Lunch Lecture

The Green Building Envelope

Dr.ir. M. Ottelé

Room 6.05

Contact: m.ottele@tudelft.nl

TU Delft

Introduction - Profile

Scientific field
"Integrated Sustainability of the Building Envelope"

Which explores the link and interaction between "Environmental footprint" and "Durability" on material- and construction level with respect to the Built Environment.

"The interaction between building materials and the living natural environment (biology) is key in my current research-, education- and management activities"

Who am I?

Marc Ottelé, Sustainability Group
Section Materials & Environment
Department 3MD
Faculty Civil Engineering and Geosciences
m.ottele@tudelft.nl

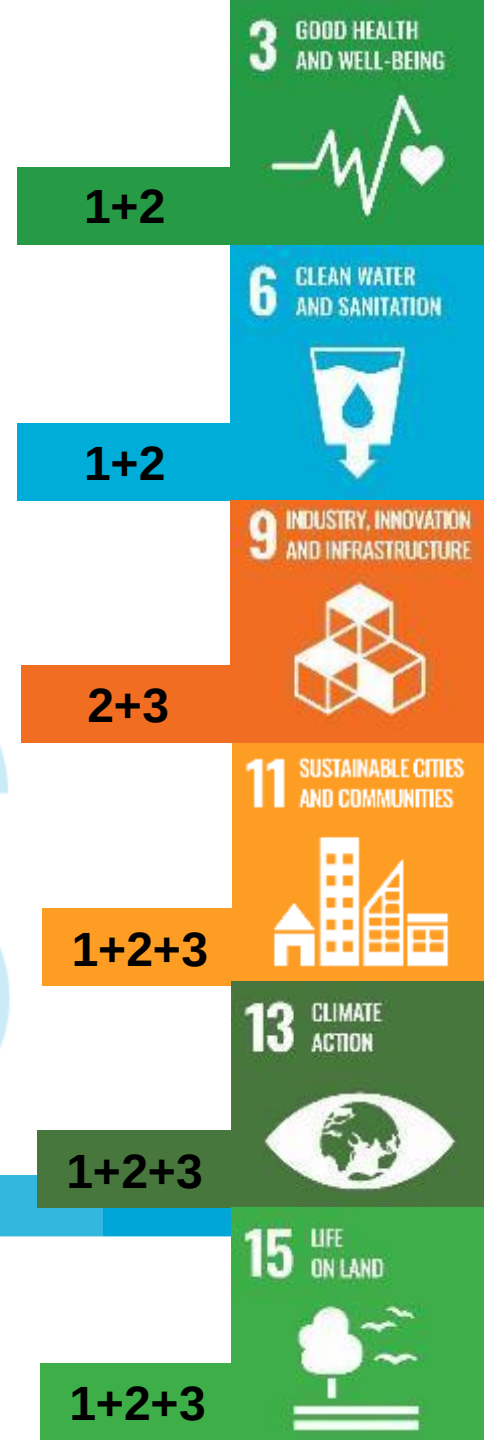
Research

My research will centre on the following key areas:

1. **Quantification of Performance Characteristics**: This includes the development of the "**Green Building Envelope strategy**" and the investigation of vertical vegetated façade systems' impact on the indoor and outdoor environment.

2. **Development of Bio-Receptive and Hybrid Materials**: I will work on developing bio-receptive and hybrid cementitious materials, like moss-receptive concrete elements to promote sustainability and ecosystem functions next to "other" green technologies within the **"Green Building Envelope"** concept.

3. **Exploration of Low Environmental impact and Circular Materials**: This involves the exploration of low environmental impact and circular (cementitious) materials in conjunction with execution technology to reduce reliance on finite resources and to minimize the environmental impact.



Introduction

- You are able to understand the **relevance** of urban green in relation to **ecosystem functionalities** of vegetation; using the **Green Envelope** approach
- You are able to understand the basic characteristics of these green technologies
- After this session you are able to recognize different vertical green concepts

Cities and buildings

A forest without trees,……..

The present urban greening is a response which thrives to improve the urban biodiversity, air quality, temperatures and water retainment of urban cities. (Cruz & Beckett, 2015)

My mission is to create
Solutions for Resilient and livable cities

Reduction of heat stress

Clean air

Bio-adapted and biobased materials

Urban farming

No flooding; retention and controlled runoff

Green environment
Increased wellbeing

Noise reduction

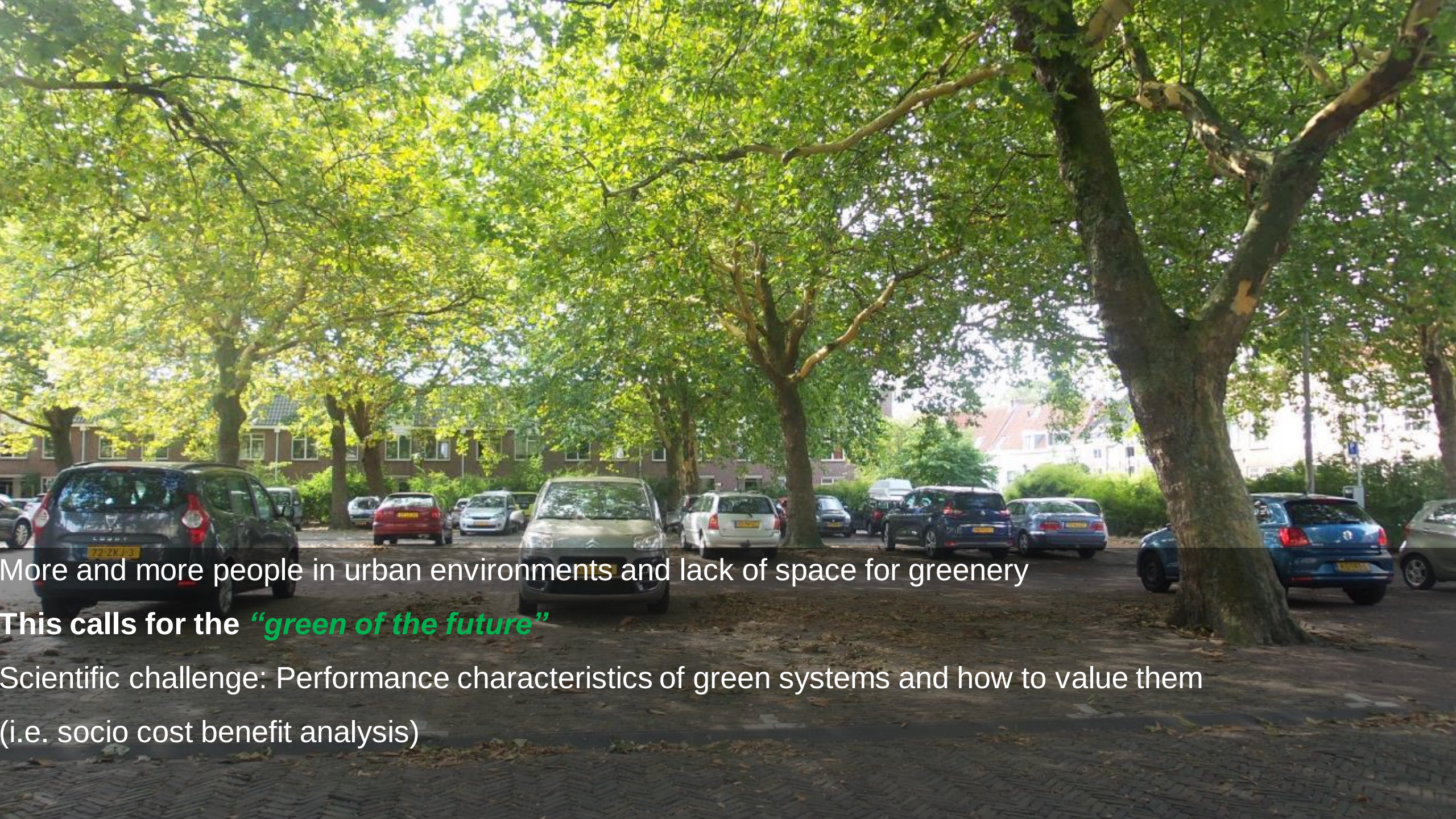
CO_2 uptake

High biodiversity

Low environmental impact

Circularity and reduction of primary resources

Climate resilient cities



More and more people in urban environments and lack of space for greenery

This calls for the *"green of the future"*

Scientific challenge: Performance characteristics of green systems and how to value them

(i.e. socio cost benefit analysis)

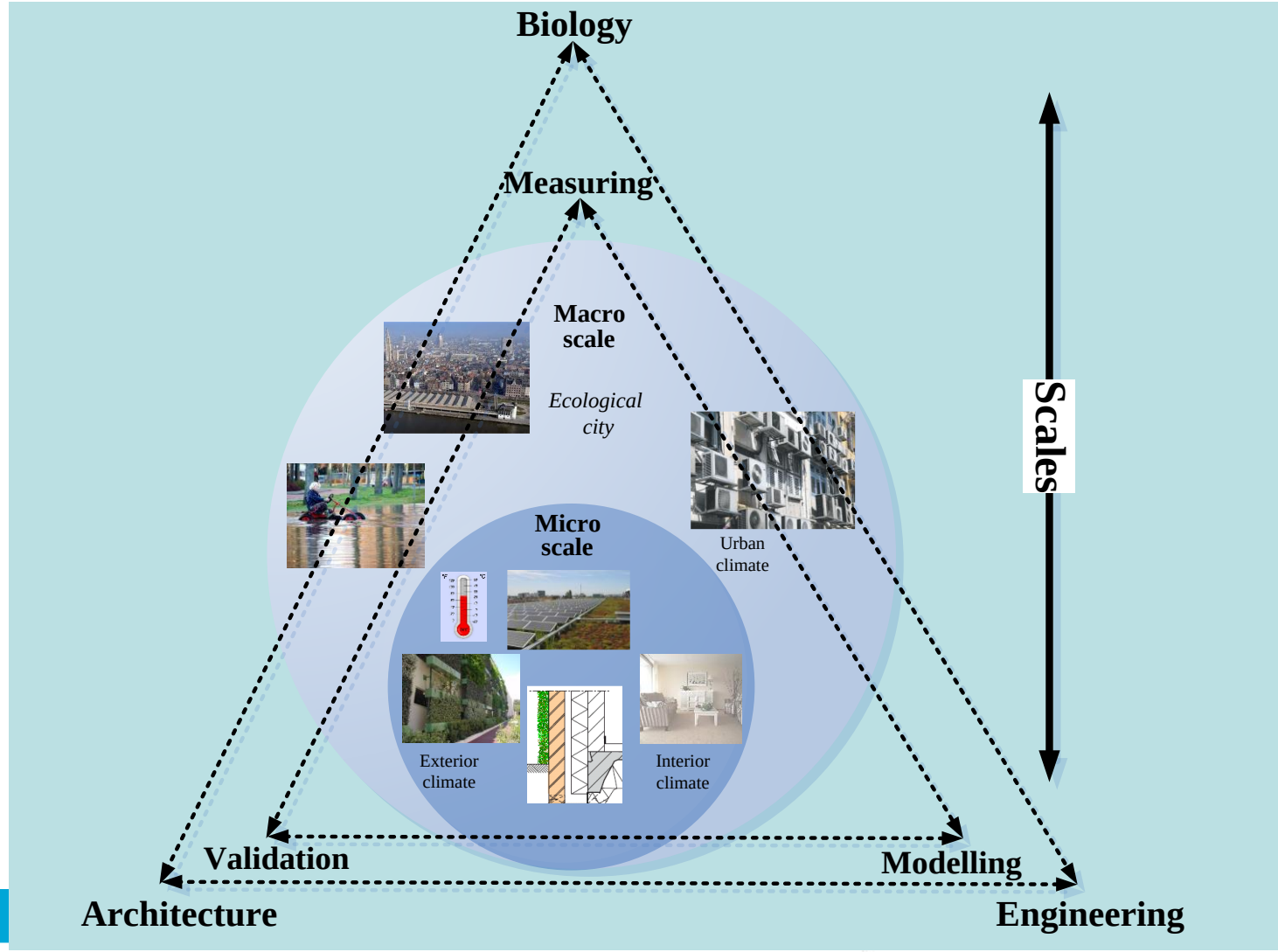
Green is multidisciplinary!

Aiming for :

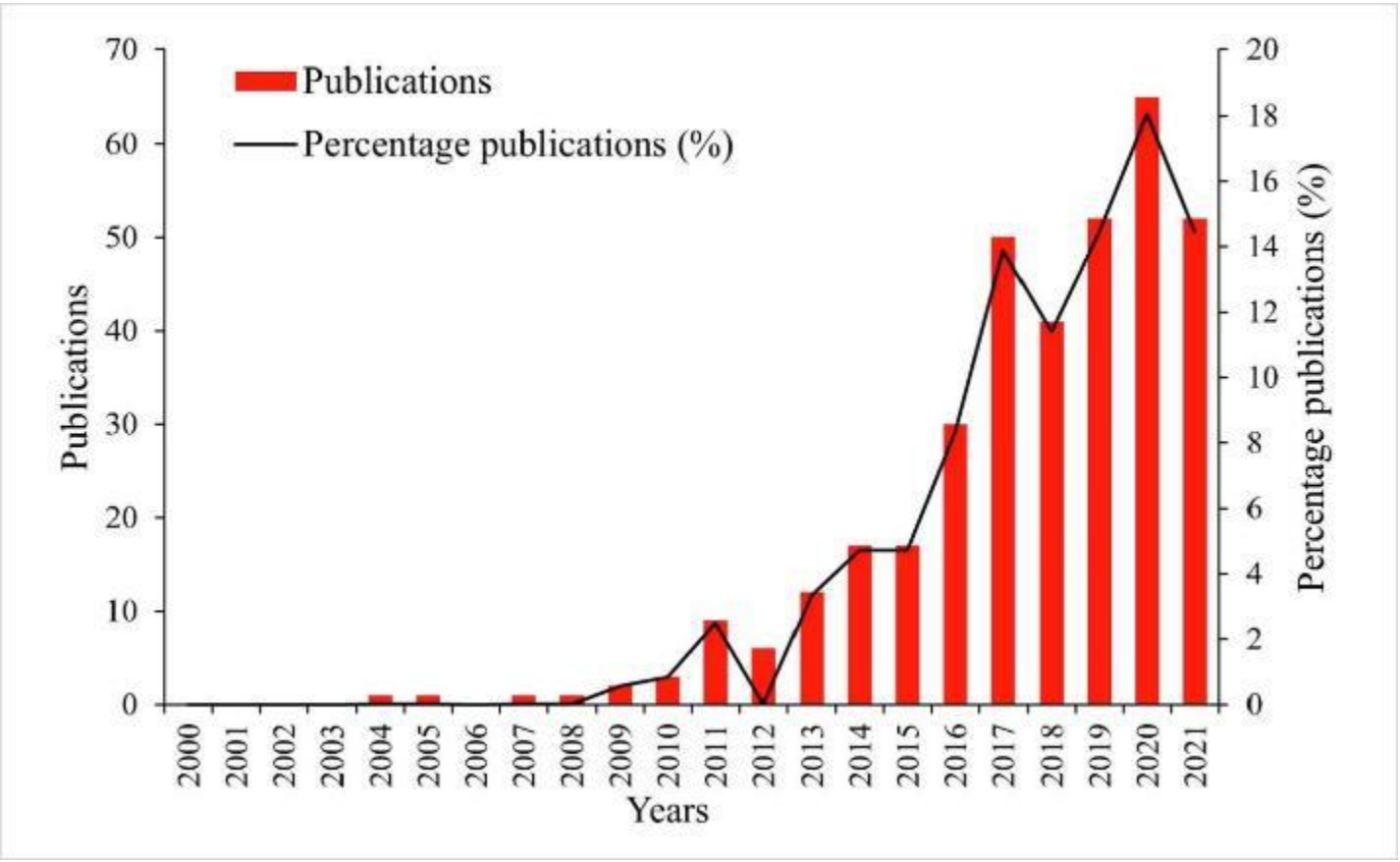
- City thermal improvement
- Building thermal improvement
- Health, wellbeing, quality of life and physiological benefits
- Resilience against climate change
- Construction systems improvement (i.e. materials, plants and design)

This means that some parameters are quantifiable while others are quantitative!

Social Cost Benefit Analysis
Physical models
empirical data collection
Field and laboratory measurements

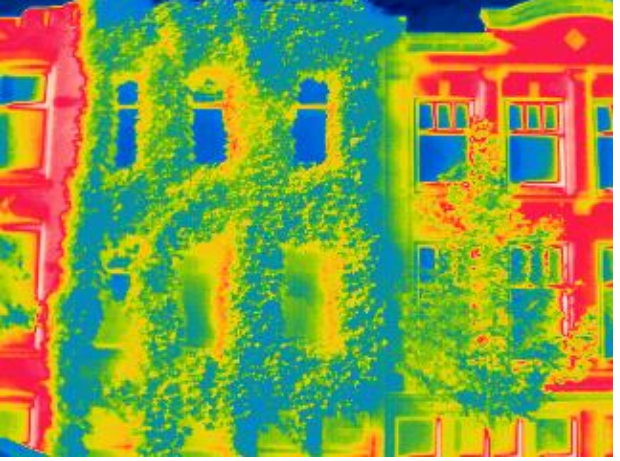


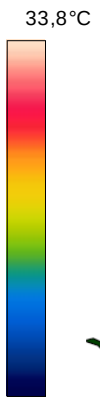
Scientific growing interest

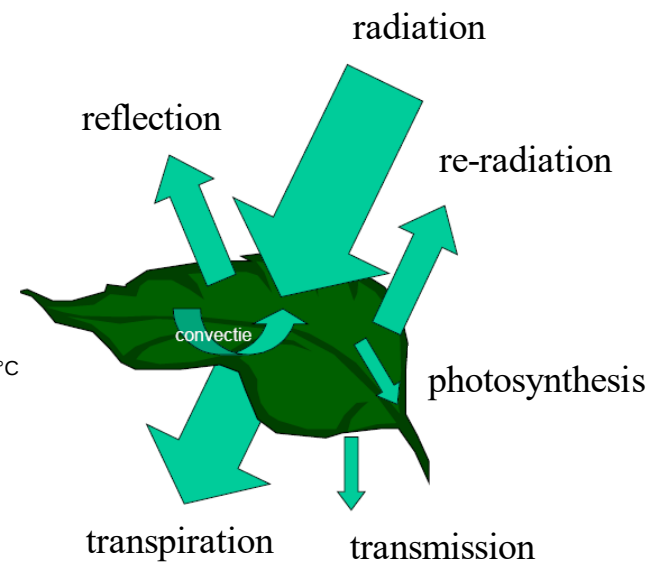


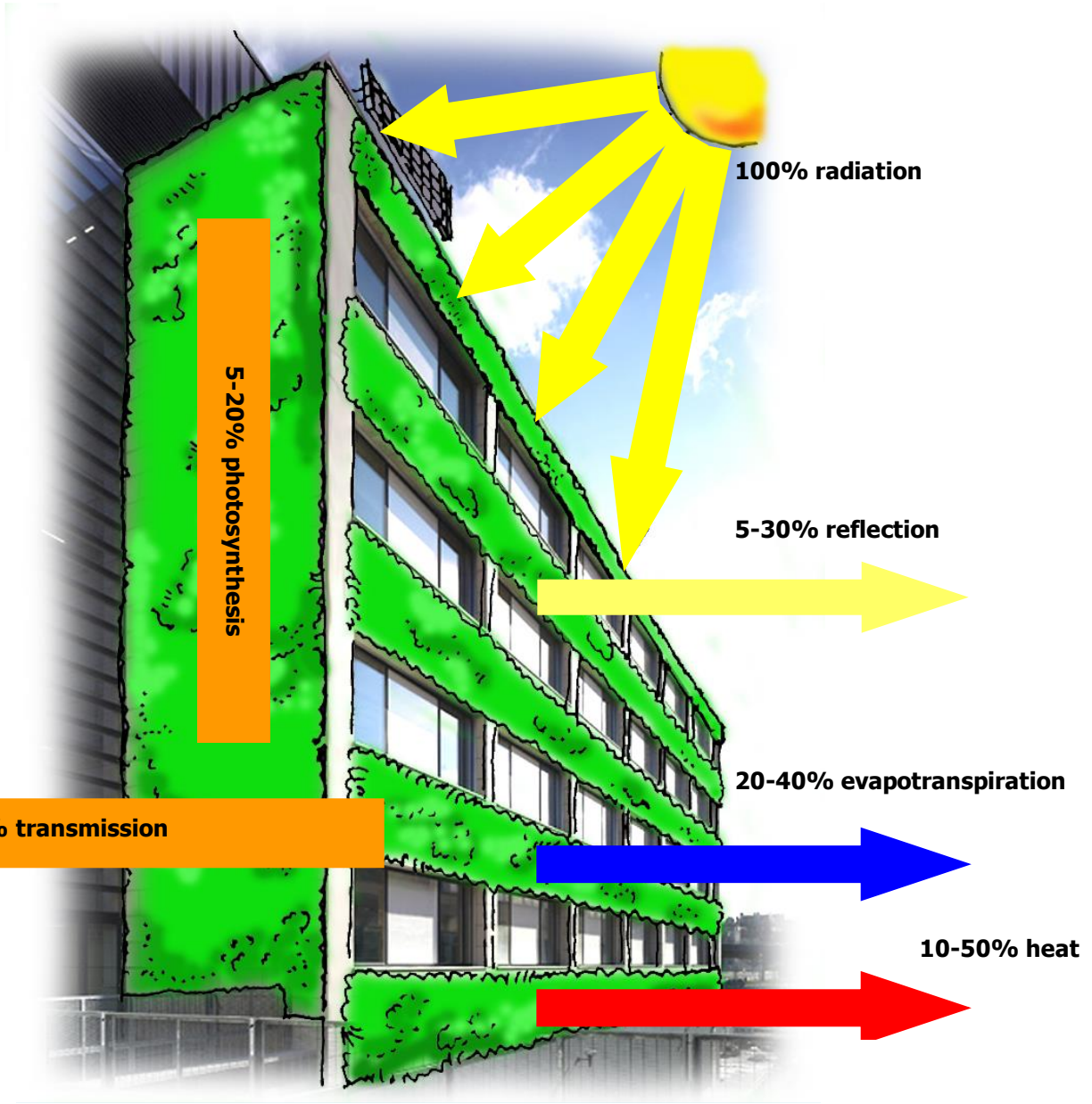
After Ashan et al, 2022

- Different topics; however, ecosystem services based
- Heat/drought/water
- Societal impact
- Human health & biodiversity
- Existing building stock i.e. retrofitting….







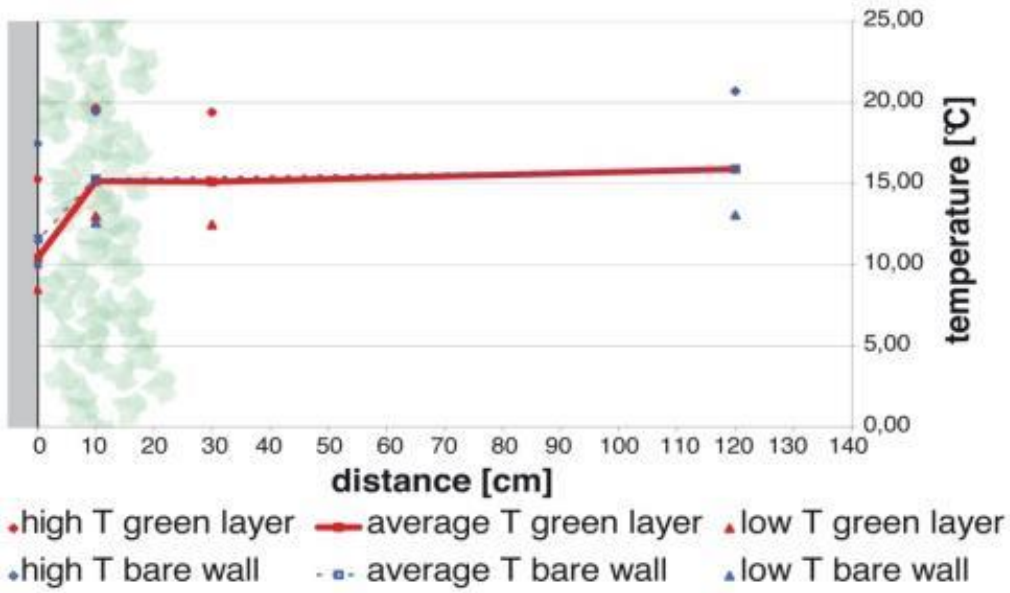


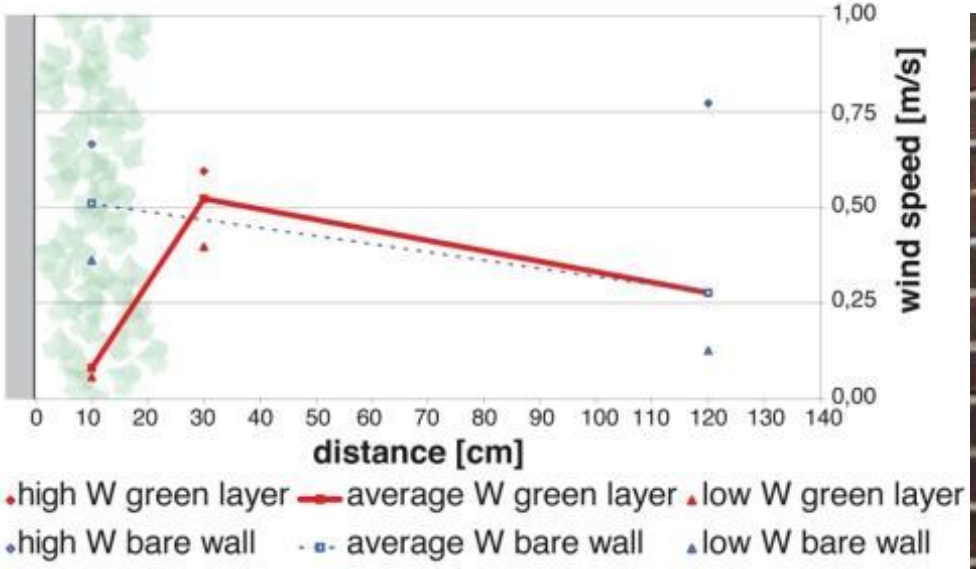
Potential energy savings up to 33.8% depending on the configuration compared to a bare reference system, no additional energy consumption has been observed for evergreen systems during warm periods (*Coma, et al 2018*)

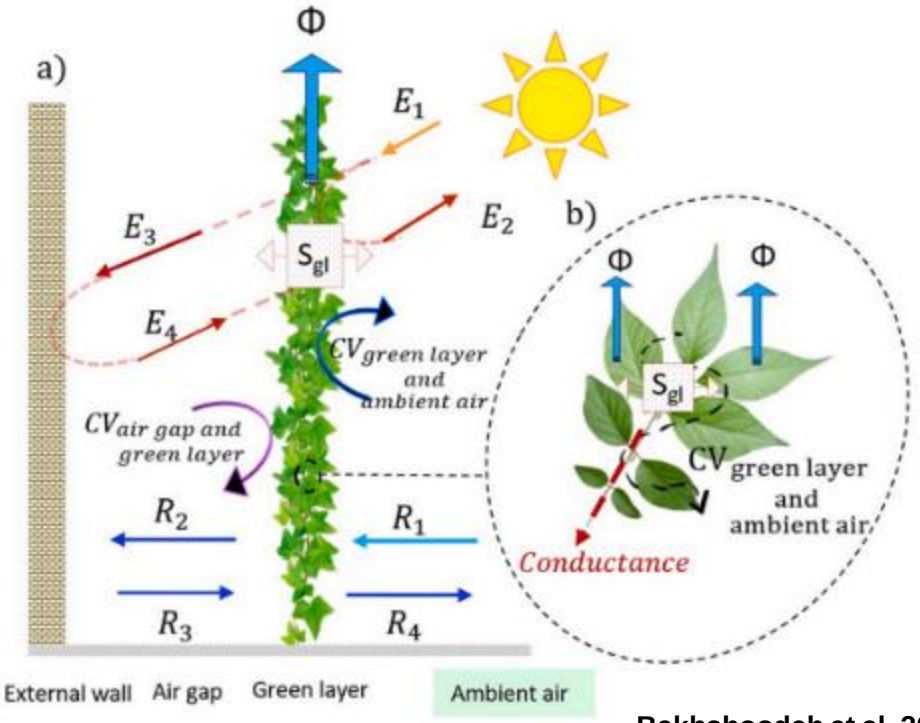
Surface temperature reduction ranging from **12-20 °C** on sunny day's (Mazzali et al., 2013)
Re-radiation is less compared to bare façade,
pedestrians feel less heat standing next green façade (Oke et al., 2017)

TU Delft
Delft University of Technology

Relation to building physics





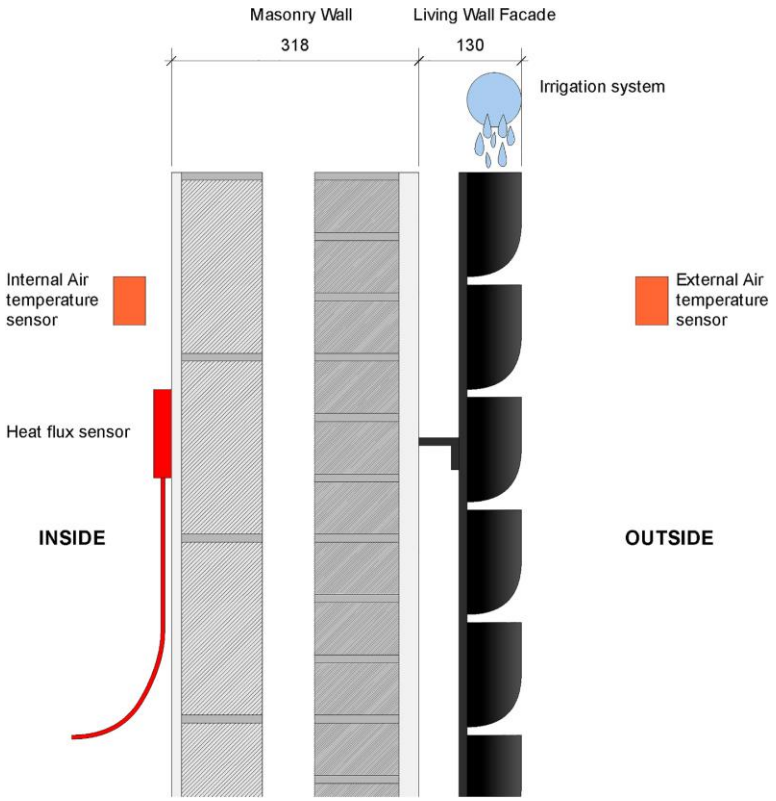


Bakhshoodeh et al. 2022

E1=receiving solar radiation
E2= reflected solar radiation by leaves
E3= transmitted shortwave radiation through vegetation
E4= portion of E3 which is reflected by exterior wall
R1= flux of longwave radiation from sky and ground
R2, R3, R4= emitted longwave radiation from vegetation and exterior wall
Φ= Transpiration from the green layer
CV= Convected heat between green layer, ambient air and air gap.

TU Delft
Delft University of Technology

Relation to building physics



(Fox et al, 2022)

Step by step we are gaining more knowledge about the impact of a green system. However still scattered research and very specific content ➔ how to follow a design strategy?

- U-value for cavity masonry wall **with** the living wall façade: 0.77 W/m^{2}K
- U-value for cavity masonry wall **without** the living wall façade: 1.12 W/m^{2}K
- U-value for this investigated LWS façade location, let to a **31.4% improvement** over the original as built state of the same wall.

Green Building Envelope

Water interaction

Filtration of greywater

Retainment of rainwater

Plant type and species

1. Driving phenomena = Latent heat

Latent heat refers to the heat **energy absorbed** or released during a **phase change** of a substance without a change in temperature.

Evapotranspiration

a) **Evaporation** occurs from surfaces such as soil, lakes, rivers, and oceans when they are exposed to solar radiation

b) **Transpiration** is the process by which water vapor is released from the stomata (small pores) on the leaves of plants.

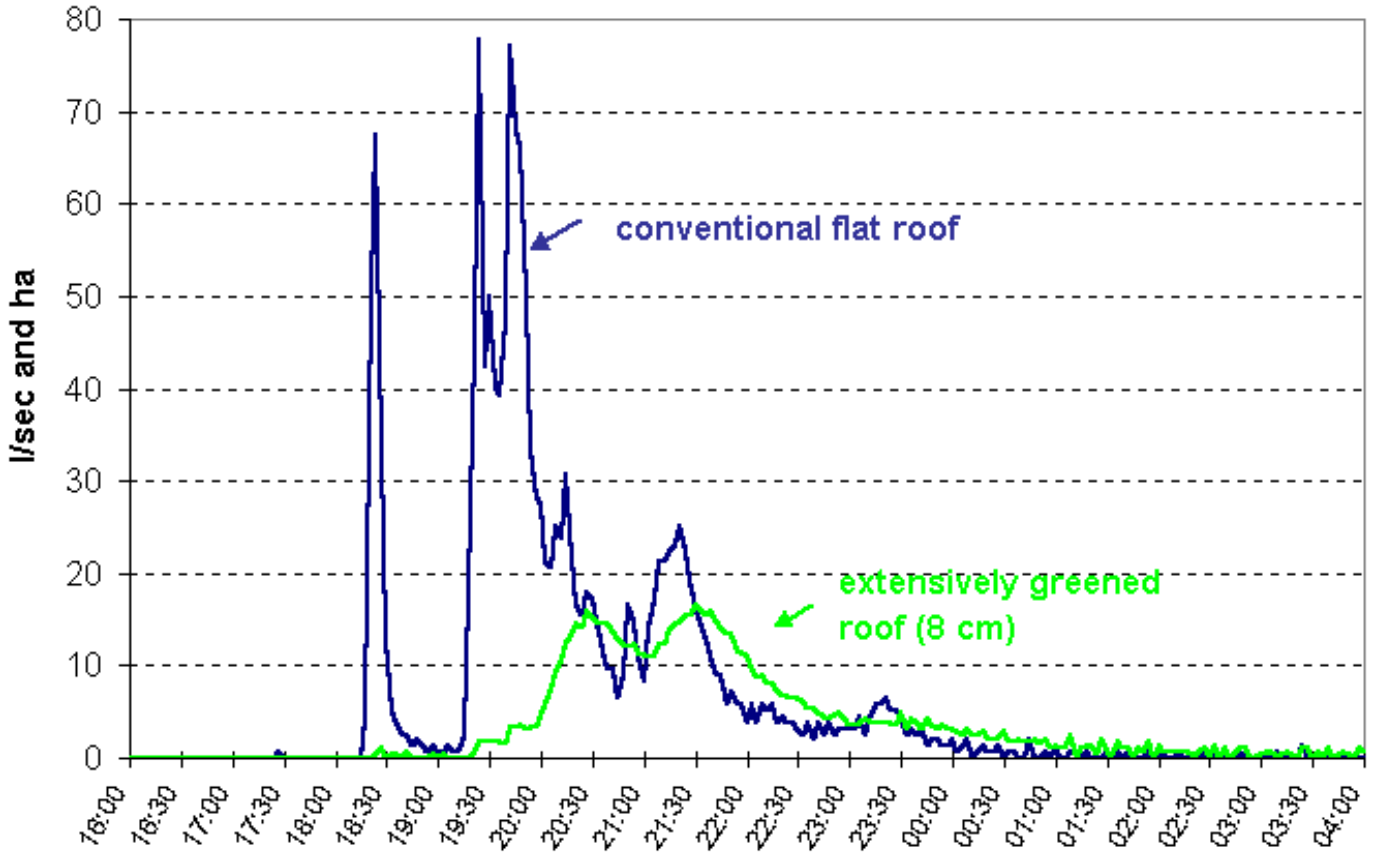
2. Surface Temperature Reduction:

The **shading effect** of vegetation reduce the surface temperature of buildings.

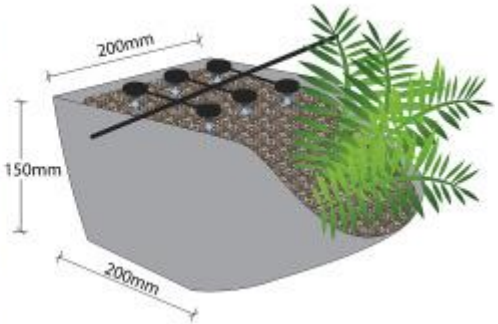
TU Delft

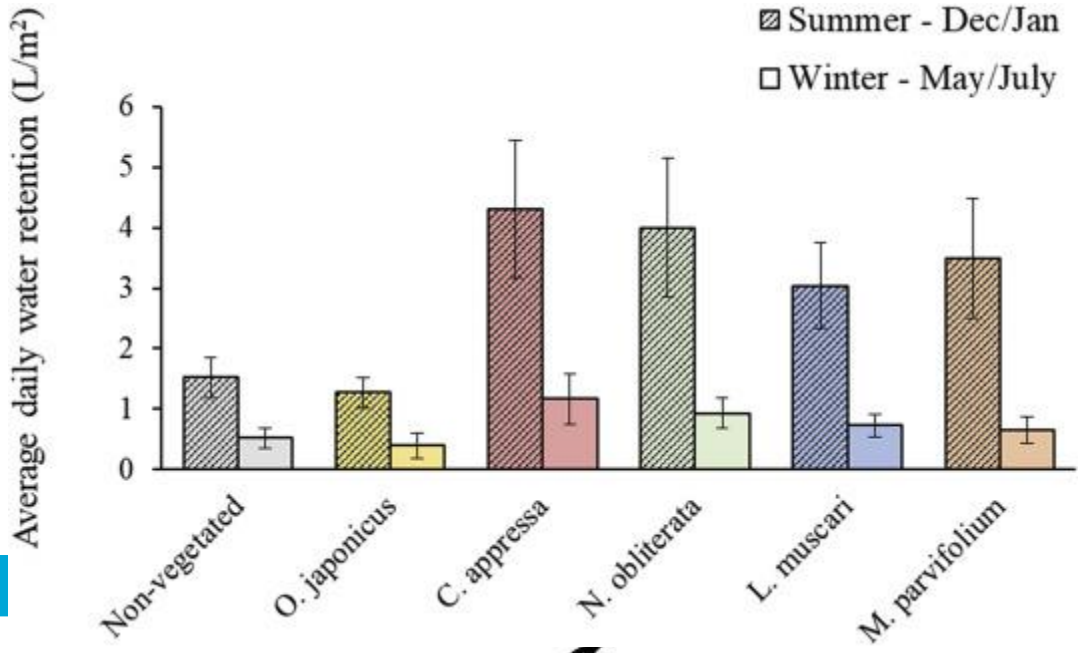
Delft University of Technology

Green Building Envelope



Berlin/Ufa: rainfall and retention (M. Schmidt,TU)





V. Prodanovic et al, 2019

Faculty of Civil Engineering and Geosciences
2024 Delft, The Netherlands

TU Delft
Delft University of Technology

Examples

Green infrastructure in cities

1. Grass/lawn and ground vegetation
2. Bioswales and infiltration possibilities
3. Trees in the street
4. **Green roofs**
5. **Green façades**
6. **Nature inclusive design**

Green Building Envelope

Source:
Christos Barbalis

Green Building Envelope Strategy

Nowadays a lot of techniques to green our built environment:

Green in the urban environment at building level							
Vertical green					Horizontal green		
Nature inclusive design	Green façade (traditional)	Living Wall concepts*	Wall vegetation or hybrid materials	Façade garden	Extensive	Intensieve	Roofgarden
Fully incorporated vegetation (balconies, terrases, façade and roof	*Consists of self-adhesive climbing plants (suture discs or suture roots).*	*Consists of vegetable (prefab) panels equipped with an irrigation system*	*Consists of plants that root in/on walls and obtain in some cases their nutrients in them.*	*A façade garden is a garden against the façade, with mainly low-growing plants.*	*Consists of vegetation with grass, herbs, moss and/or sedum as vegetation*	*The vegetation consists of grass and low planting (shrubs/trees)*	*Accessible overgrown roof with trees and shrubs.*

**The so-called living wall systems (LWS) consist of integrated or prefab systems that are applied to a construction or auxiliary frame in which the plants can root in an (artificial) substrate. In addition, a nutrient watering system is necessary to ensure that the green façade continues to exist.*

Concepts of vertical greenery

1) Direct façade greenery (self climbing plants)

2) Indirect façade greenery (with supporting systems)

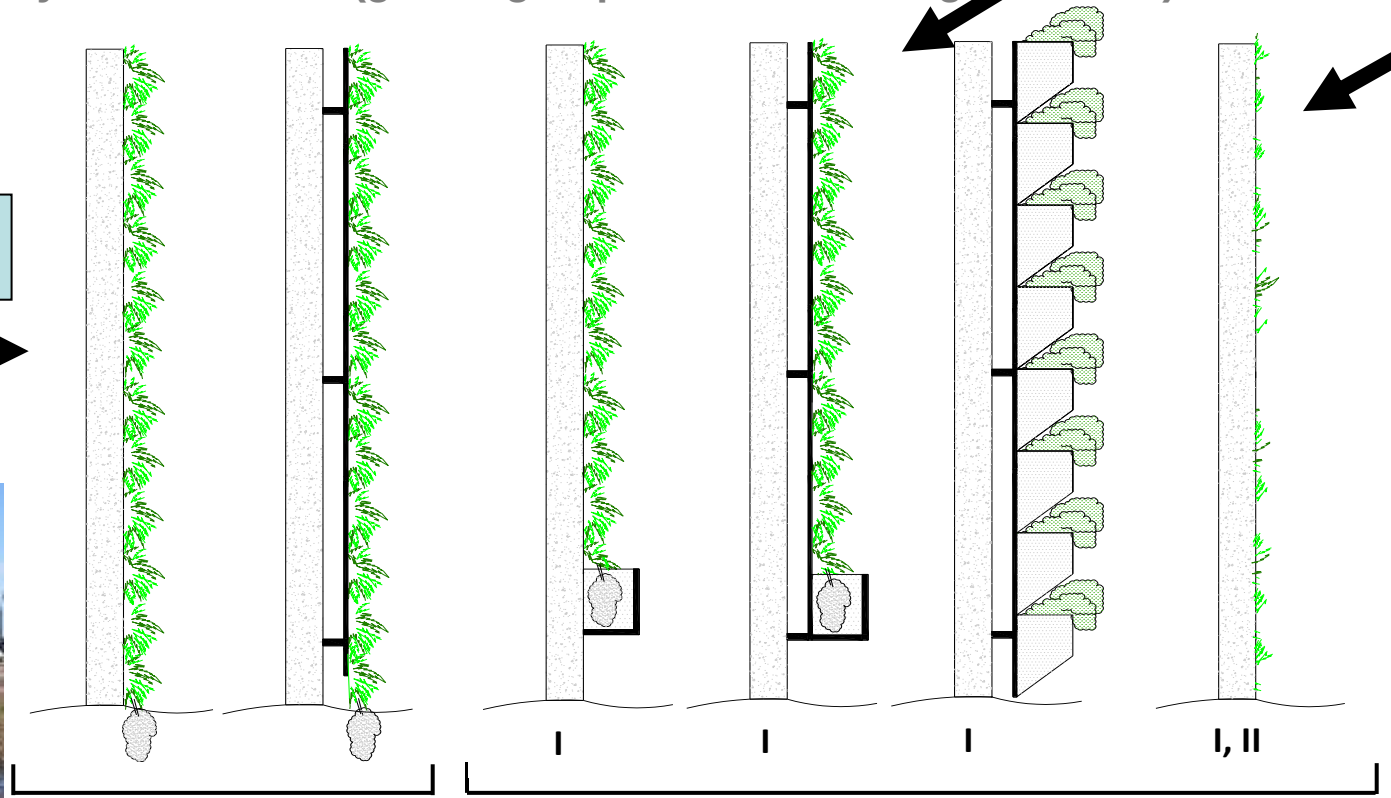
3) Living wall systems (LWS)

4) Bioreceptive and hybrid materials (growing of plants on building materials)

LWS based

Wall vegetation
Bioreceptive/hybrid

Green façades



**rooted into the ground;
(directly and indirectly)**

**in potting soil, artificial substrates; either rooted in material
(I = hydroponic) (II = self sustaining)**

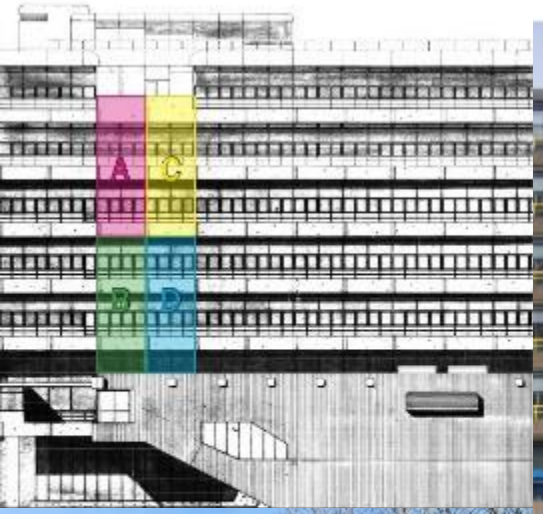




Heineken
ORIGINAL


ENTRANCE

Upcoming Research project



11. Jo van den Broek (rechts) en Jaap Bakema buigen zich over de maquette van het Hoofdgebouw en Stevin II en III van de faculteit Civiele Techniek. Het Hoofdgebouw, dat hier nog vier verdiepingen telt (zie afb. 10), is gezien vanuit het Zuidoosten, met op de voorgrond Stevin III, circa 1965 (HNI).

Living CEG Lab

Current and future societal challenges entail enhancing the climate resilience of the **existing building stock in urban areas**. This proposal **highlights the potential positive impact of vegetation** in the transformation journey towards a livable, sustainable, and energy-efficient Built Environment, employing a **Performance Indicator Approach for different green systems**.

TU Delft

Delft University of Technolog

Wrap up

- Ecosystem functionalities are missing or are insufficient in dense urban areas
- In particular vegetation contributes to a more pleasant and healthier environment (shadow, albedo, reflection, evapotranspiration,...)
- Vegetation is multifunctional, it brings shadow, is able to purify air, is able to lower the temperature, is able to decrease energy demand, is……. However not fully researched yet.
- However there are many studies, but still not everything is quantified in detail which makes it still difficult for decision makers!
- We see a (new) movement in Architecture and Civil Engineering how to deal with climate change in urban areas.

Thank you for the attention
Questions?

Dr.ir. Marc Ottelé

m.ottele@tudelft.nl

TU Delft