The 7th International Energy Agency Annex 44 Forum -
Integrating Environmentally Responsive Elements in Buildings

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Green Roofs As An Environmentally Responsive Element in Buildings

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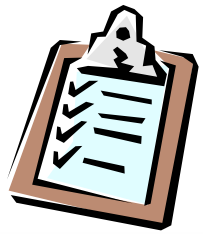


- What is Green Roof?
- Potential Benefits
- Our Research Studies
- Applications in Hong Kong

What is Green Roof?

- Green roofs
  - Living vegetation installed on the roofs
  - Could help mitigate urban heat island and enhance building thermal & environmental performance
  - Also known as eco-, vegetated and nature roofs
- Three major types
  - Extensive green roofs
  - Semi-intensive green roofs
  - Intensive green roofs

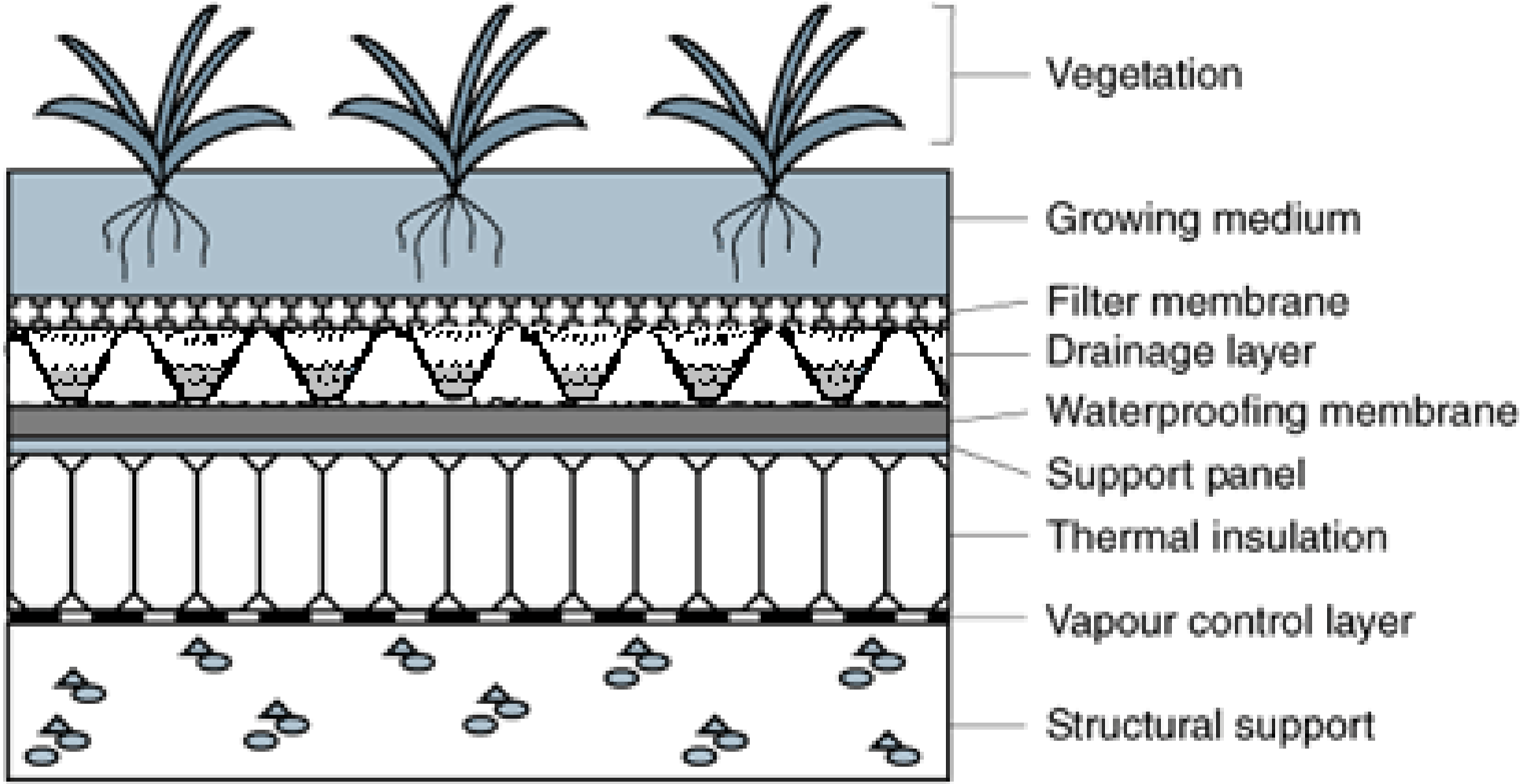
Extensive green roof
(Putrajaya International Convention Centre, Malaysia)

Intensive green roof
(Millenium Park, Chicago, USA)

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

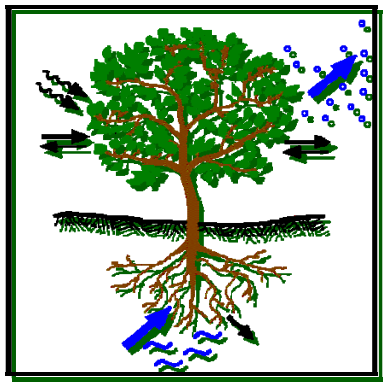


Green roof systems from Germany (left) and Japan (right)

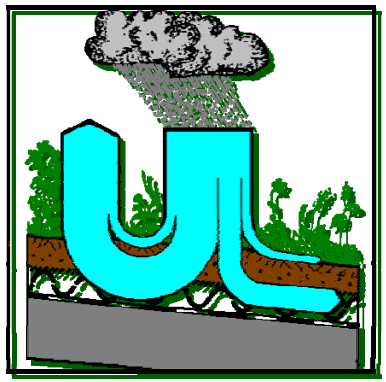
Potential Benefits

- Major aspects
  - Visual and aesthetic
  - Ecological
  - Local microclimate and thermal
  - Amenity
- Benefits for the community (public)
- Benefits for building owners & users (private)

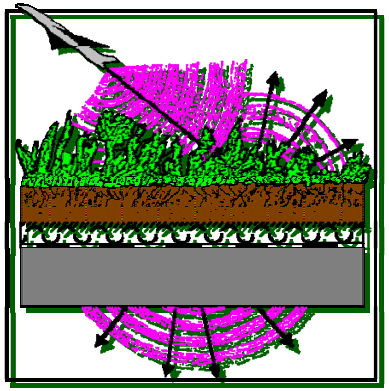
Environmental Benefits



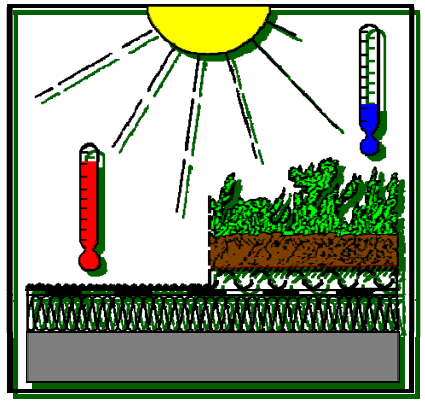
Oxygen Release



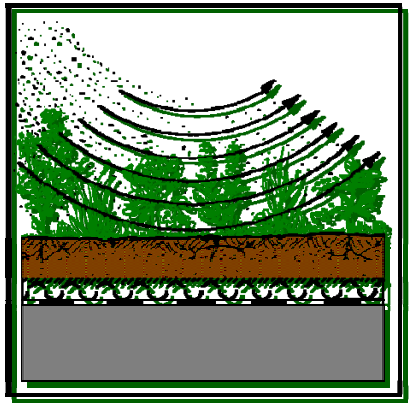
Water Retention



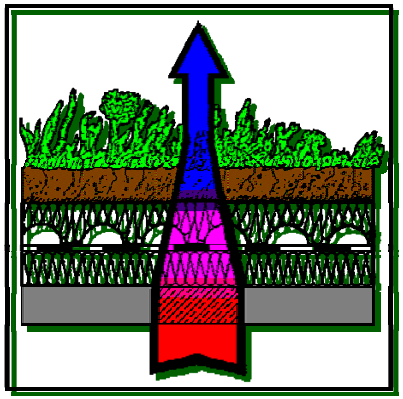
Noise Reduction



Heat Reduction

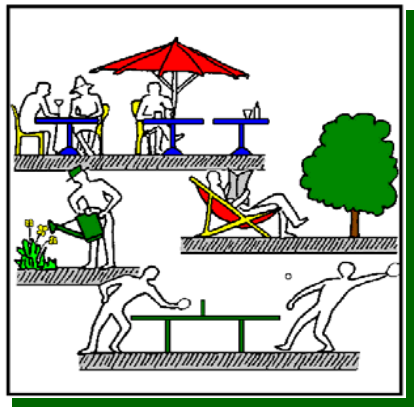


Dust Reduction



Save of Energy

Wildlife Attraction



Use of Space

[Source: Zinco (www.zinco.de)]

Our Research Studies

- Multi-disciplinary approach
  - Engineering
  - Architecture
  - Construction
- Current research topics
  - Energy and environmental performance
  - Modular green roof systems
  - Thermal modelling (green roofs & living walls)
  - Life cycle assessment

Green roof research at a construction site office (2002-2006)

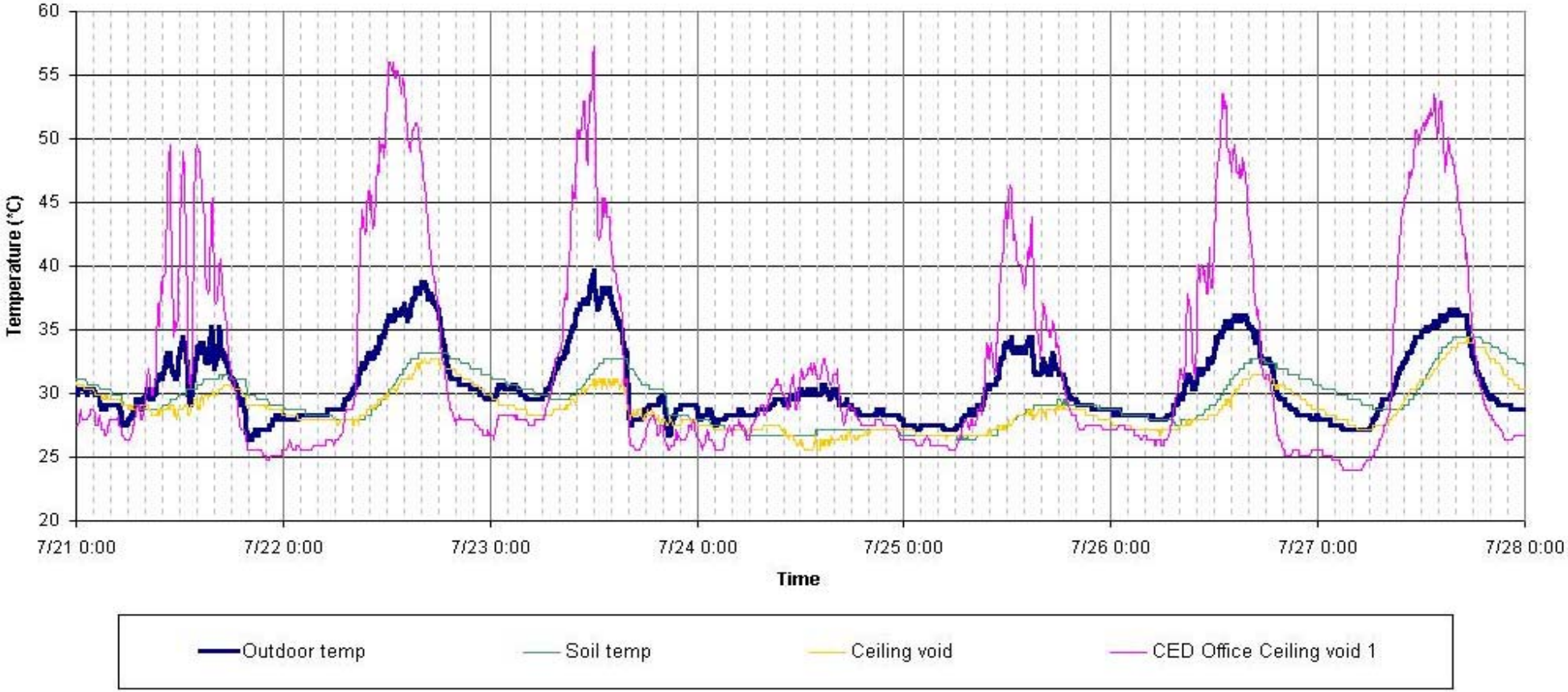
Green site office

Modular design

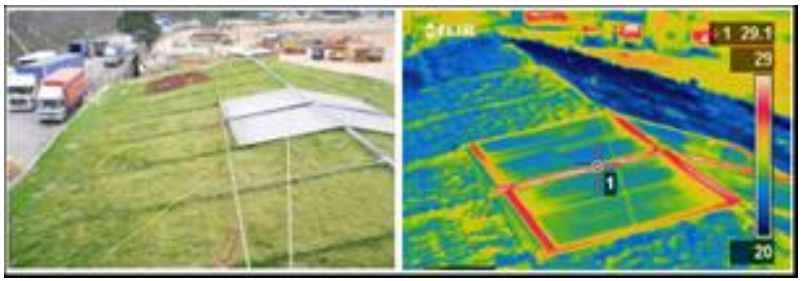
Green site office and typical site office

Water sprinkler

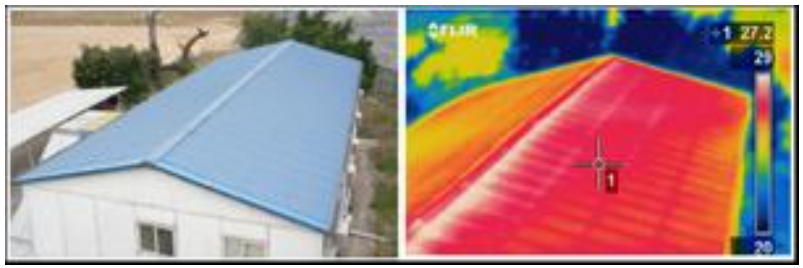
Green roof research at a construction site office (cont'd)



Infrared pictures:



Green roof



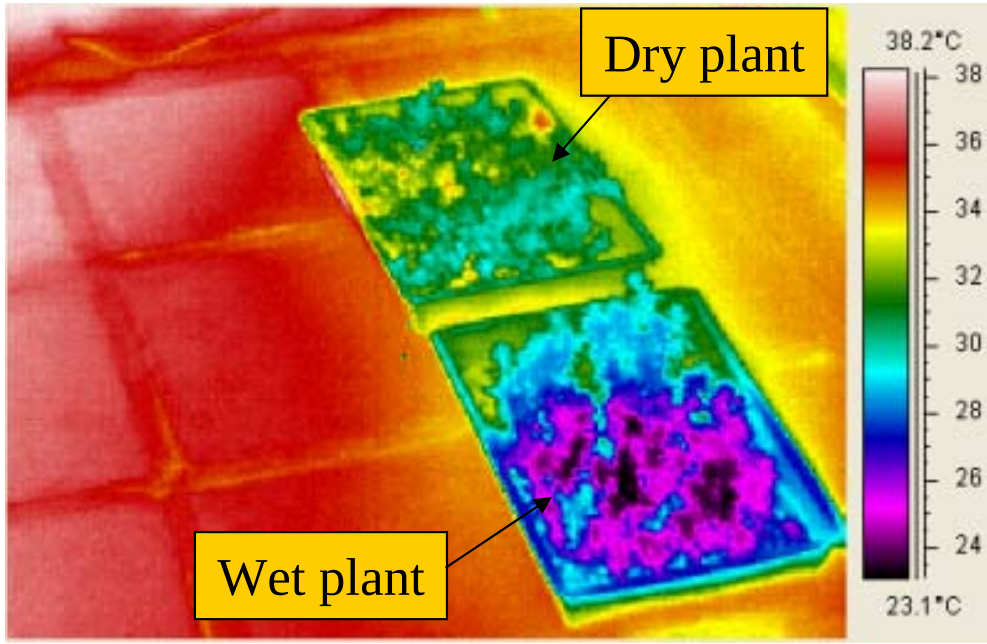
Conventional roof

Study of modular green roof systems (on-going)

Aluminum trays

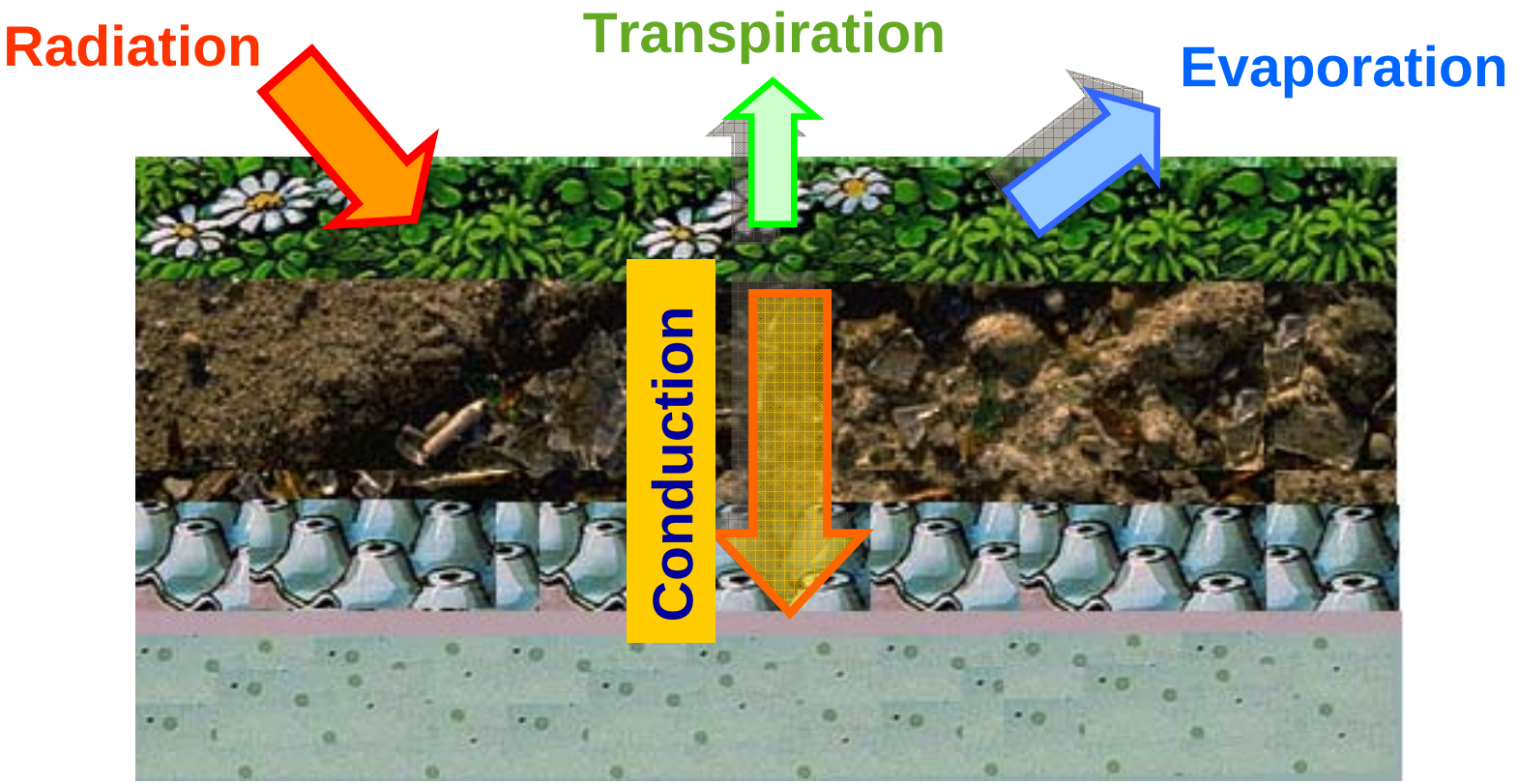
Wooden boxes

Plastic trays



Plastic trays (infrared photo)

Thermal modelling of green roofs

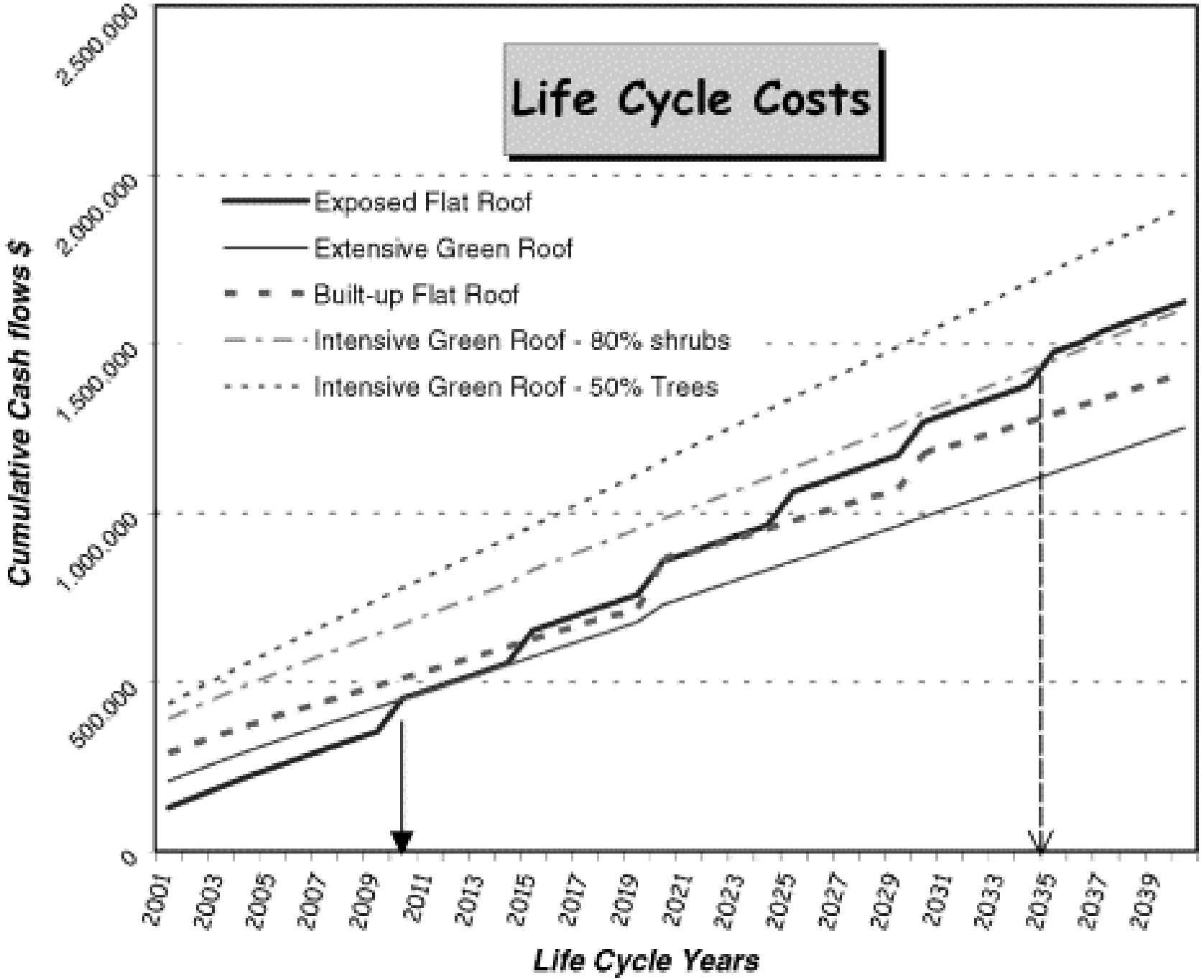


Radiation: $R_n = R \exp(-k_s LAI)$

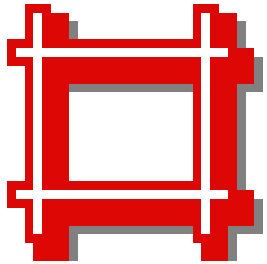
Evapo-transpiration: $q'' = -2LAI \dfrac{\rho C_p}{\gamma(r_e + r_i)} \left(\dfrac{w\Re T}{h_m}\right)$

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

Life cycle cost analysis of green roofs



Applications in Hong Kong



- Hong Kong situation
  - Driving forces:
    - Government, building designers & green groups
  - Major barriers:
    - High-density & high-rise buildings (limited roof areas)
    - Limitations in existing buildings (a design challenge)
    - Economic factors (hard to measure the benefits)
- Our R&D strategy
  - Technical knowledge
  - Demonstration & pilot projects
  - Education & training (local people & stakeholders)

Examples of green roofs in Hong Kong

HK Wetland Park

Tai Lung Veterinary Laboratory

A school in San Po Kong

EMSD New Headquarters

Research & development of green roofs for a primary school

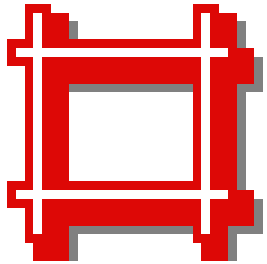
Pilot study:
Roof of a function room
Roof area = 58 sq.m
Soil depth = 150 mm

Studies on thermal performance & sedum

Proposed project:
Roof of an assembly hall
Roof area = 530 sq.m
Soil depth = to be determined

Studies on modular system & life cycle performance

Applications in Hong Kong



- Issues to consider when applying green roofs:
  - Position and orientation of the roof
  - Height of the roof above ground
  - Roof pitch (flat or slopped)
  - Weight limitation of the roof
  - Preferred planting
  - Levels of maintenance (usually low is better)
  - Possibility of rainwater recycling
  - Sustainability of components (recycled materials)

Green roofs as an environmentally responsive element in our minds.

Thank You

謝 謝！