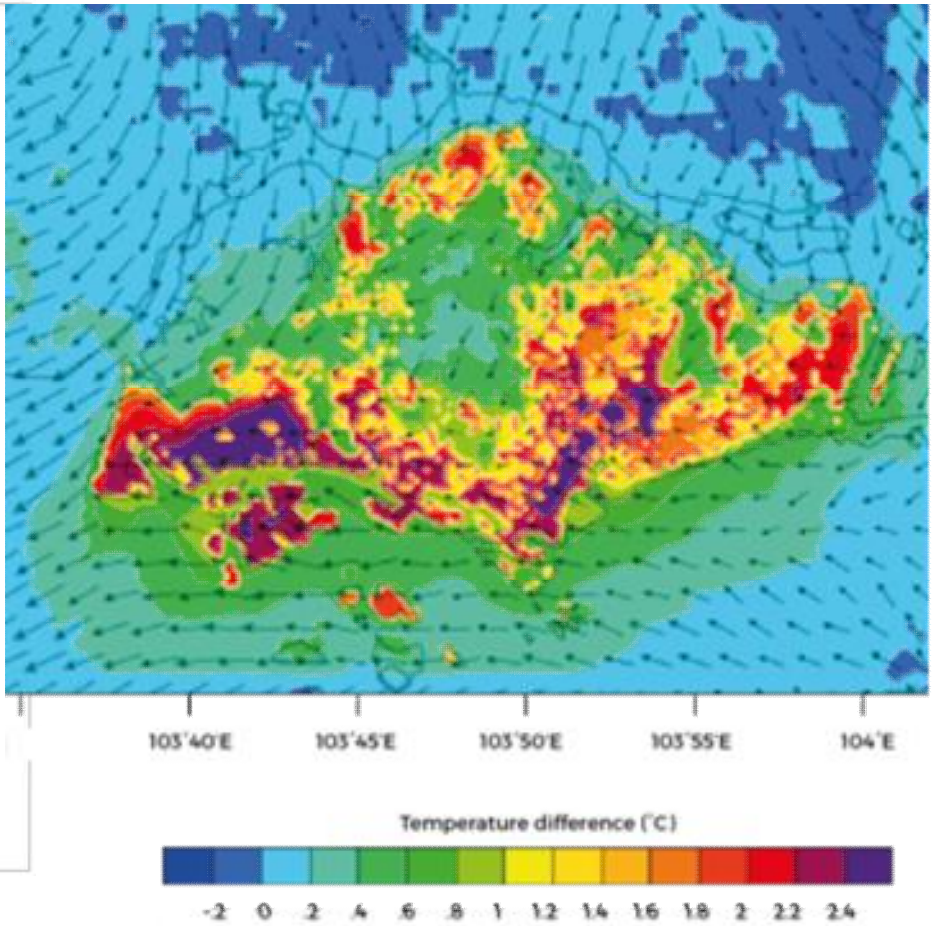
- Possible benefits:
  - 1. Environmental
  - 2. Economic
  - 3. Social & aesthetics

Potential benefits

- 1. Environmental benefits:
  - Mitigate urban heat island
  - Improve air quality
  - Stormwater management
  - Create natural habitat
  - Increase biodiversity
  - Insulate and absorb sound
  - Possible urban farming

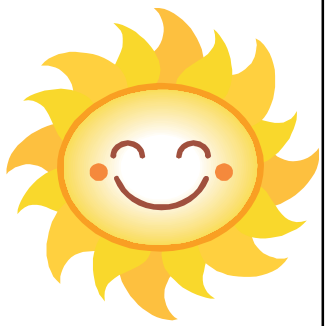
Urban heat island effects in Hong Kong and Singapore





(Source: Goggins WB, Chan EYY, Ng E, Ren C, Chen L (2012) Effect Modification of the Association between Short-term Meteorological Factors and Mortality by Urban Heat Islands in Hong Kong. PLOS ONE 7(6): e38551. http://doi.org/10.1371/journal.pone.0038551SCMP and Hong Kong Observatory and http://www.coolingsingapore.sg/uhi-singapore/)

Potential benefits



- 2. Economic benefits:
  - Improve roof durability
  - Increase roof material lifetime

  - Reduce building cooling load and energy costs
  - Provide open space & increase property value
  - Attracts buyers and tenants
  - Attracts and retains employees
  - Green building credit points & image

Potential benefits

- 3. Social & aesthetic benefits:
  - Aesthetic for urban space (natural outlook)
    - Relief from concrete construction
  - Provide usable green space for sports & leisure
    - Community gardens, recreational/relaxing space
  - Community participation for greening
    - Such as urban agriculture
  - Enhance local employment
    - For greenery installation & maintenance

Potential benefits

- Other possible benefits:
  - Urban farming (e.g. growing vegetables, herbs)
    - Make best use of roof space; may be organic
  - Education (environmental, scientific, liberal study)
    - Integrated with school curriculum
  - Community and social functions
    - Exercises & hobbies for children, adults & elderly
  - Healing landscape (e.g. horticultural therapy)
    - Sensory, meditation effects; manage emotion/stress

Urban farming on green roofs

Farming on the roof

Vegetables and herbal plants

Water melon

Green beans

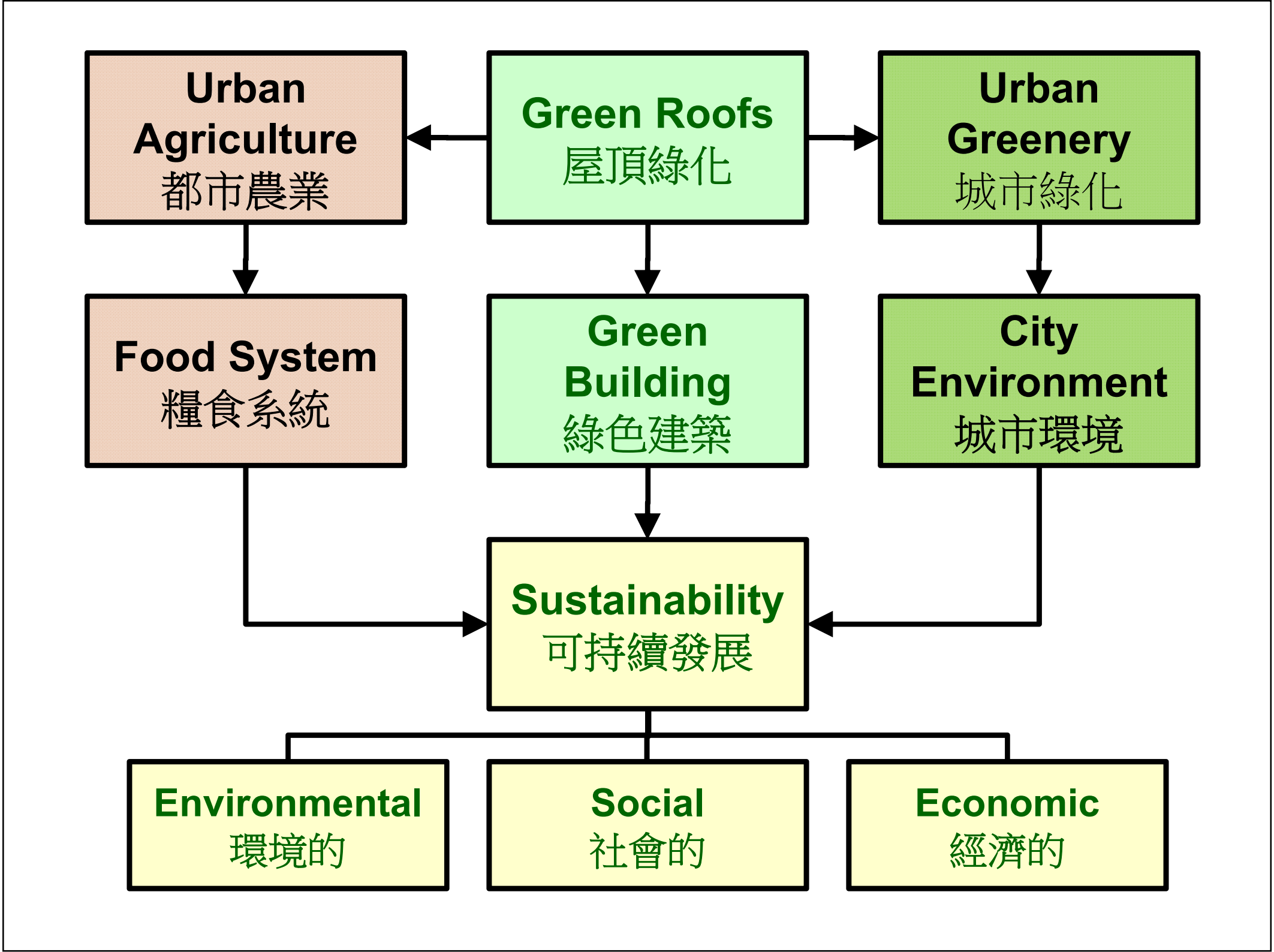
(Photos taken by Dr Sam C M Hui; Acknowledgement: St. Bonaventure Catholic Primary School)

School education green roof projects

(Source: Environment and Conservation Fund)

Urban farming & education

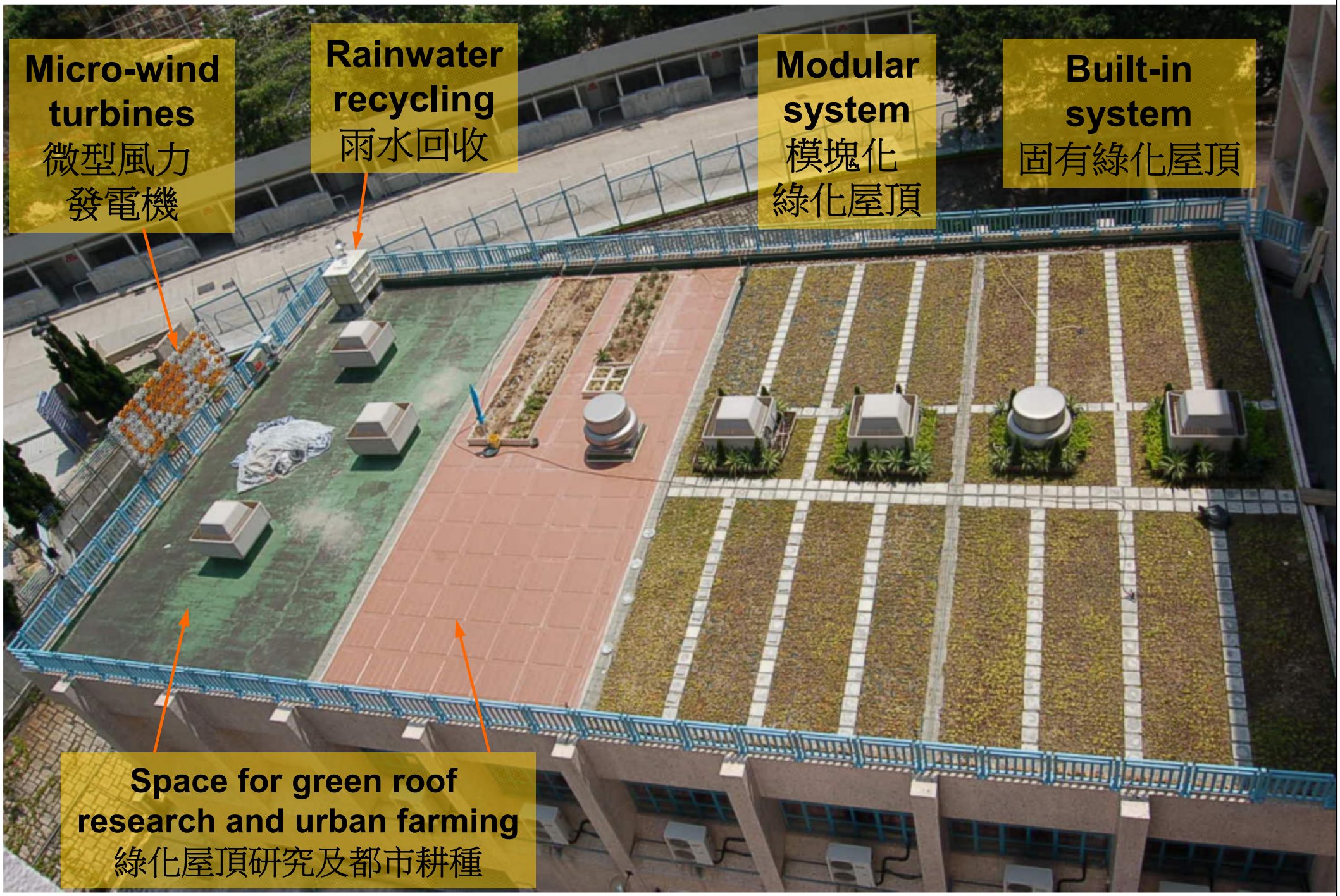
Horticultural therapy & social functions


Urban Agriculture
都市農業
Green Roofs
屋頂綠化
Urban Greenery
城市綠化
Food System
糧食系統
Green Building
綠色建築
City Environment
城市環境
Sustainability
可持續發展
Environmental
環境的
Social
社會的
Economic
經濟的

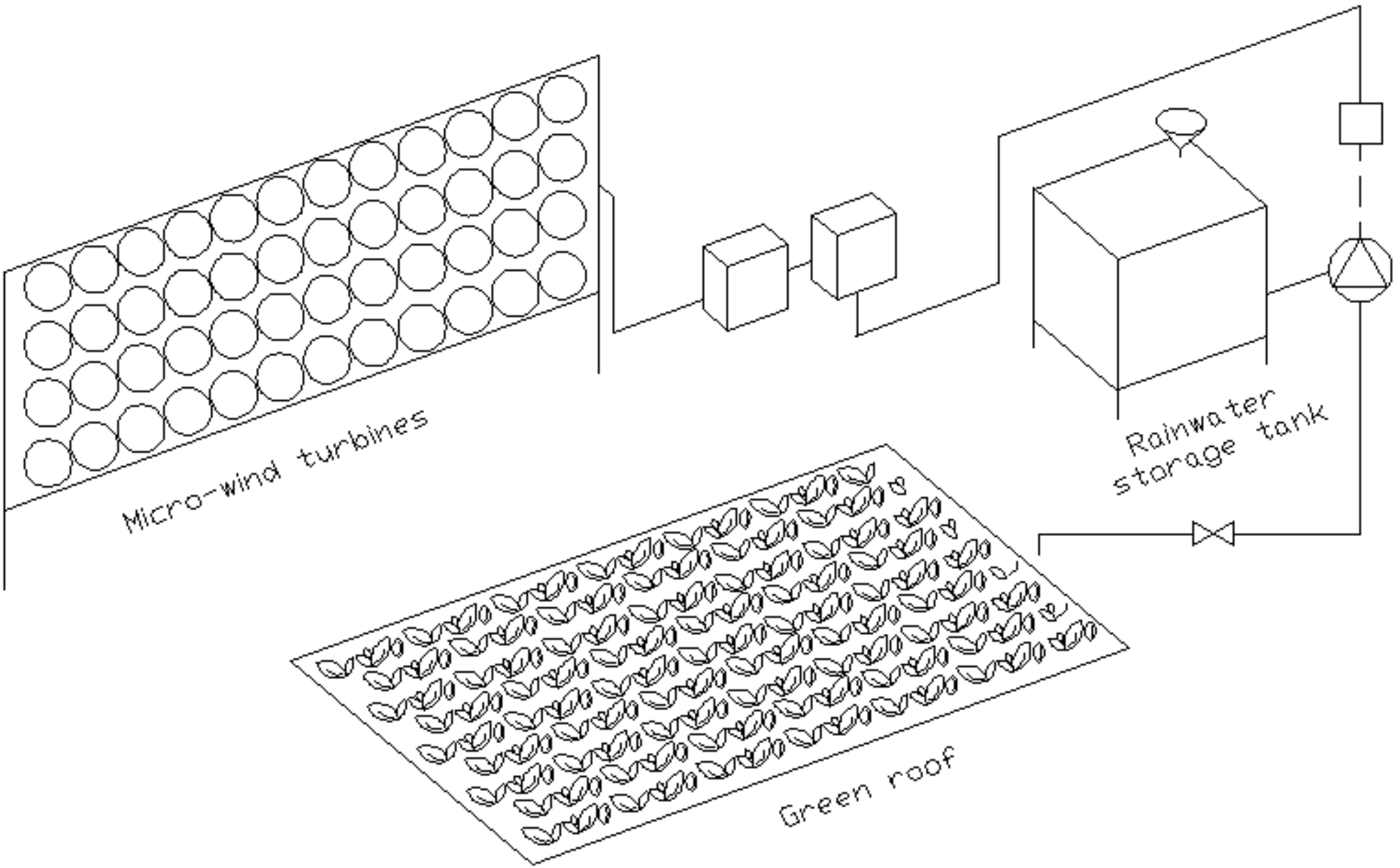
Sustainable technologies

- Possible integration with greenery to enhance green building performance
  - Rainwater harvesting
  - Renewable energy (e.g. solar photovoltaic & wind)
  - Composting (for producing fertilizer)
- Farming & food production
  - Agricultural green roofs
  - Edible living walls

Green roof research with integrated systems



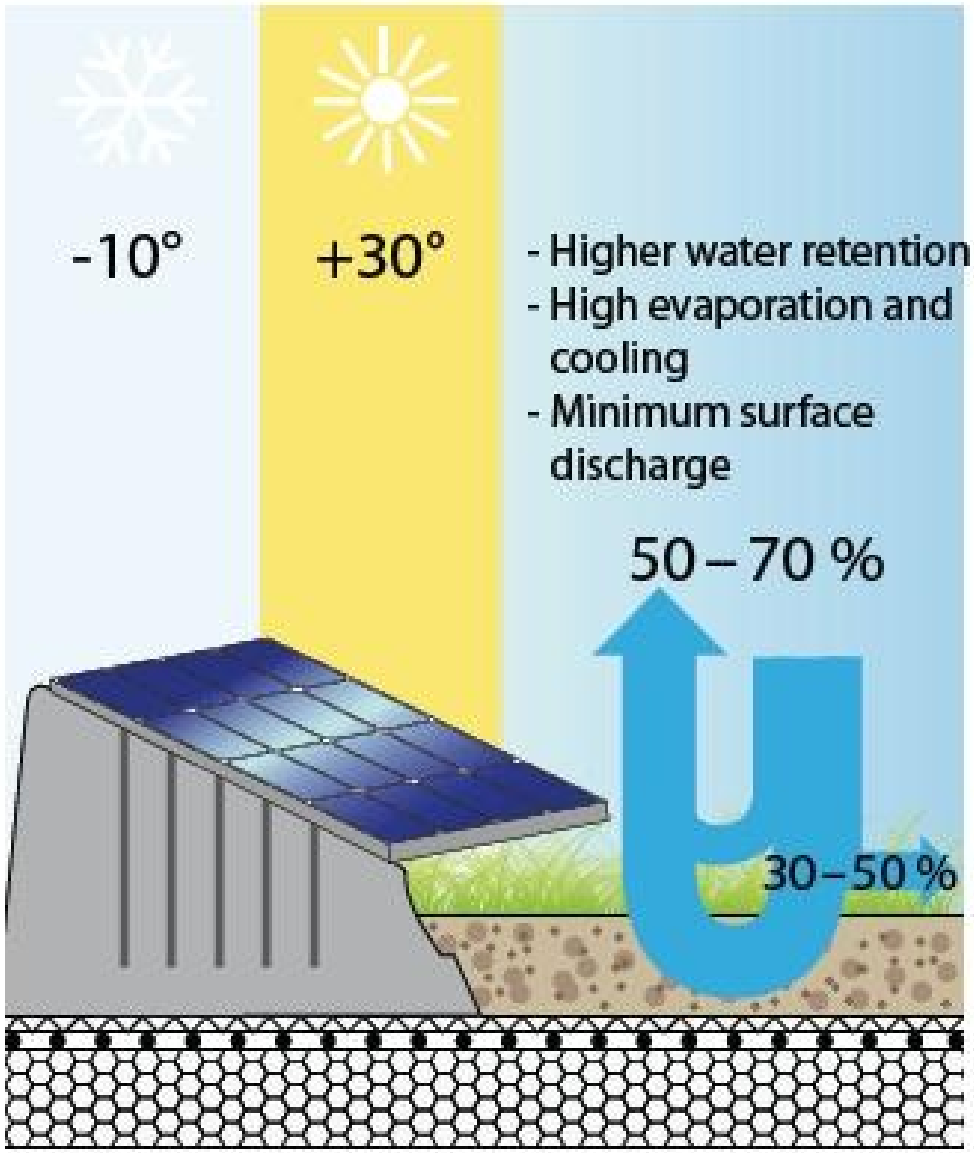
Integration of green roof, rainwater recycling and renewable energy
屋頂綠化，雨水回收利用和可再生能源的集成



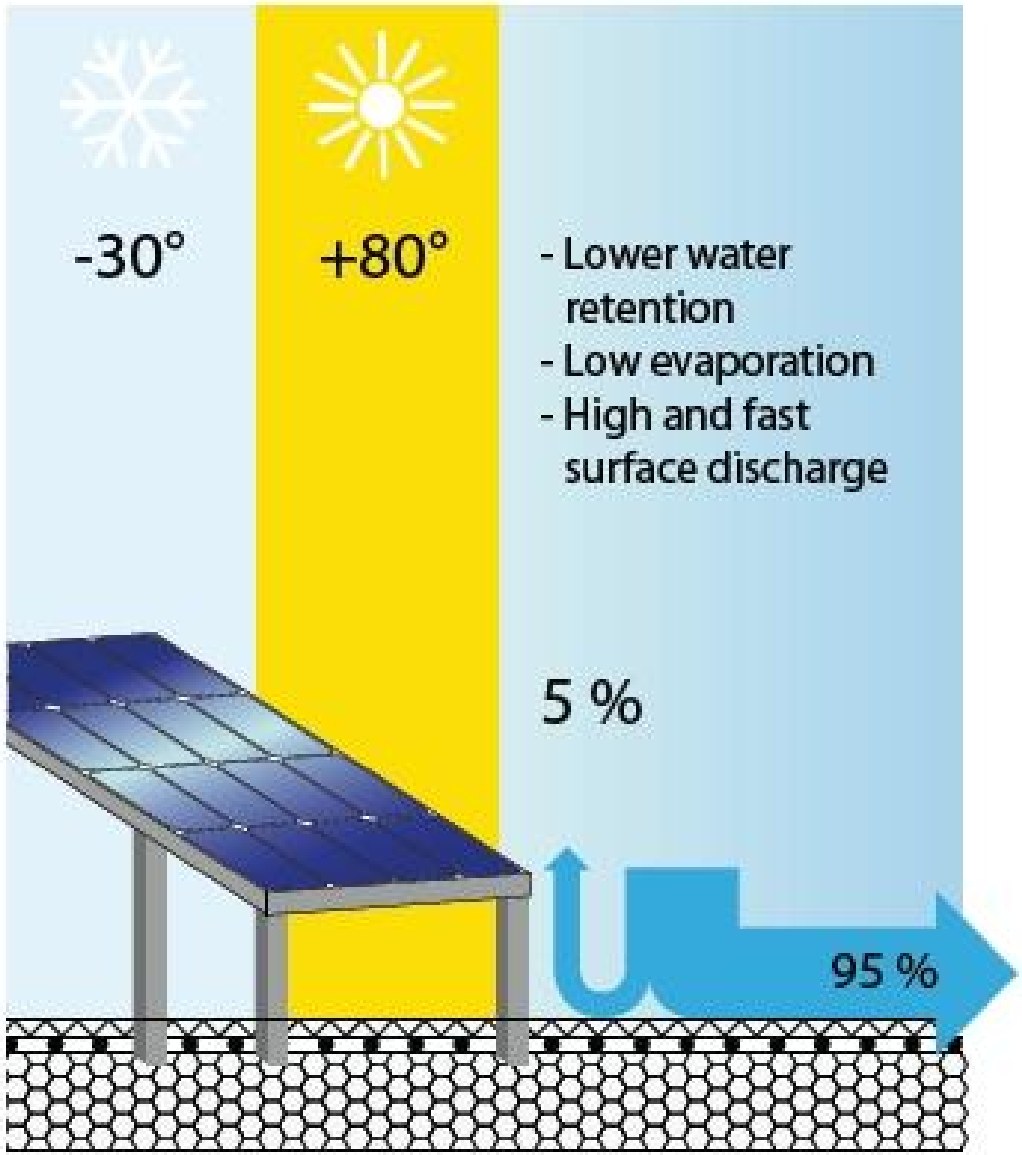
Integration of green roof and solar energy systems

(Source: www.zinco.de)

Integrated solar and extensive green roof



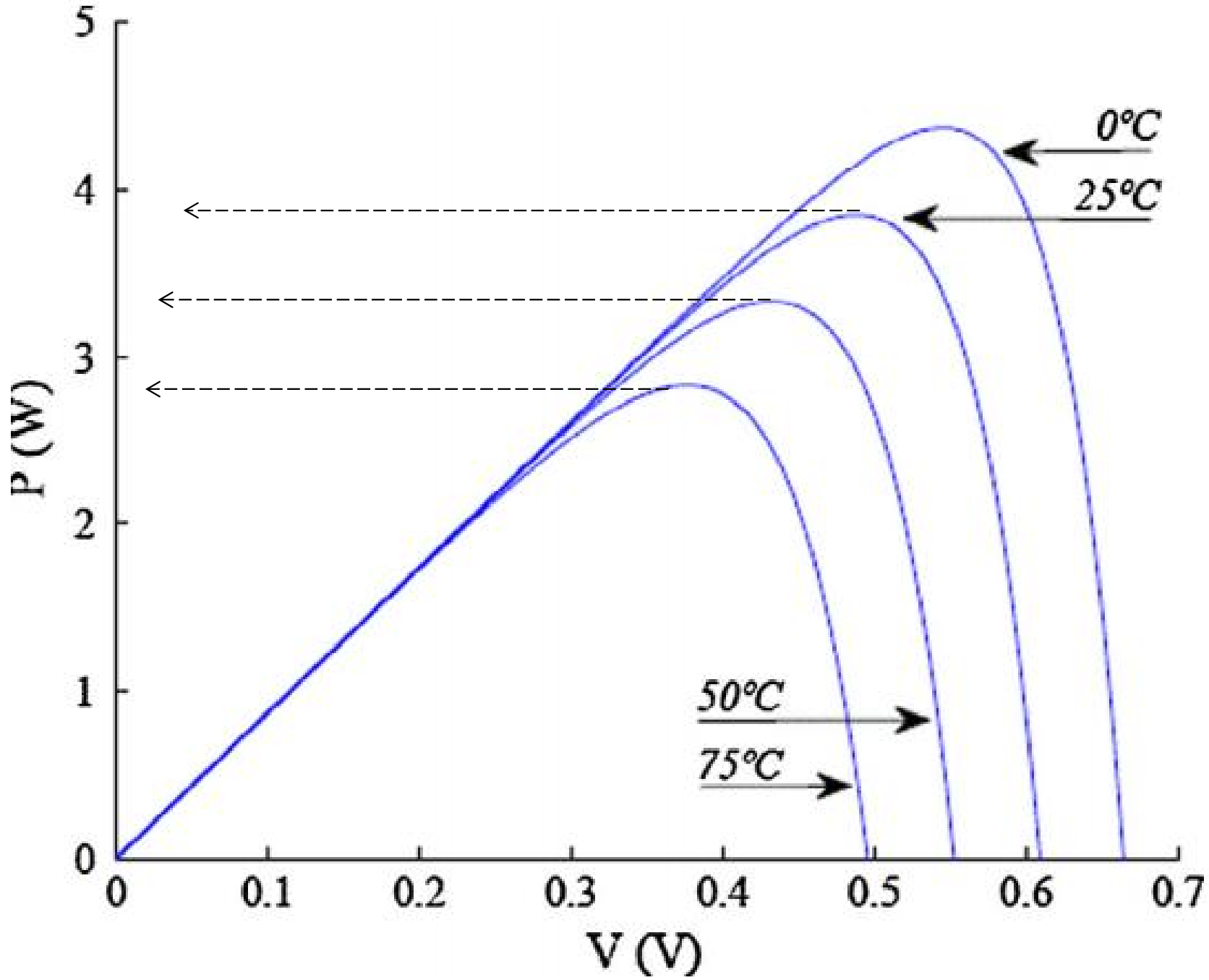
A combination of solar power and green roof.: "SolarGreenRoof" secured by a superimposed load.



Solar power plant anchored in the roof substructure without roof greening.

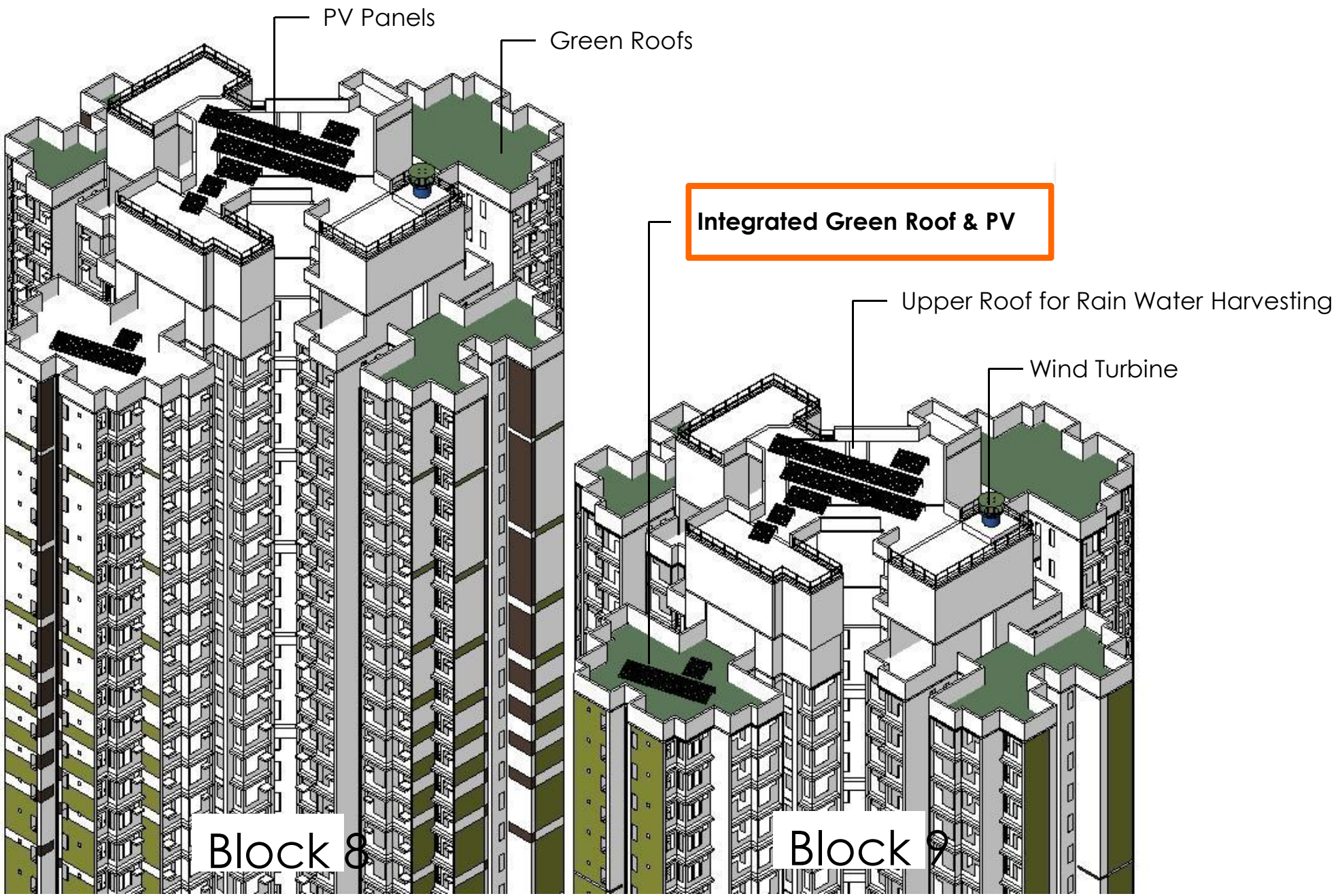
(Source: http://www.optigruen.de/)

Power-Voltage characteristics as a function of PV module temperature



(Source: Moharram, K. A., Abd-Elhady, M. S., Kandil, H. A. and El-Sherif, H., 2013. Enhancing the performance of photovoltaic panels by water cooling, *Ain Shams Engineering Journal*, 4 (4): 869-877.)

Research on integrated green roof and PV in Hong Kong

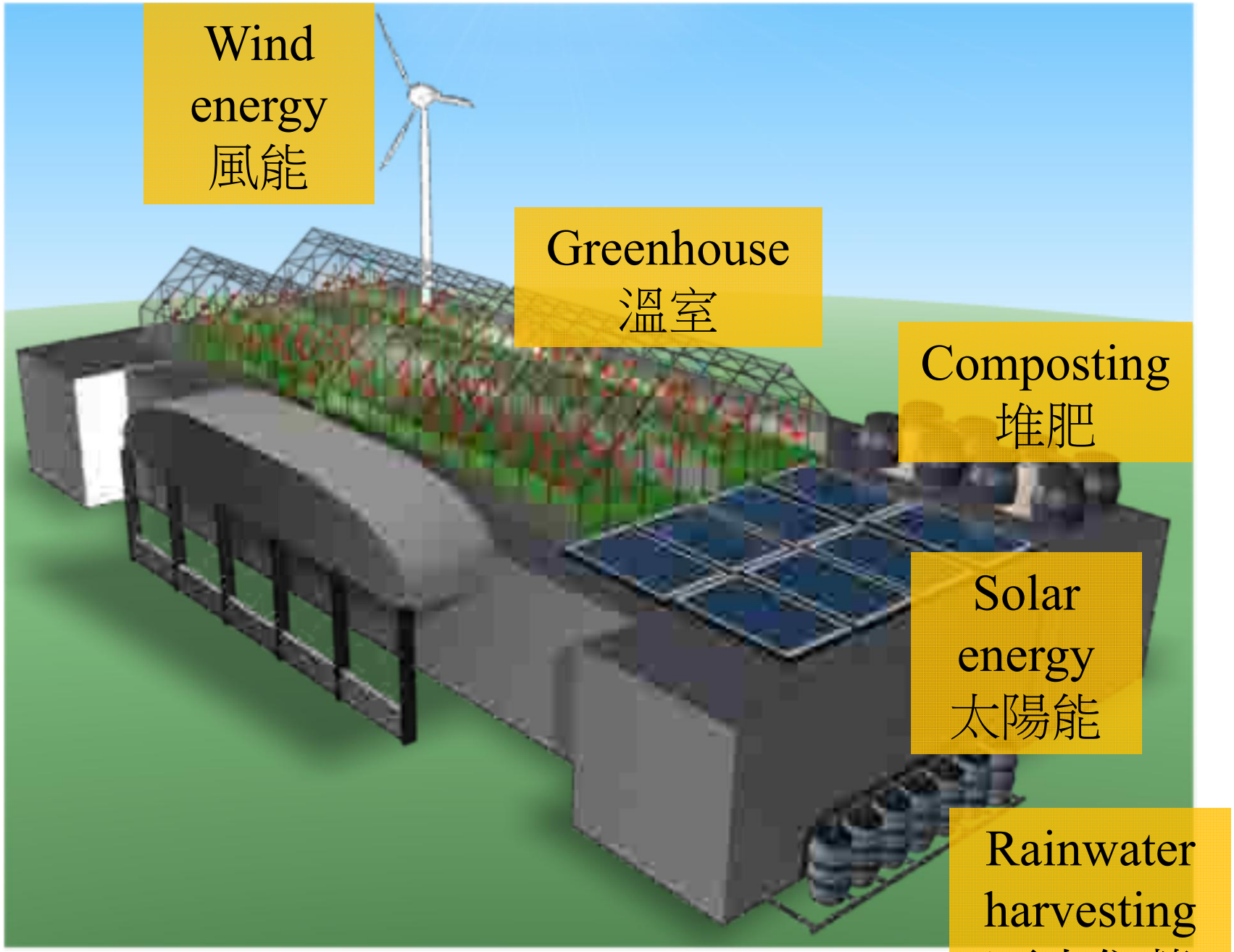


(Source: Housing Authority, Hong Kong)

Research on integrated green roof and PV in Hong Kong

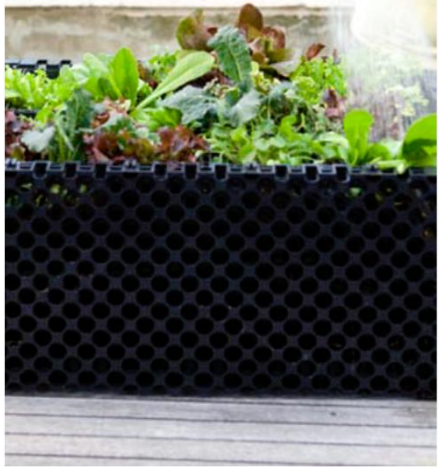
(Photos taken by Dr Sam C M Hui)

Sustainable rooftop farming 可持續屋頂耕種



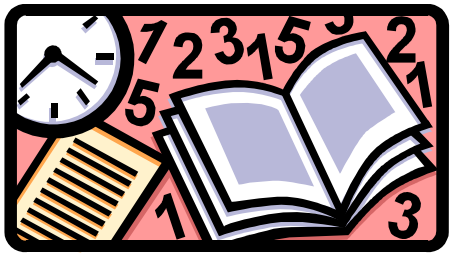
(Source: www.skyvegetables.com)

Edible vertical garden 可食用垂直花園

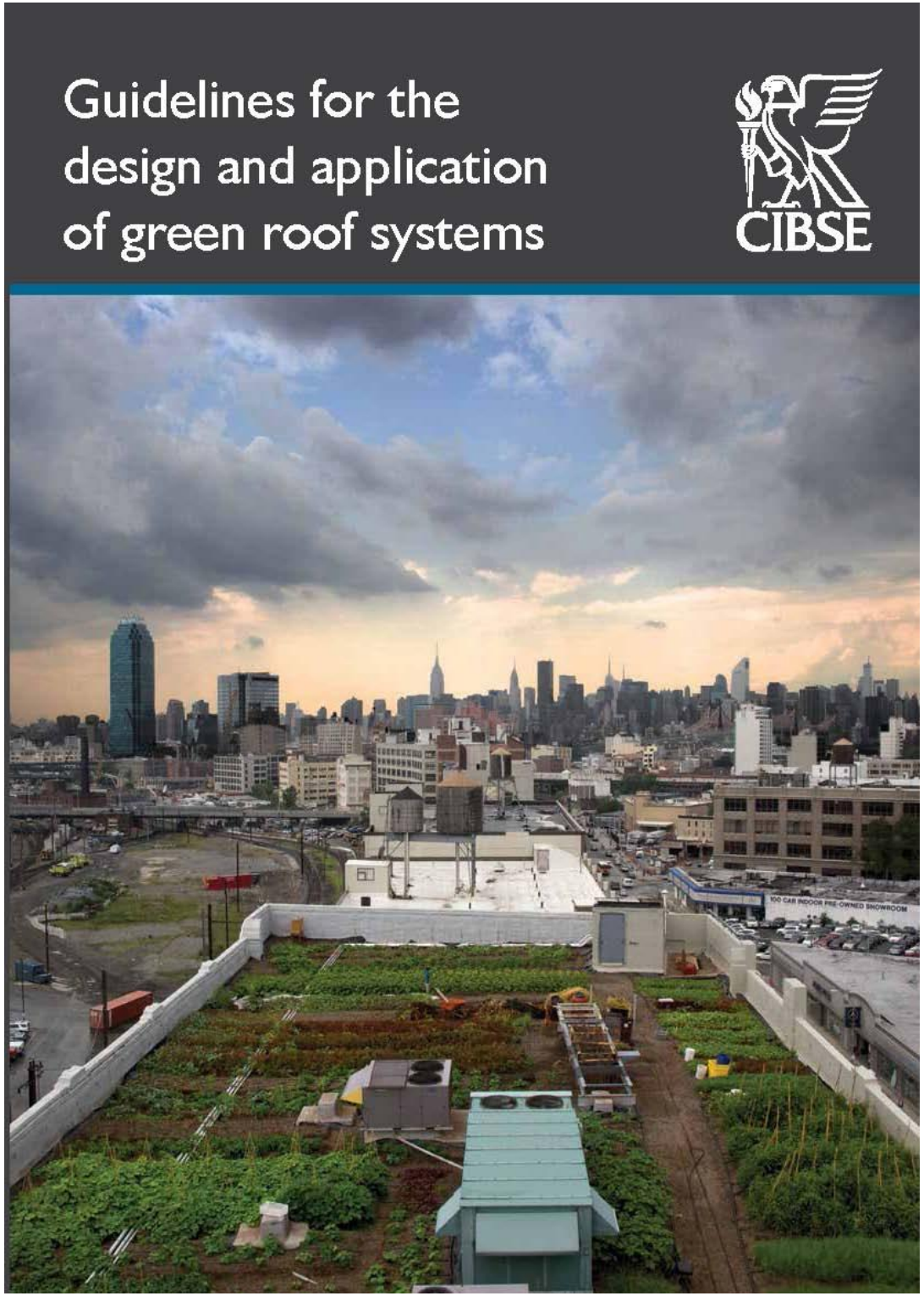


(Source: www.lifeisagarden.com.au)

Useful references



- ABRI, 2015. *Roof Greening Technical Handbook*, Architecture and Building Research Institute (ABRI), Ministry of the Interior, Taiwan. (in Chinese) 內政部建築 研究所, 2015. 《屋 頂綠化技術手冊》, 內政部建築研究所, 臺北. http://smartgreen.abri.gov.tw/download_Count_hits.php?no=187
- FLL, 2008. *Guidelines for the Planning, Construction and Maintenance of Green Roofing*, 2008 edition, Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V. (FLL), Bonn.
- Hui, S. C. M., 2013. *Guidelines for the Design and Application of Green Roof Systems*, Chartered Institution of Building Services Engineers, London.



Hui, S. C. M., 2013. *Guidelines for the Design and Application of Green Roof Systems*, Chartered Institution of Building Services Engineers, London. (ISBN 978 1 906846 40 4)
屋頂綠化系統的設計與應用指引

1. Introduction 引言
2. Scope 範圍
3. Definitions 定義
4. Planning Requirements 規劃要求
5. Design Considerations 設計注意事項
6. Construction Methods 施工方法
7. Maintenance Issues 維護問題
8. Project Management 項目管理

Q & A