



Rooftop Greening and Urban Farming in Hong Kong

香港綠化屋頂和都市農業



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Contents 內容



- Introduction 引言
- Potential benefits 潛在的好處
- Green roof examples 屋頂綠化的例子
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- Experiences in the world 世界城市的經驗
- Conclusions 結論



HONG KONG 香港





Introduction 引言

- Hong Kong Special Administrative Region (HKSAR) 香港特別行政區



- Land area 土地面積: 1,104 km²
- Population 人口: 7.18 millions
- Population density 人口密度: 6,504 persons/ km²
- High urban density to meet population growth
高建築密度應付人口增加



- Urban heat island and lack of greenery space
城市熱島和缺乏綠化空間的問題日益嚴重





Introduction 引言

- Promote green roofs and vertical greening to achieve urban sustainability 推展綠化屋頂和垂直綠化，實現城市可持續性
- Common types of roof greening: podium gardens and sky gardens 屋頂綠化的常見類型：平台花園和空中花園
- New greening techniques: 新的綠化技術
 - Extensive green roofs 粗放型屋頂綠化
 - Living walls & green facades 活生牆和綠化牆



A residential podium garden 住宅平台花園



(Photos taken by Dr Sam C M Hui)

Sky gardens in commercial buildings 在商業大廈的空中花園



(Kowloon Commerce Centre 九龍貿易中心)



(HSBC Building Mongkok 旺角匯豐大廈)



Introduction 引言

- Our research 我們的研究*
 - Started in 2002 從2002年開始
 - 1. Assess the potential & impacts of urban greening 評估城市綠化的潛在影響
 - 2. Develop practical guidelines & information 制定切實可行的指引及信息
 - 3. Evaluate building greening policy 評估建築綠化政策
 - 4. Promote education & technology development 促進教育和科技發展





Introduction 引言

- Examples of previous studies: 以前研究例子
 - Energy and environmental performance of green roofs and living walls 綠化屋頂和活生牆的節能和環保性能
 - Design and assessment of modular green roof systems 模塊化屋頂綠化系統的設計與評估
 - Life cycle analysis of green roof urban farming 屋頂綠化都市農業的生命週期分析
 - Feasibility study of green noise barriers 綠化隔音屏障的可行性研究

Green roof research at a construction site office in Hong Kong 在香港建築地盤辦事處的屋頂綠化研究 (2002-2006)



Green site office



Modular design

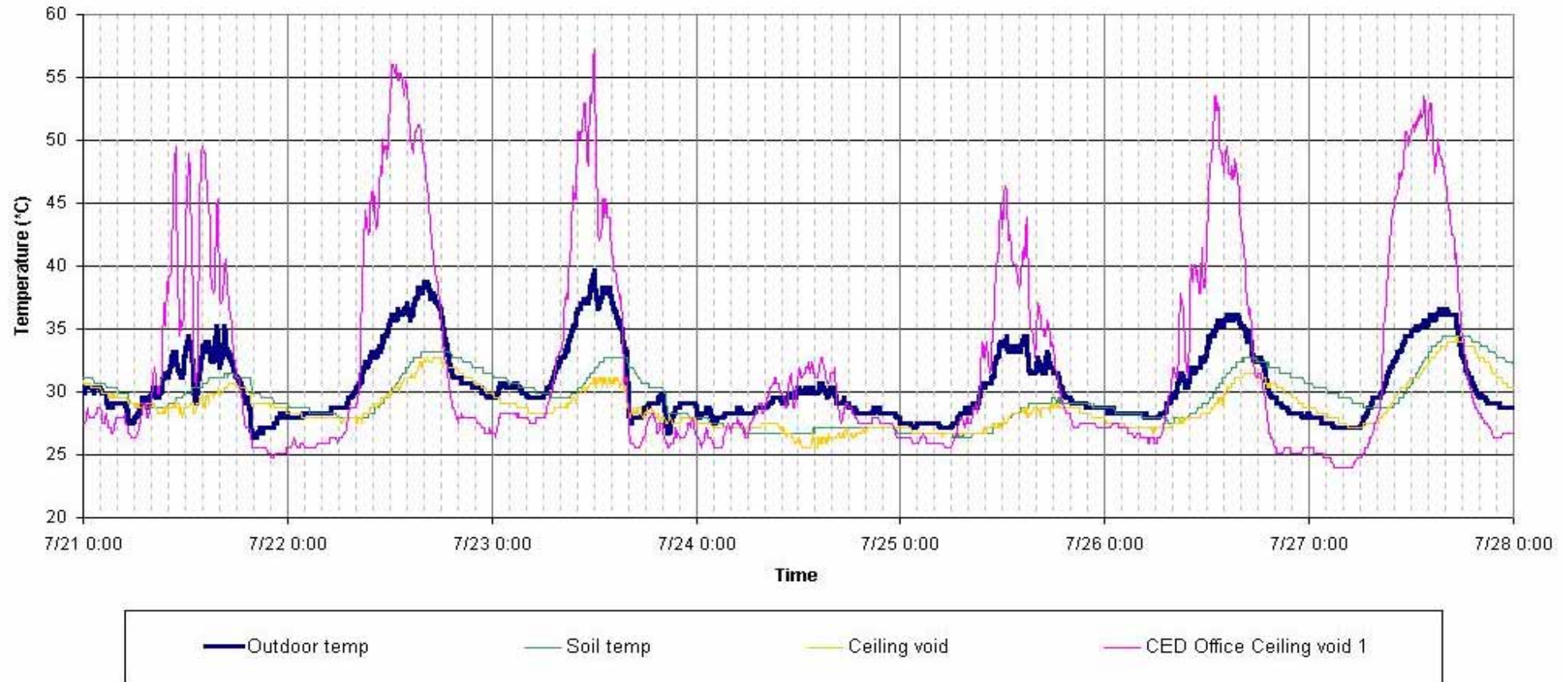


Green site office and typical site office

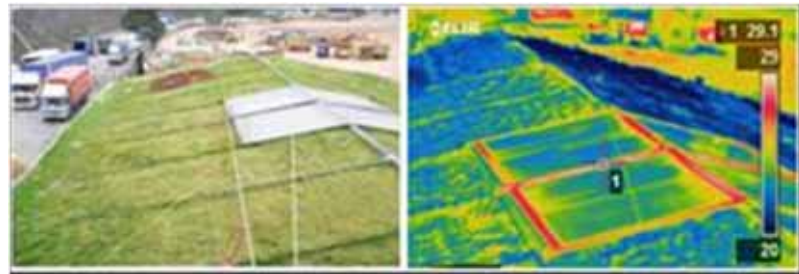


Water sprinkler

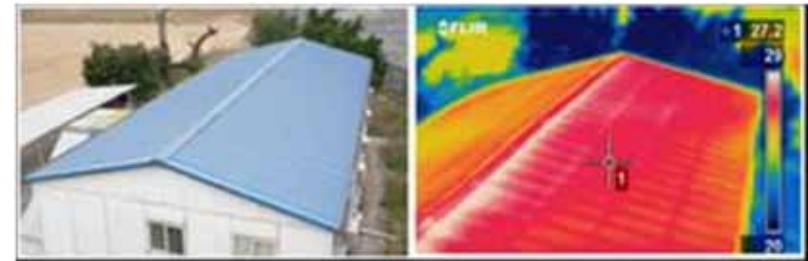
Green roof research at a construction site office in Hong Kong 在香港建築地盤辦事處的屋頂綠化研究



Infrared pictures:



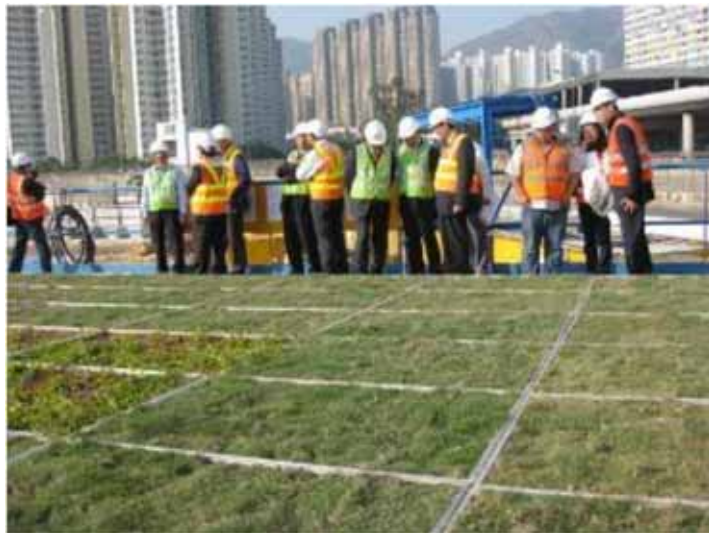
Green roof



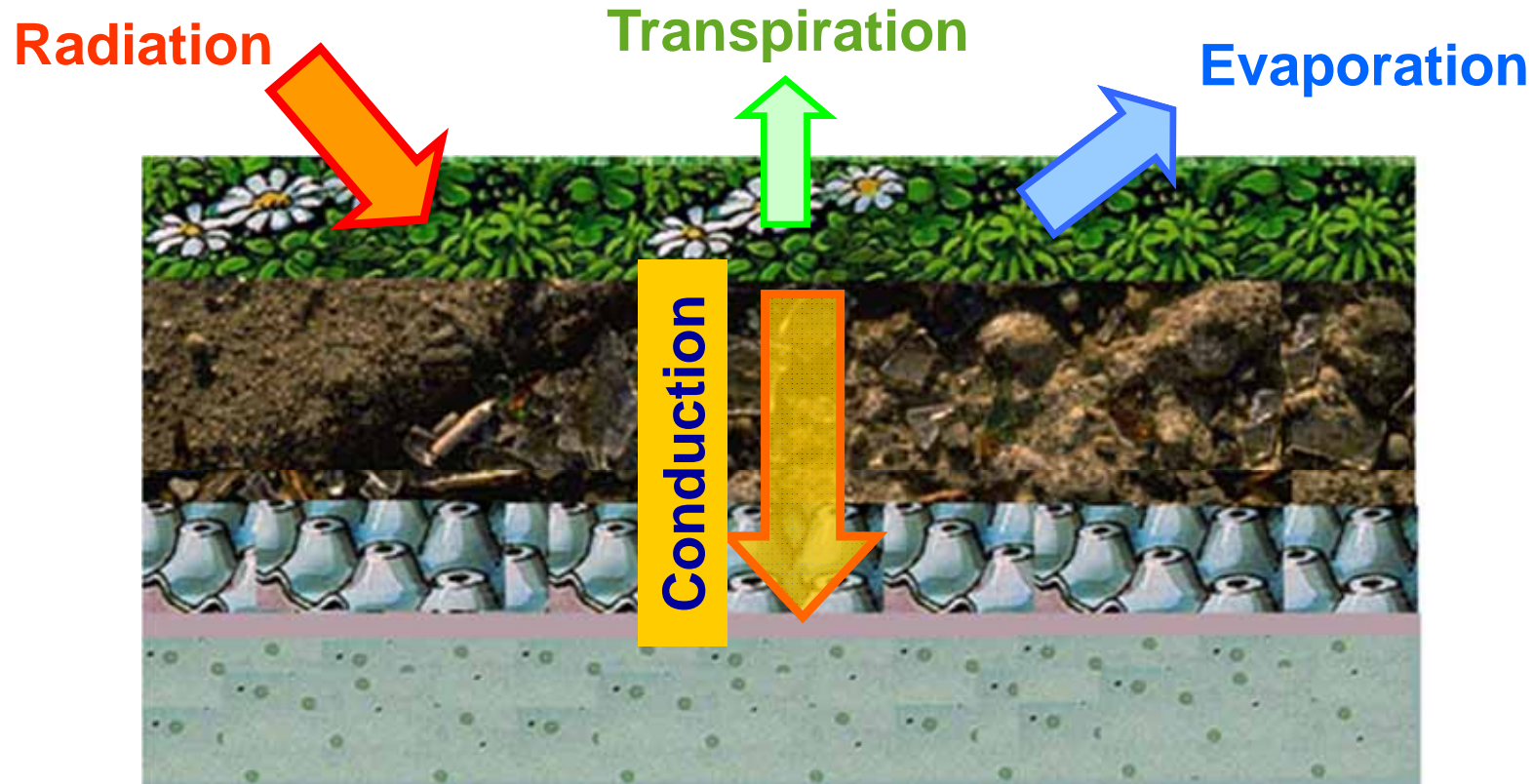
Conventional roof

Green roof and vertical green for construction site offices

在建築地盤辦事處的屋頂綠化和垂直綠化的應用



Thermal modelling of green roofs 綠化屋頂的導熱建模



Radiation: $R_n = R \exp(-k_s LAI)$

Evapo-transpiration: $q'' = -2LAI \frac{\rho C_p}{\gamma(r_e + r_i)} \left(\frac{w \mathcal{R} T}{h_m} \right)$

Conduction: $q'' = (T_{s1} - T_{s2}) / R_{total}$

Study of modular green roof systems (2007-2008)

模塊化屋頂綠化系統的研究



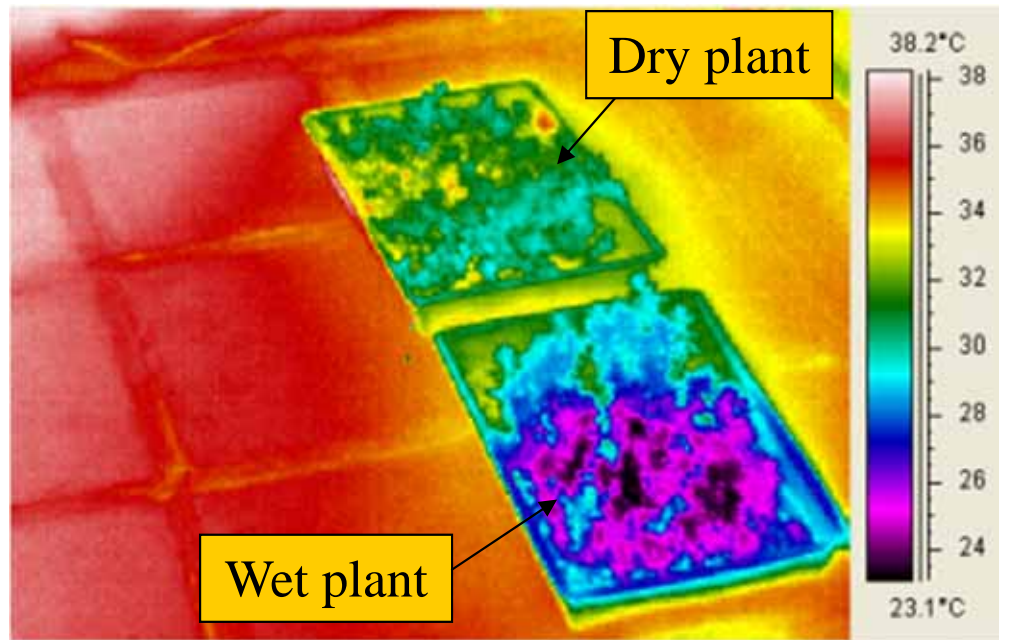
Aluminum trays



Wooden boxes



Plastic trays



Plastic trays (infrared photo)

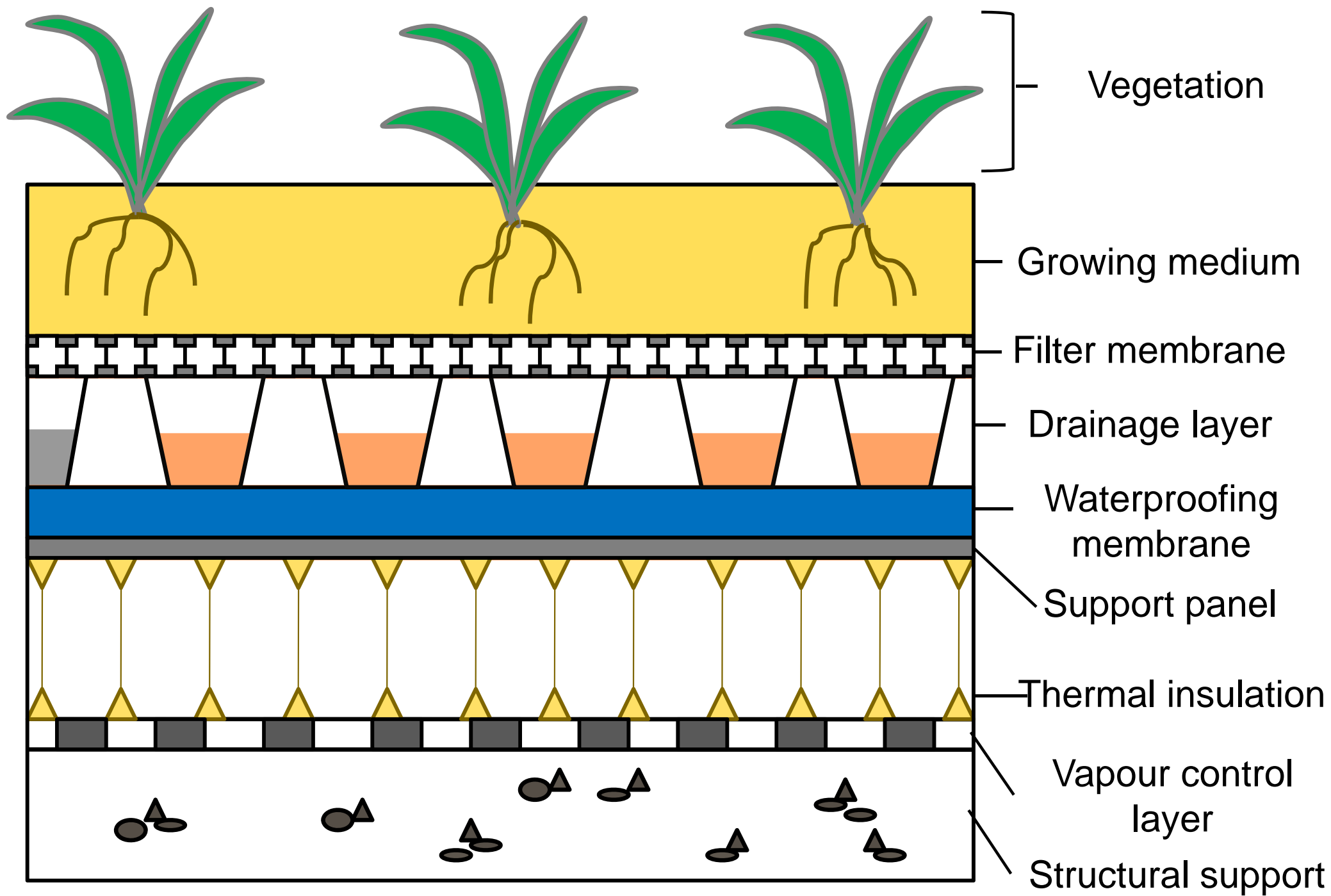
Green roof systems from Germany (left) and Japan (right)

綠化屋頂系統：德國（左）和日本（右）



Typical structure of extensive green roof

粗放型屋頂綠化的典型結構



Green noise barrier 綠色隔音屏障



(Source: Highway Department, HK)

Guidelines for the design and application of green roof systems



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



Potential benefits 潛在的好處



- Green roofs & vertical greening 綠化屋頂和垂直綠化
 - Building integrated vegetation 建築綜合性植被
 - Urban cityscape 城市景觀
 - Green infrastructure 綠色基礎建設
- Possible benefits: 可能的好處
 - 1. Environmental 環境的
 - 2. Economic 經濟的
 - 3. Social 社會的



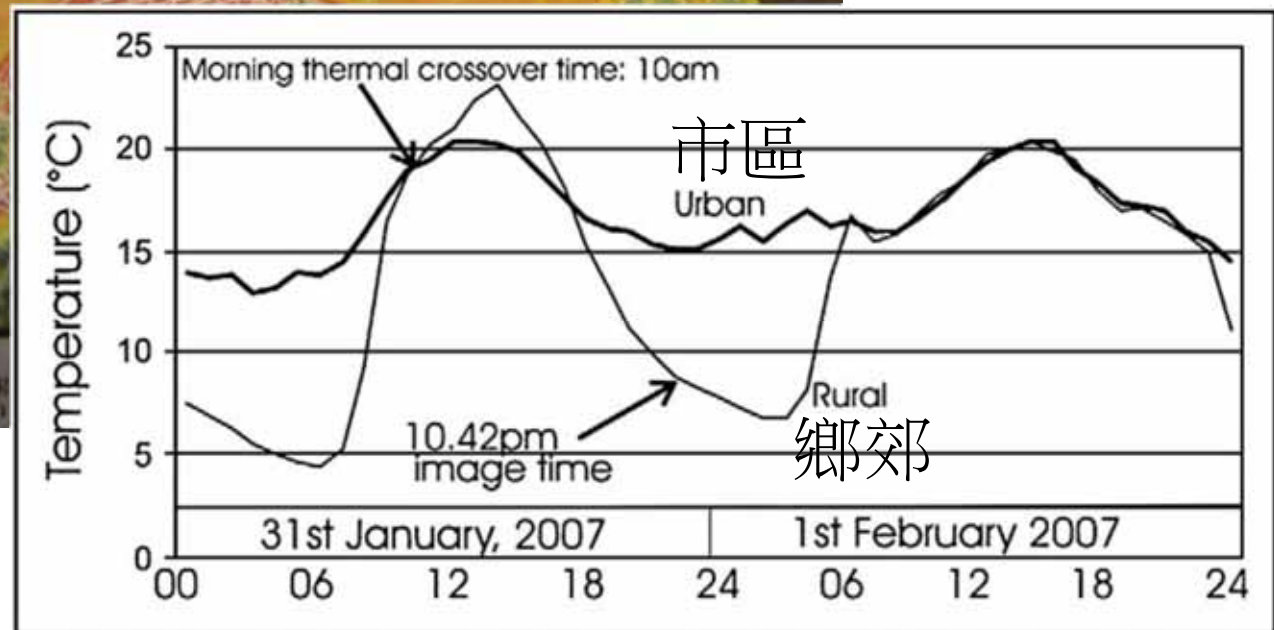
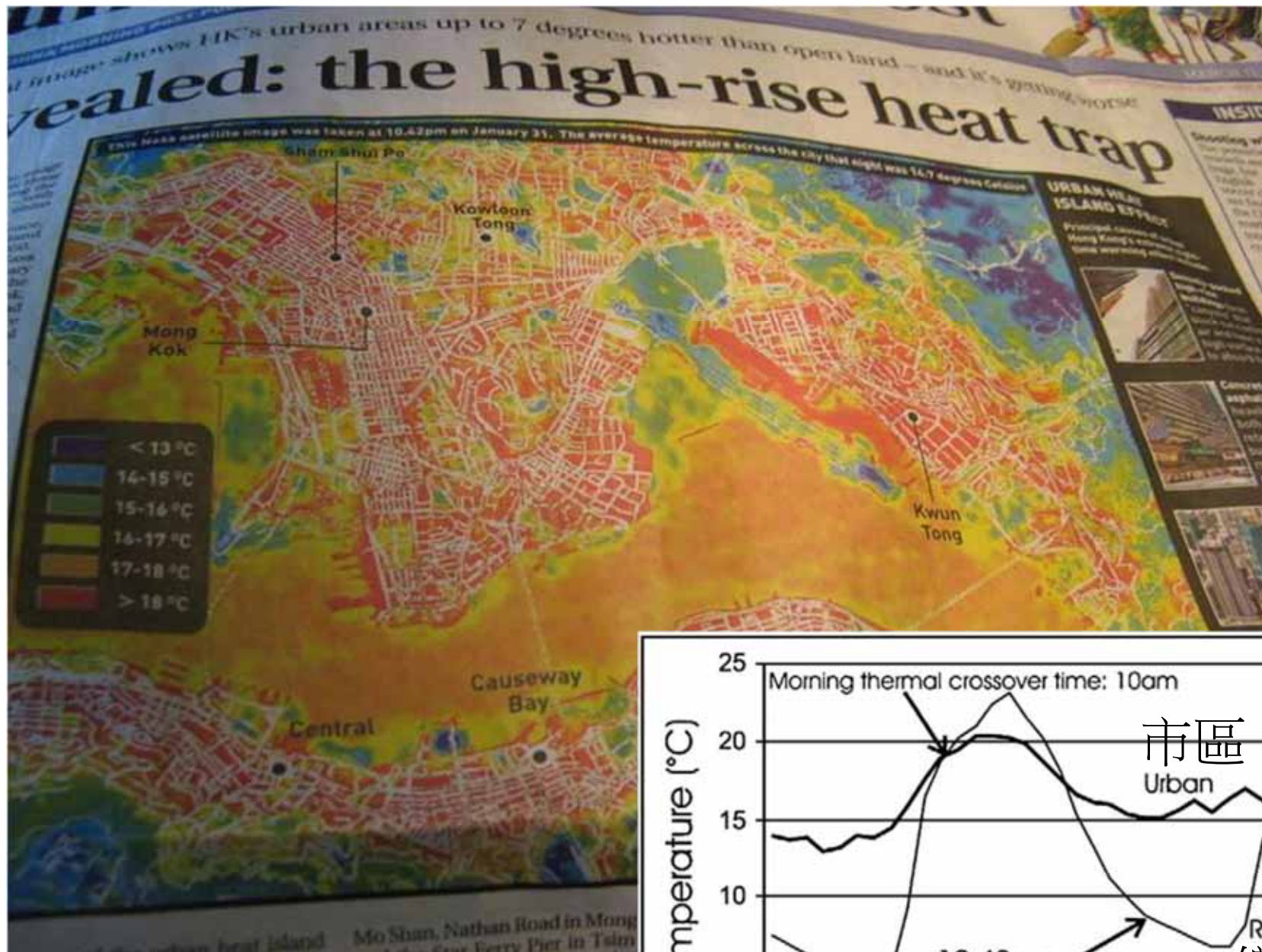
Potential benefits 潛在的好處



- 1. Environmental benefits: 環境的好處
 - - Mitigate urban heat island 緩解城市熱島
 - - Improve air quality 改善空氣質量
 - - Stormwater management 改善城市雨水管理
 - - Create natural habitat 建立自然棲息地
 - - Increase biodiversity 增加生物多樣性
 - - Insulate and absorb sound 隔音和吸音
 - - Possible urban farming 可作都市農業



Urban heat island in Hong Kong 香港城市熱島



(Source: SCMP and Hong Kong Observatory)

Potential benefits 潛在的好處



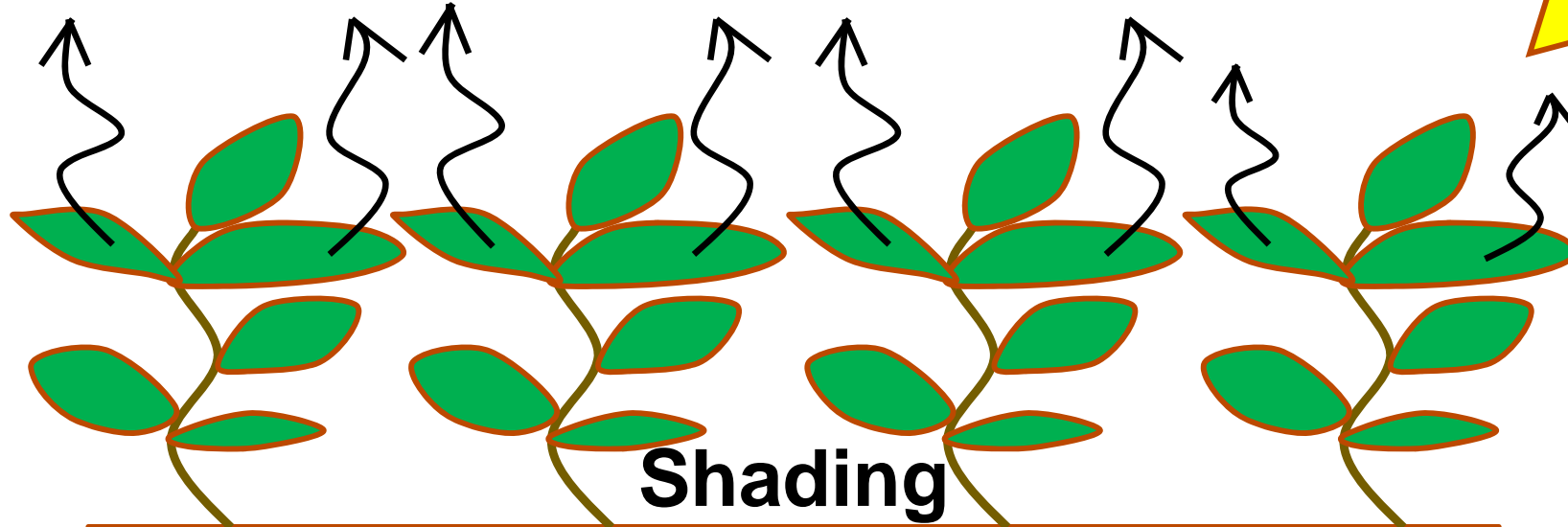
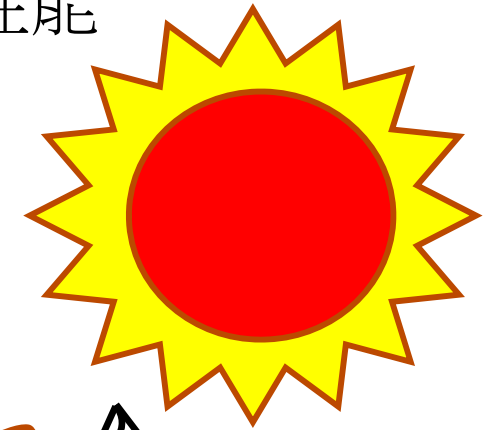
- 2. Economic benefits: 經濟的好處
 - - Improve roof durability 提高屋頂的耐久性
 - - Increase roof material lifetime 增加屋頂的壽命
 - - Reduce building cooling load and energy costs
降低建築冷負荷和能源成本
 - - Provide open space & increase property value 提供開放空間，可增加物業價值
 - - Green building credit points & image
綠色建築評估得分和形象



Thermal properties of green roofs 綠化屋頂的熱學性能

Outdoor

Evapo-transpiration



Shading

Thermal mass

Insulating property

Roof slab

Indoor

Potential benefits 潛在的好處



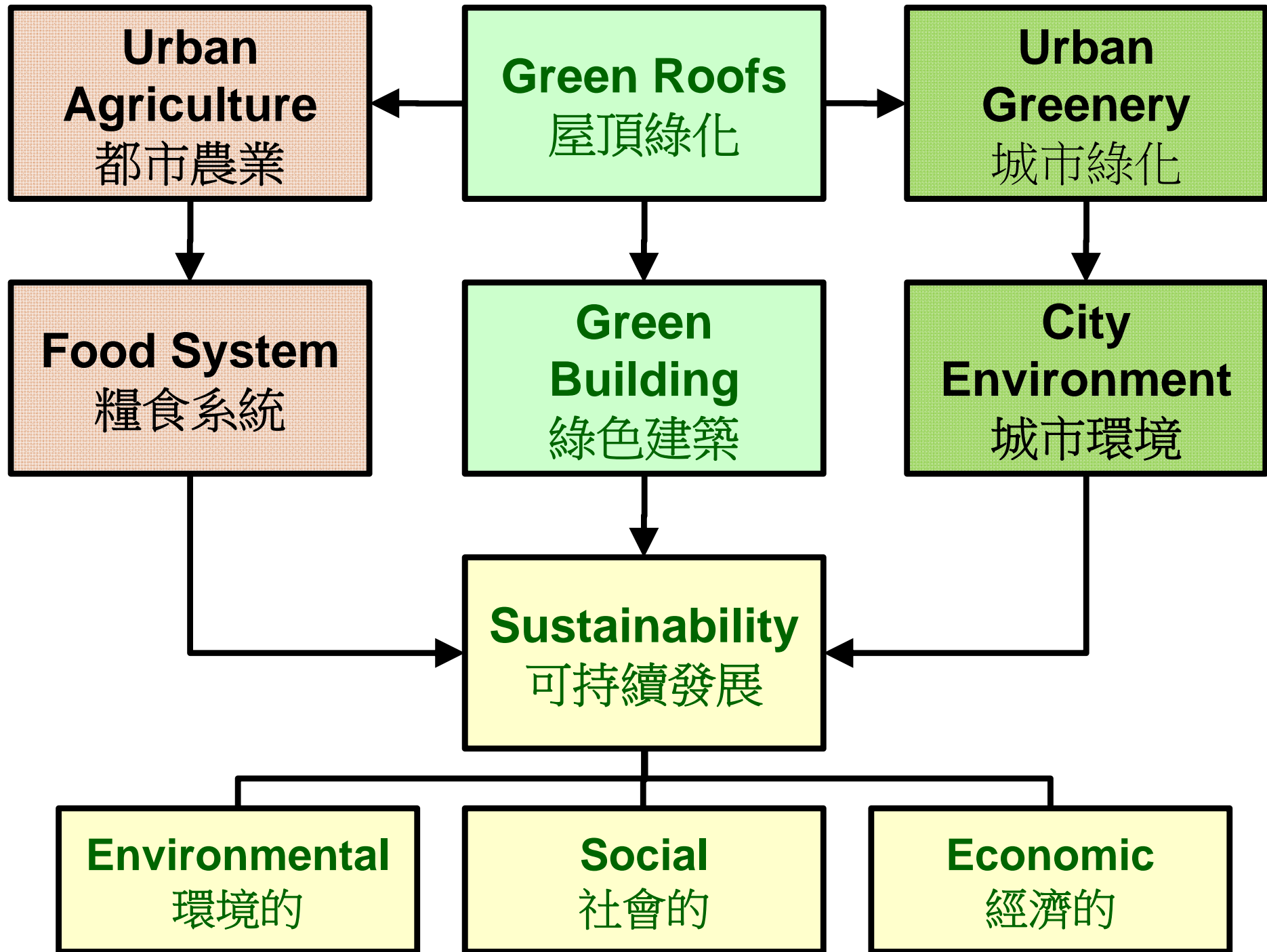
- 3. Social benefits: 社會的好處
 - - Aesthetic for city space 美化市容的空間
 - - Provide community green space & gardens for sports & leisure 提供社區綠地和花園，可作運動和休閒
 - - Community participation 提供社區的積極參與
 - - Provide education opportunities 提供教育機會
 - - Enhance local employment 加強地方就業



School education green roof project 學校教育屋頂綠化工程



(Source: Environment and Conservation Fund)



Green roof examples

屋頂綠化的例子



- Green roof application is growing fast in Hong Kong in recent years 屋頂綠化的應用，近年來在香港正在快速增長
 - 1. Government projects (as demonstration)
政府項目 (如示範) (> 250 nos.)
 - 2. School projects (with incentives/subsidies)
學校項目 (獎勵/補貼)
 - 3. Private projects (for “green” image)
私人項目 (為“綠色”的形象)

Examples of green roofs in Hong Kong 香港屋頂綠化的例子



Ocean Park 海洋公園



EMSD Headquarters 機電署總部



Parklane, TST 尖沙咀柏麗大道



HK Wetland Park 濕地公園

Hong Kong Wetland Park Phases II 香港濕地公園第二期



(Source: Architectural Services Department)

Greening at Tamar project 添馬艦發展工程的綠化



(Photos taken by Dr Sam C M Hui)

Government green roof projects 政府綠化屋頂項目



Sewage treatment plant 污水處理廠

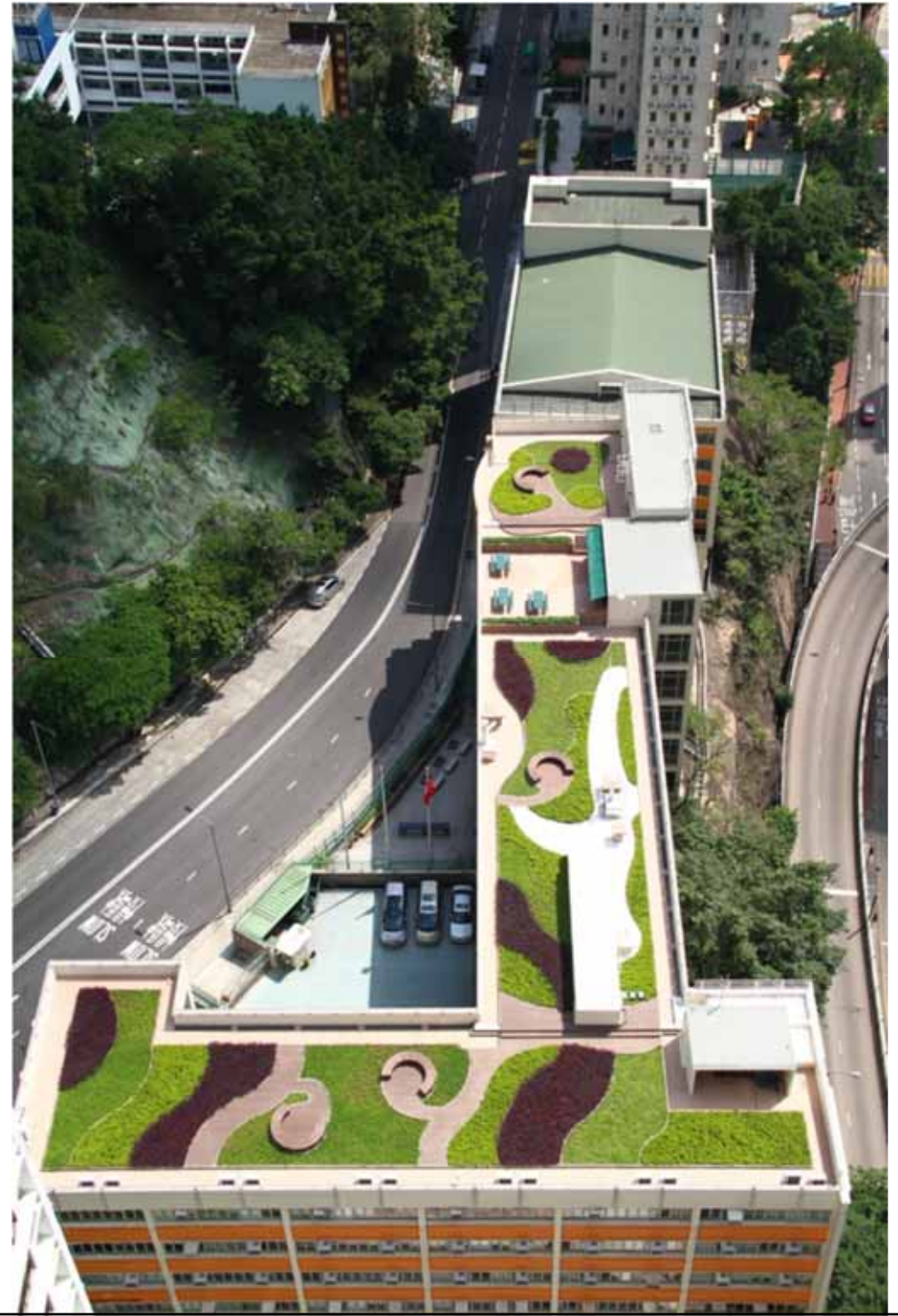


Refuge room 垃圾房



Sewage pumping station
污水泵站

School green roof project 學校屋頂綠化工程



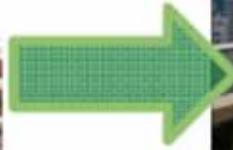
(Source: Architectural Services Department)

HKU Centennial Campus 香港大學百週年校園

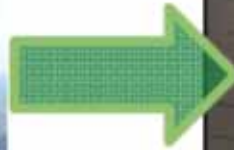


(Photos taken by Dr Sam C M Hui)

Introduce greening on existing rooftops 現有的屋頂引入綠化



Wood deck was built as a path and resting area



Paving and vertical greening on roof garden

Source: The Hong Kong Jockey Club Headquarters

Green roof farming (Hysan Place, Causeway Bay)

屋頂綠化農耕 (銅鑼灣希慎廣場)



(Photos taken by Dr Sam C M Hui)

Major considerations

主要考慮因素



- Key factors for planning 主要規劃因素

- Structural loading 結構負荷
- Accessibility 能否容易到達
- Waterproofing 屋面防漏水
- Drainage 排水渠務
- Maintenance 維護保養

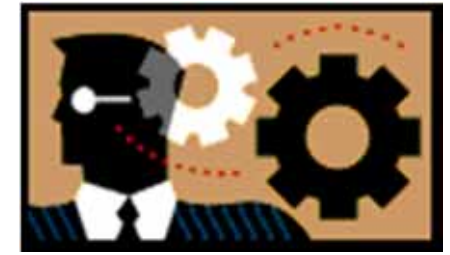


- Other design considerations 其他設計考慮

- Selection of plants (e.g. hardy plants) 選擇植物
- Stakeholders' involvement & support 參與支持

Major considerations

主要考慮因素



- Climatic factors 氣候因素
 - Typhoons: strong wind might blow away the vegetation and soil 颱風：強風會吹走植被土壤
 - Heavy rainfalls: hold and drain the rain water without creating pools of stagnant standing water 大雨：不積水池的雨水排水
 - High temperature: affect some plant species 高溫：某些植物物種的影響
 - Strong sunlight: solar and UV radiation 強烈的陽光：太陽能和紫外線輻射

Major considerations

主要考慮因素



- High-rise buildings: very limited roof spaces
高層建築：屋頂的空間非常有限
 - Better to apply green roofs to medium- or low-rise buildings/structures or podium roofs 更好地適用於中或低矮建築物/構築物或平台屋頂綠化
 - Podium/sky gardens 平台，空中花園
- Structural loading 結構荷載
 - Determine validity and cost 確定有效性和成本
 - For existing buildings 對於現有建築物
 - Light-weight greening systems 輕質綠化系統

Green roof on a low-rise building 在低層建築的屋頂綠化



(Source: Hongkong Electric Co., Ltd.)

Major considerations

主要考慮因素



- Costs and commitments 成本和承諾
 - Capital cost (direct & indirect costs) 資本成本(直接和間接成本)
 - Recurrent maintenance costs 經常維修保養費用
 - Life-cycle costs 生命週期成本
 - Risk of failure costs 失敗的風險成本
 - Maintenance commitments 維護承諾
 - Ownership 擁有權



Major considerations

主要考慮因素

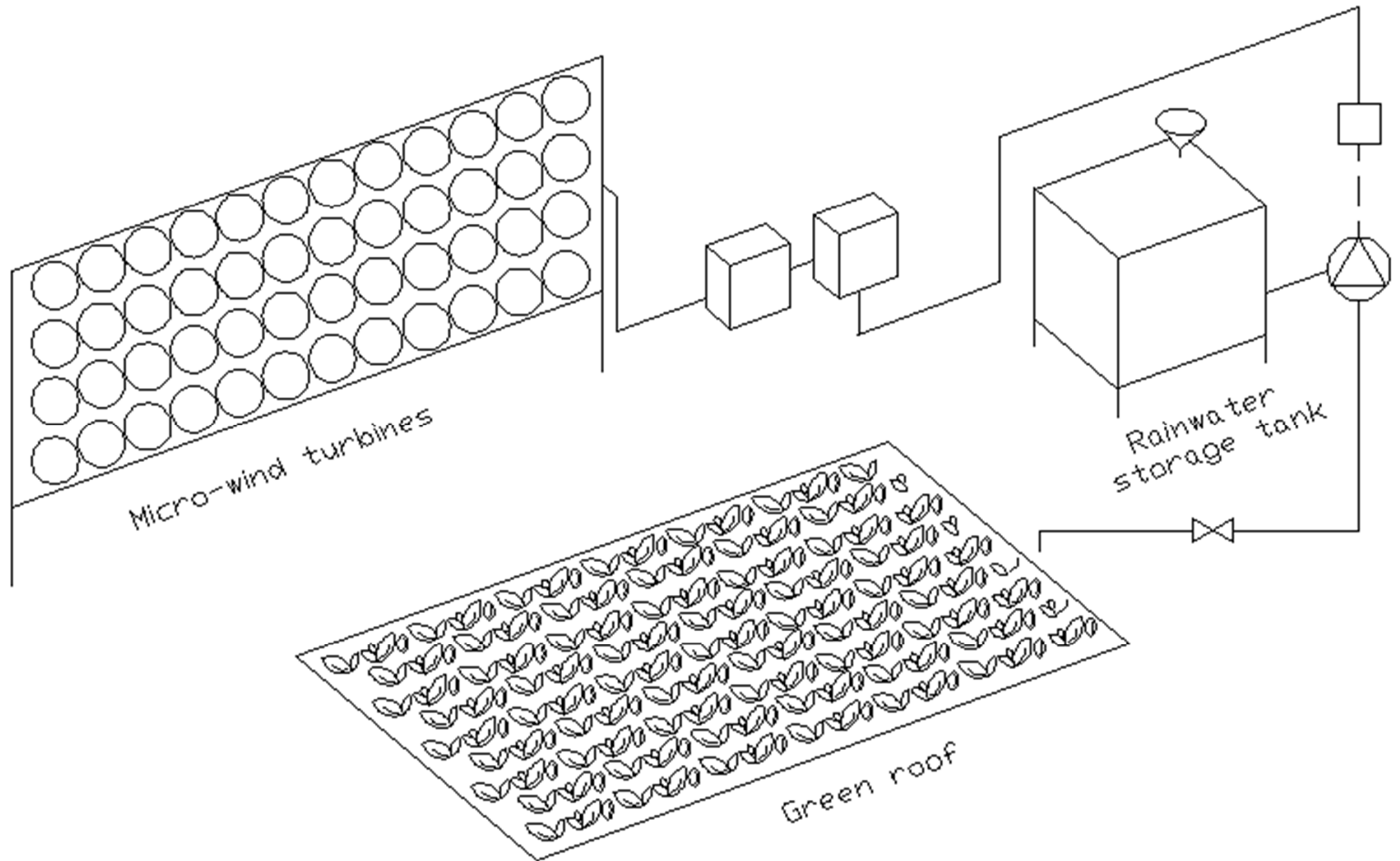


- Sustainable technologies 可持續發展技術
 - Rainwater harvesting 雨水收集
 - Renewable energy (e.g. solar photovoltaic & wind) 可再生能源(如太陽能光伏和風能)
 - Composting (for producing fertilizer) 堆肥(用於生產肥料)
- Farming & food production 農業和食品生產
 - Agricultural green roofs 農業屋頂綠化
 - Edible living walls 可食用的活生牆

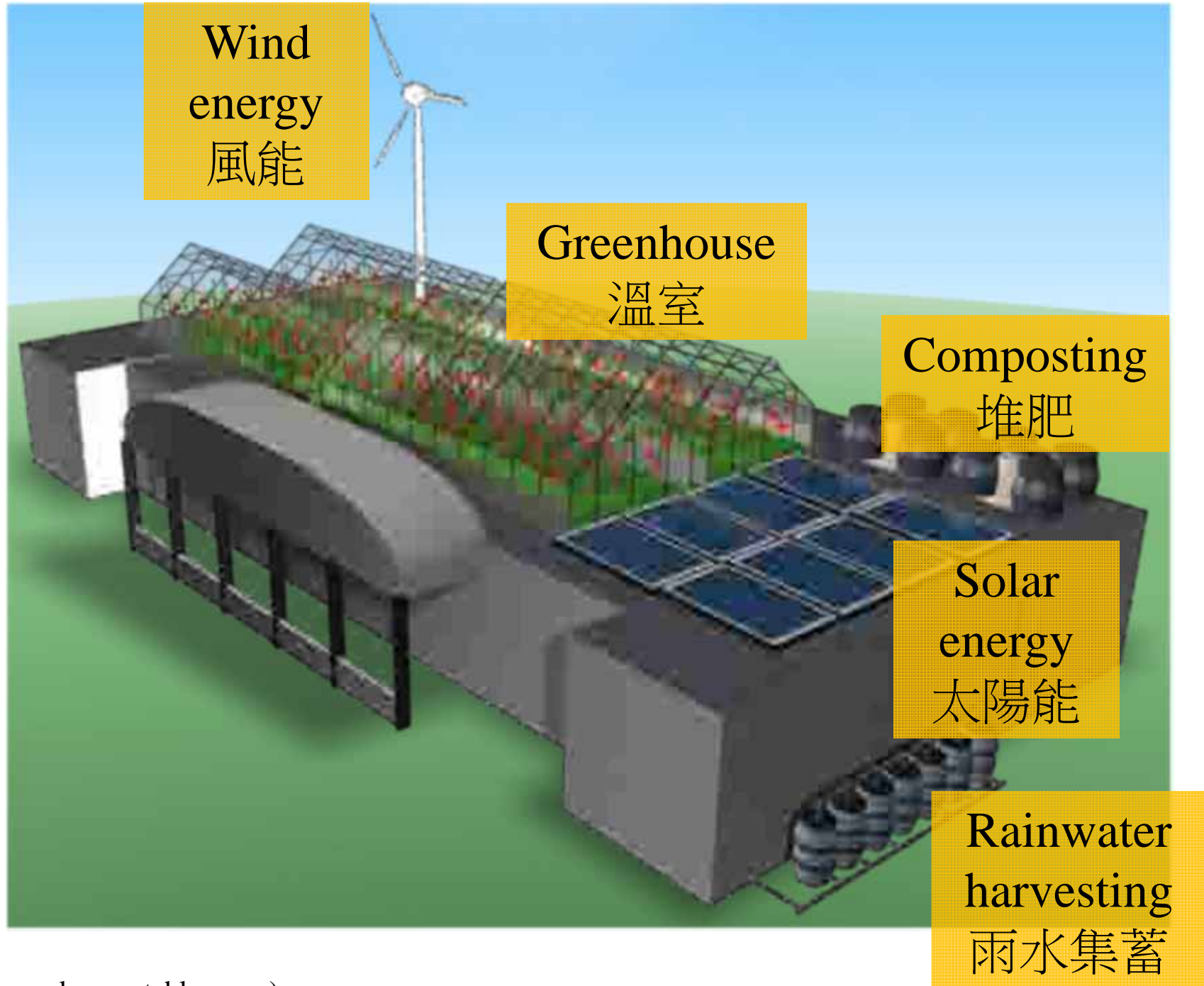


Integration of green roof, rainwater recycling and renewable energy

屋頂綠化，雨水回收利用和可再生能源的集成



Sustainable rooftop farming 可持續屋頂耕種



Experiences in the world

世界城市的經驗



- Eagle Street Rooftop Farm in Brooklyn, New York City, USA 美國紐約的鷹街屋頂農場 (www.rooftopfarms.org)
- Roppongi Hills, Tokyo, Japan 東京市的六本木新城屋頂農場 (www.roppongihills.com)
- Green roof farm in Osaka, Japan (Namba Parks) www.nambaparks.com 在日本大阪（難波公園）的綠化屋頂農地
- Rooftop container garden in Taipei, Taiwan 台灣台北市的容器天台花園農場和種植箱應用組合 (<http://photo.xuite.net/yiutsay>)

Eagle Street Rooftop Farm in NYC 美國紐約的鷹街屋頂農場
(Source: <http://blog.anandaharvest.org>)



Rice paddy and vegetable plot at Roppongi Hills in Tokyo, Japan 東京六本木山の稻田和菜地



(Source: www.greenroofs.com)

Green roof farm in Osaka, Japan (Namba Parks) www.nambaparks.com

在日本大阪（難波公園）的綠化屋頂農地



(Source: www.treehugger.com, www.toho-leo.co.jp and www.nambaparks.com)

Container roof garden in Taiwan 台灣集箱屋頂花園



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

Experiences in the world

世界城市的經驗



- Examples 例子: (in USA, Japan and Taiwan)
 - 大都市的新農業 - 空中有機菜園 (3:50)
<http://youtu.be/i2x3i56M5Vk>
 - 日本空中農場(TVBS電視台) (1:20) http://youtu.be/r5cn6m_FF3A
 - 都市農夫 III 東京銀座樓頂 養蜂樂園 (2:33)
<http://youtu.be/1pIaR9MFY3o>
 - 都市頂樓種菜，綠化屋頂、降低溫度，節能減碳又環保 (9:02)
<http://youtu.be/KHZSqZbwdLM>
 - 0721華視新聞雜誌-都市農業 打造綠屋頂 (10:29)
<http://youtu.be/watch?v=J4uUq21KANU>
 - 【年輕人讚起來】20140515 - 屋頂上的開心農場 (24:00)
<http://www.youtube.com/watch?v=-WKHOAEwhlg>

Rooftop urban farming in the world 世界上的屋頂都市耕種



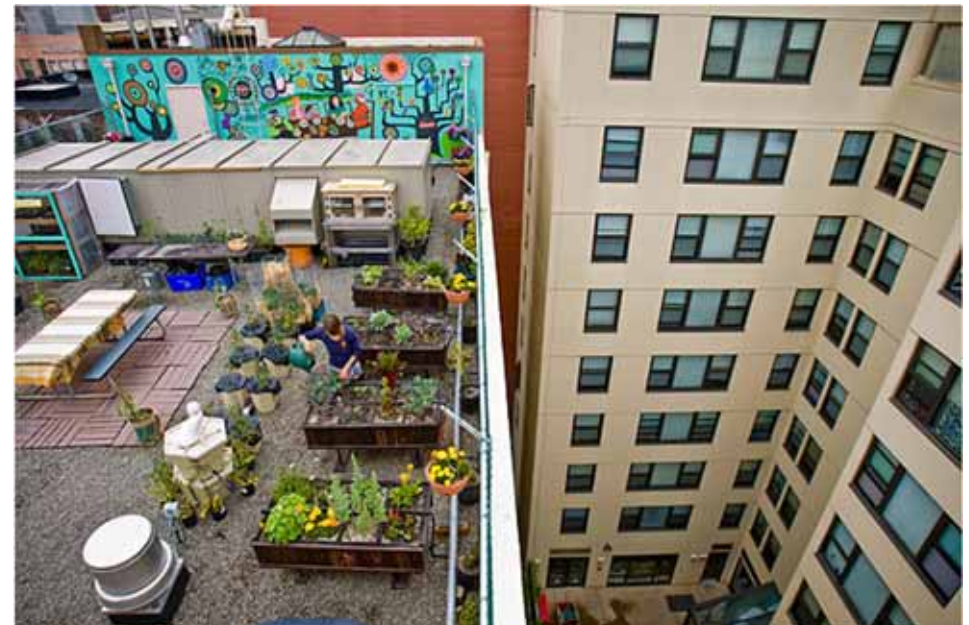
Bangkok, Thailand (fruits, rice) 泰國曼谷(水果, 米)



Tokyo, Japan (greenhouse) 日本東京(溫室)



London, UK (with bee keeping) 英國倫敦(含養蜂)



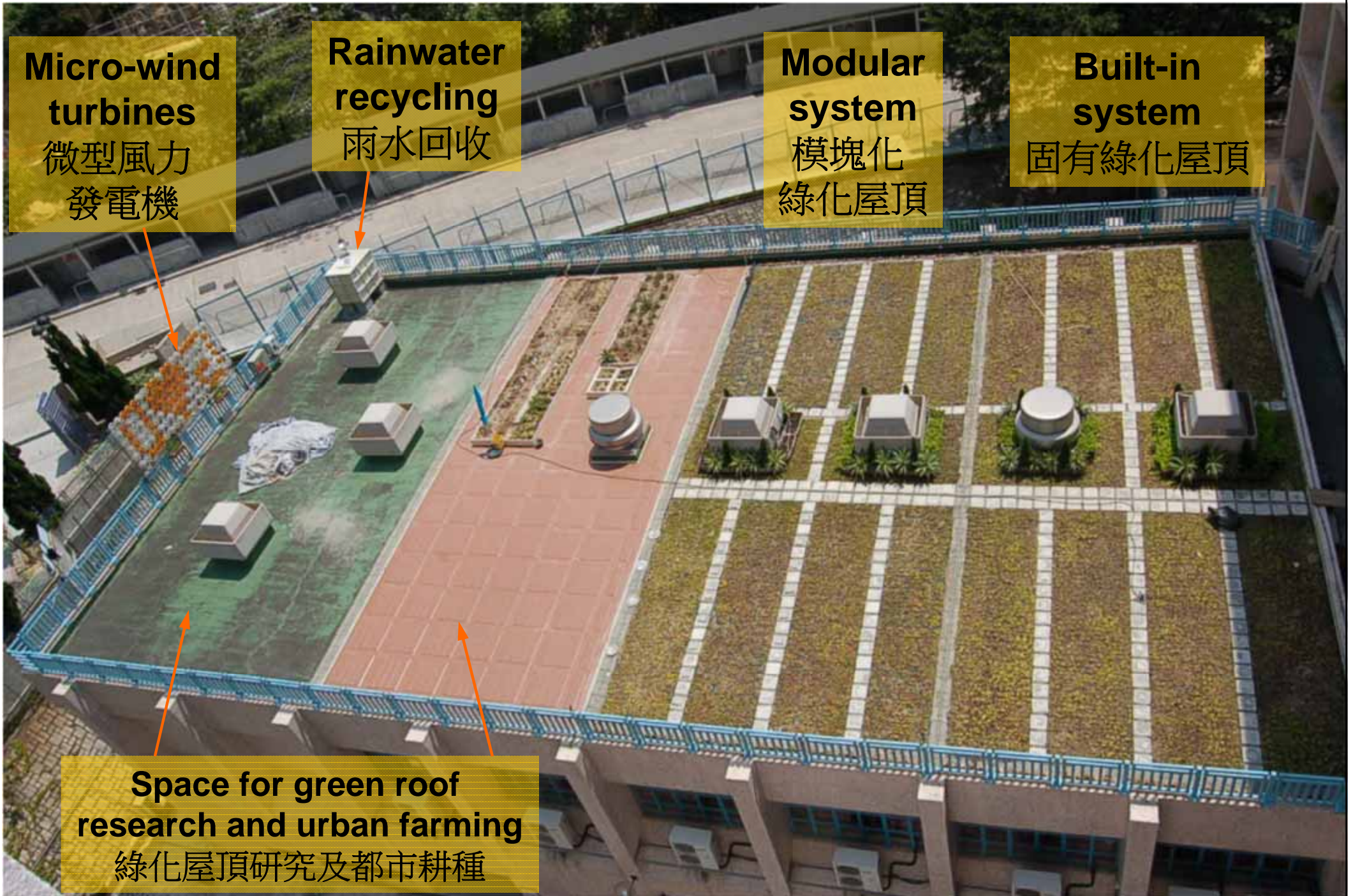
San Francisco, USA (kitchen) 美國舊金山(廚房)

Table 1. SWOT analysis of rooftop urban farming in Hong Kong

表 1：香港屋頂都市耕種的 SWOT 分析

Strengths 優勢	<ul style="list-style-type: none">- 新鮮的食物，安全和降低運輸成本- 提供許多對環境及社會的福利- 更好地利用屋頂空間（可以有許多功能）
Weaknesses 弱點	<ul style="list-style-type: none">- 缺乏屋頂農業的空間- 農業被視為日漸衰落行業- 都市農業缺乏研究與發展
Opportunities 機會	<ul style="list-style-type: none">- 對有機及安全的食品需求不斷增長- 可以發揮社區及休閒農業的優點- 需要管理和康復不少舊式樓宇
Threats 威脅	<ul style="list-style-type: none">- 缺乏相關信息和機會- 缺乏都市農業相關的研究數據- 颱風襲擊及空氣污染

Green roof research with integrated systems 綠色屋頂的綜合系統研究



Urban farming on green roofs

綠化屋頂都市農耕



Farming on the roof
農業上的屋頂



Vegetables and herbal plants
蔬菜和草本植物



Water melon 西瓜



Green beans 青豆

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

Edible vertical garden 可食用垂直花園



Soil-less green roof farming (purple potato) 無土屋頂綠化種植紫薯

[An elderly home in HK 香港的一間安老院]



(Photos taken by Dr Sam C M Hui)

Conclusions 結論



- Rooftop farming for sustainable and livable city 屋頂城市農業來達到可持續宜居城市
- Hong Kong has good potential for green roof urban farming 香港有很好的潛力，可以促進屋頂城市農業
- Need to consider technical issues & local conditions 要考慮技術問題和當地的條件
- Target is sustainable rooftop farming 目標是可持續屋頂耕種

THANK YOU 謝謝!!



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