



# Green-blue Infrastructures in cities

Lectures for future  
Wien, 21. Okt. 2019

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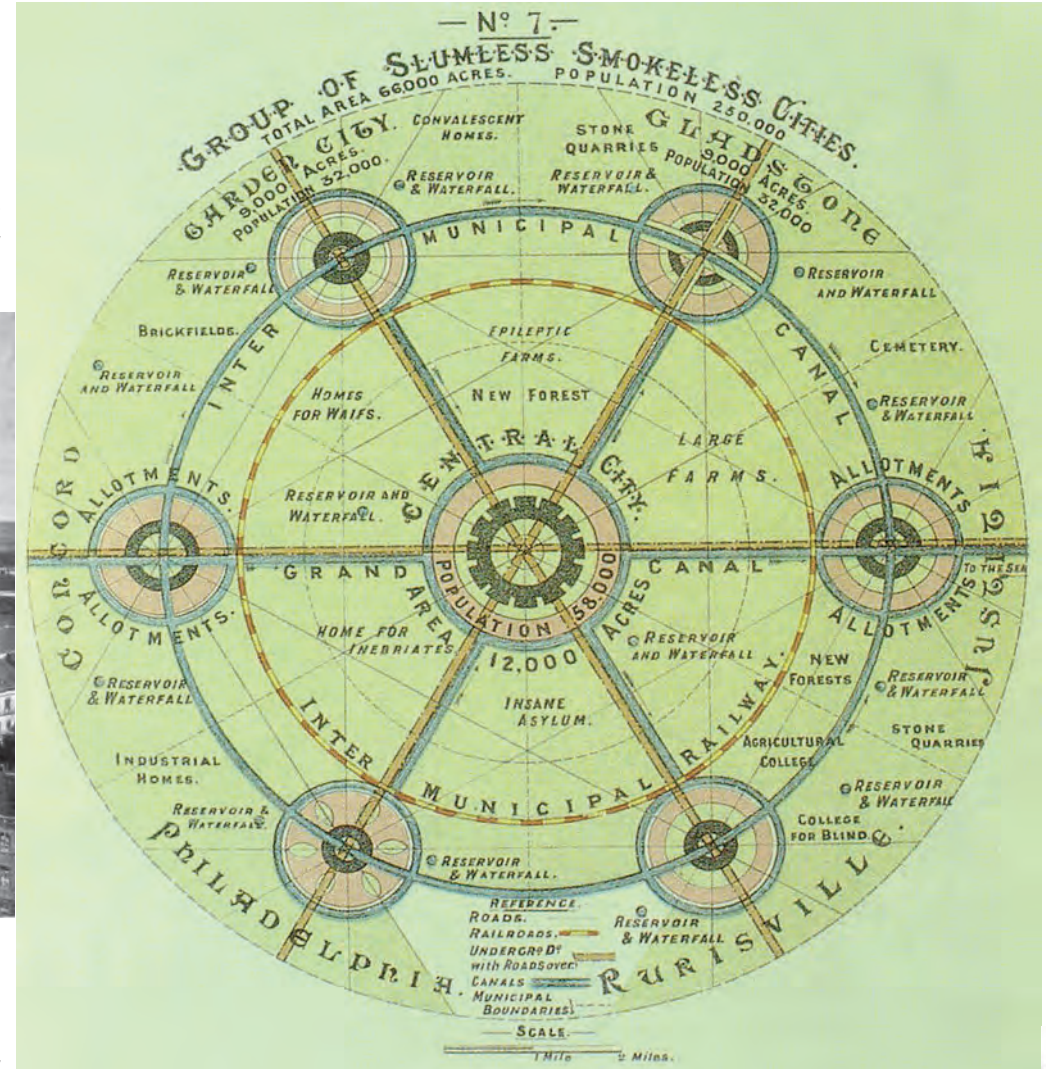
Img. 1: Rendering of London with green roofs  
(Source: Greater London Authority, 2008)



about 1898  
Industry  
--> Air pollution



Img. 3: Brewery in Praha (about 1900)



Img. 2: Ebenezer Howard  
Concept of a Garden City





## Green Belts

Areas around Cities that must held free of buildings to provide clean air and recreation

## „Emerald Necklace“

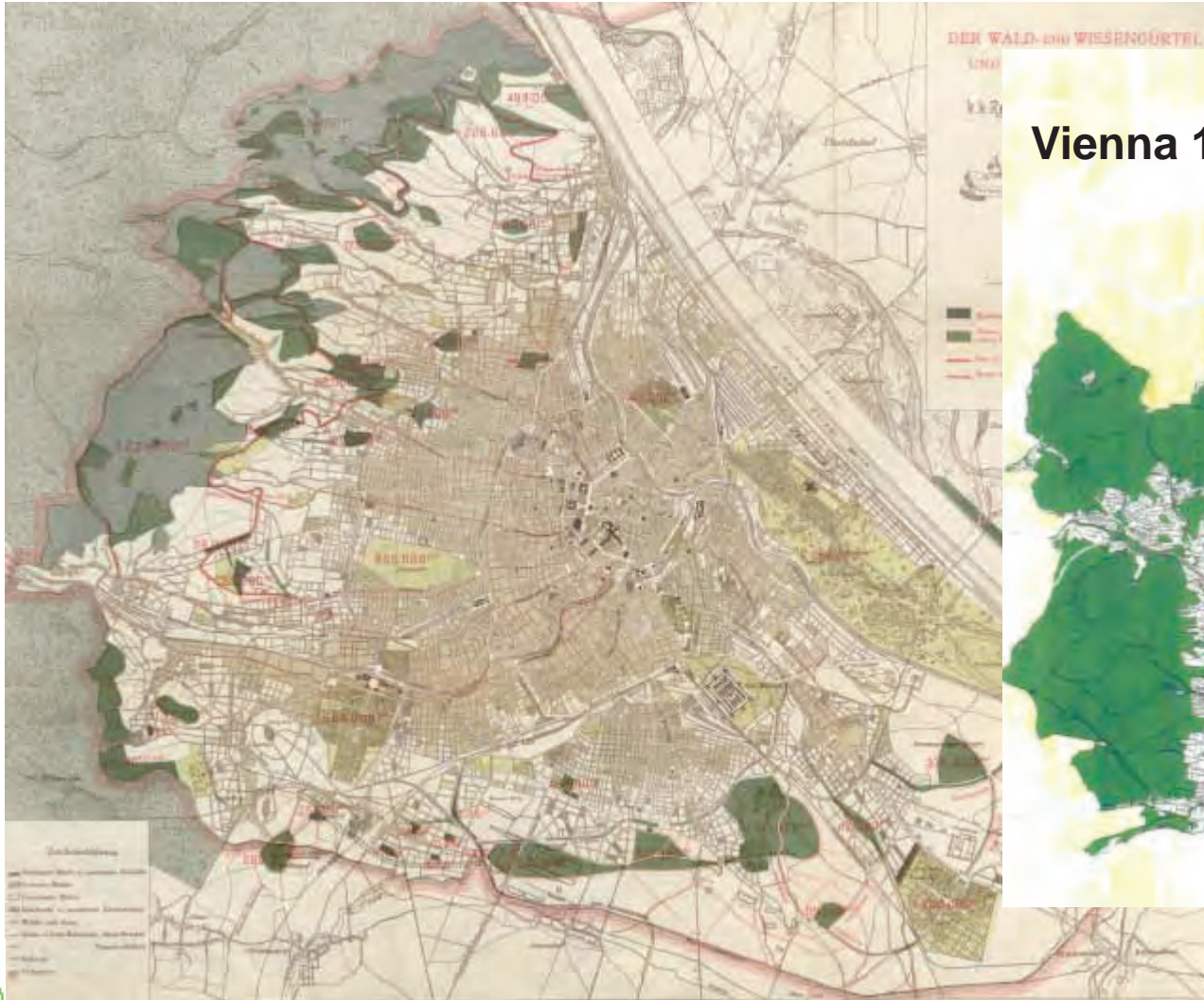
### Wien 1905

### Wald und Wiesengürtel

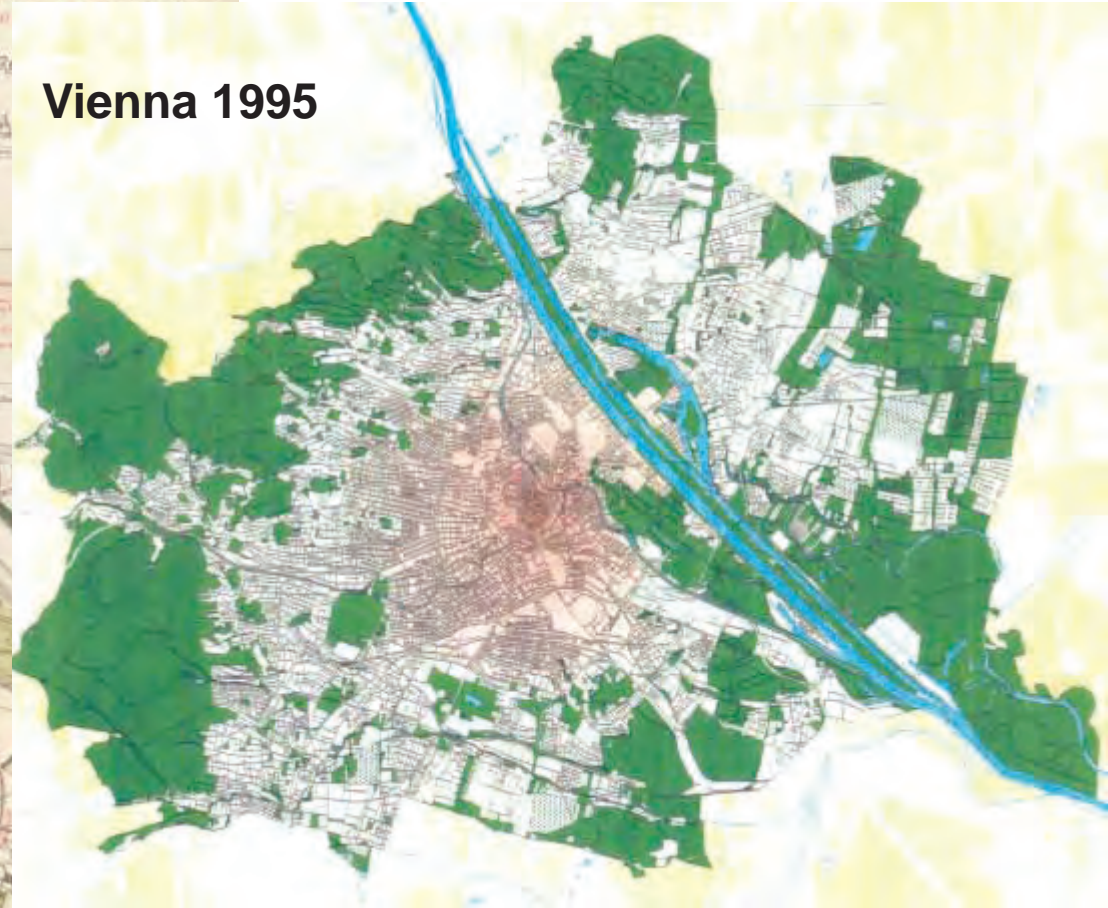
Img. 4: Green Belt Vienna 1905  
<https://www.wien.gv.at/stadtentwicklung/projekte/landschaft-freiraum/landschaft/gruenraum/entwicklung/gruenguertel/1905.html>







## Vienna 1995



Img. 5: Green Belt Vienna 1995  
<https://www.wien.gv.at/stadtentwicklung/projekte/landschaft-freiraum/landschaft/gruenraum/>





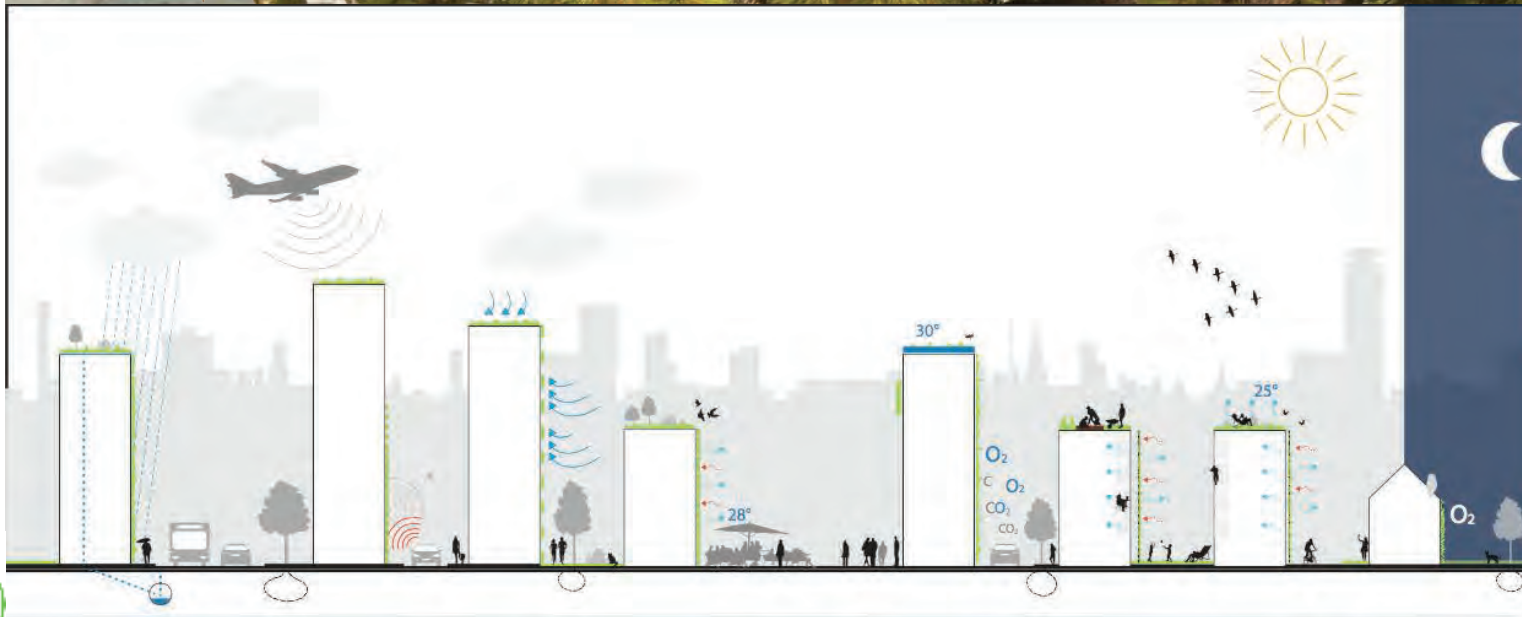


What are the benefits of green infrastructure?  
What can plants do for cities?





# What are the benefits of green infrastructure? What can plants do for cities?



provide  
O<sub>2</sub>  
Shadow  
habitats for animals  
space for humans to be

reduce  
noise  
CO<sub>2</sub>  
wind  
heat

filter fine particles  
hold rainwater back

Img. 7: Pfoer 2012 in: Pfoer 2013





# Blue Infrastructure

Space to collect and hold water

**Open rivers and streams  
no „hard“ channels**



Img. 8: Leipzig

Img. 9: Wienfluss at Spittelau







## Parks

from very big scaled  
to the small one around the corner



Img. 10: Vienna, Türkenschanzpark

Img. 11: Central Park New York  
source: [https://commons.wikimedia.org/wiki/File:Global\\_Citizen\\_Festiva'\\_Central\\_Park\\_New\\_York\\_City\\_from\\_NYonAir\\_\(15351915006\).jpg](https://commons.wikimedia.org/wiki/File:Global_Citizen_Festiva'_Central_Park_New_York_City_from_NYonAir_(15351915006).jpg)







# Urban Wilderness

just let nature grow



Img. 12: Urban wilderness just in front of my door

Img. 13: Urban wilderness just in front of my door







Img. 17: *Fraxinus excelsior* (ash tree)

# Trees

There is nothing better than a tree  
if there is enough **space**

Img. 14: -13 Trees at Kunsthaus Wien on the floor, the roof and out of the window

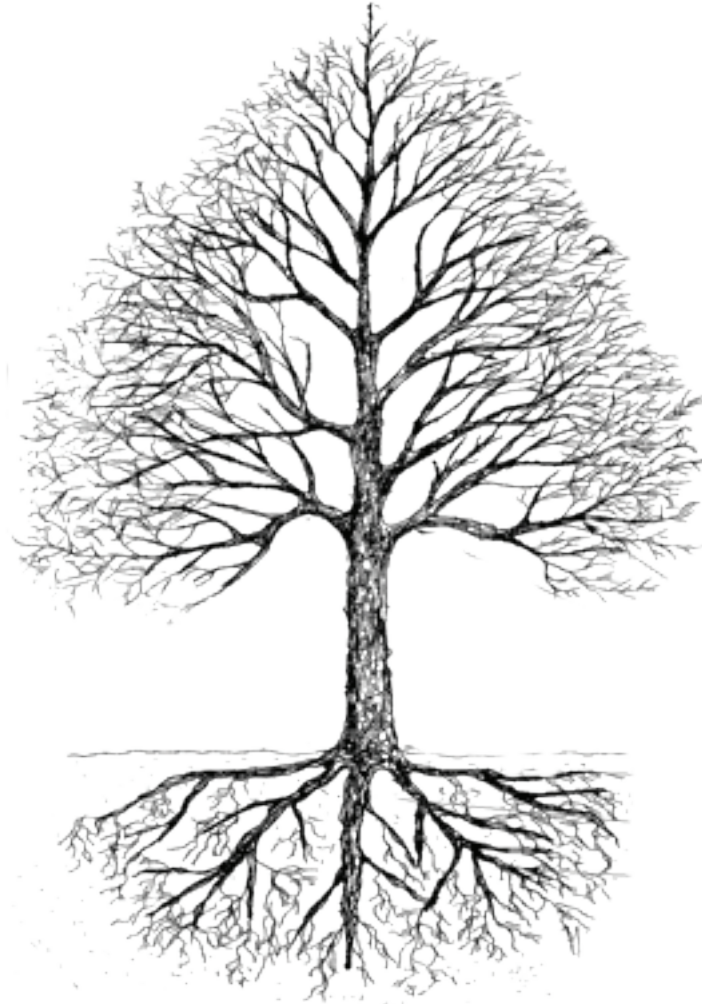


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Excursus:

## How to plant a tree:





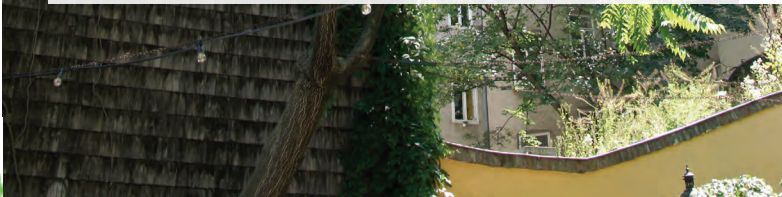


minimum of needed space:

| Crown form   | Volume of hole    | Area of tree pit  | Broadness |
|--------------|-------------------|-------------------|-----------|
| small crown  | 12 m <sup>3</sup> | 6 m <sup>2</sup>  | 2,5 m     |
| middle crown | 18 m <sup>3</sup> | 12 m <sup>2</sup> | 3,5 m     |
| big crown    | 24 m <sup>3</sup> | 16 m <sup>2</sup> | 4,5 m     |

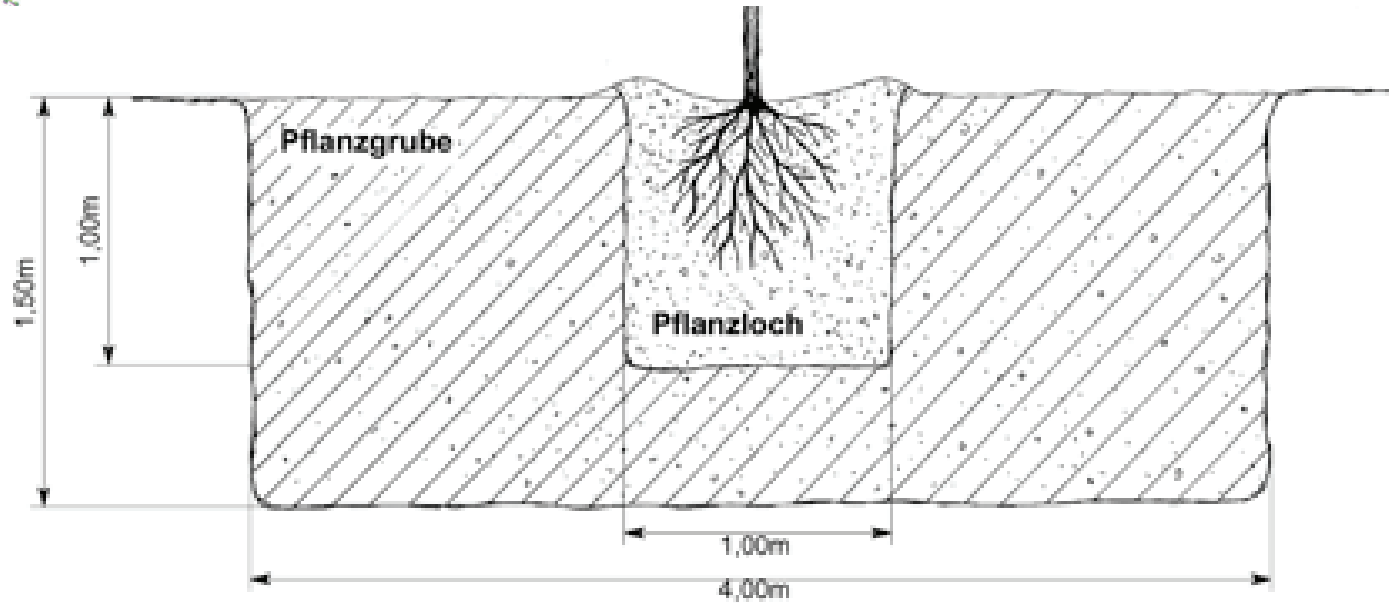
Img. 19: Sizes of Planthole, tree pit and broadness of stripe with trees along roads.

Source: Florineth, 2010, modified.



Excursus:

## How to plant a tree:







Trees in streets have to deal with a lot of stress because often root and crown has not enough space

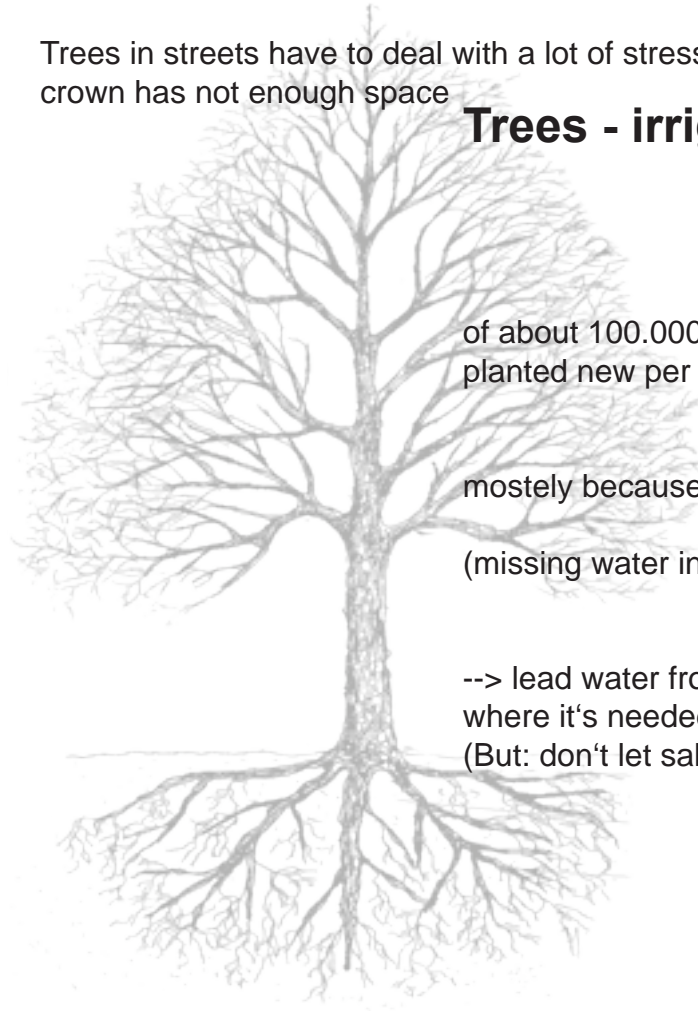
## Trees - irrigation

of about 100.000 Trees 1500 have to be planted new per year in Vienna (1,5%)

mostly because they **dry** out

(missing water in summer, salt in winter)

--> lead water from sealed surface to trees where it's needed  
(But: don't let salty water reach the tree in Winter?)



Img. 20: dead tree (source: Richard Gleim) <http://gnogongo.de/toter-baum-vor-der-mullverbrennungsanlage/>







# Raingardens

planted hole to let runoff rainwater trickle away in the ground.

Substrate needs to let water seep away quickly but also hold it to irrigate the plants when its not raining

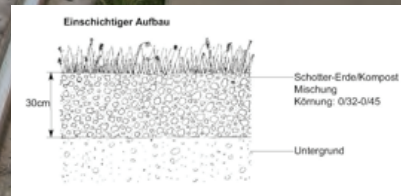


Img. 21: Raingarden in London

Img. 22: Rainwater tickeling in Vienna







## non sealed surface

to let rainwater tricle into the ground  
where it comes

for example:

### gravel turf

special grain size distribution mixed with compost  
for surfaves with low load stress (parking lots, ac-  
ces roads, rails)

### paving



Img. 24: paving

Img. 23: green rails in Stuttgart



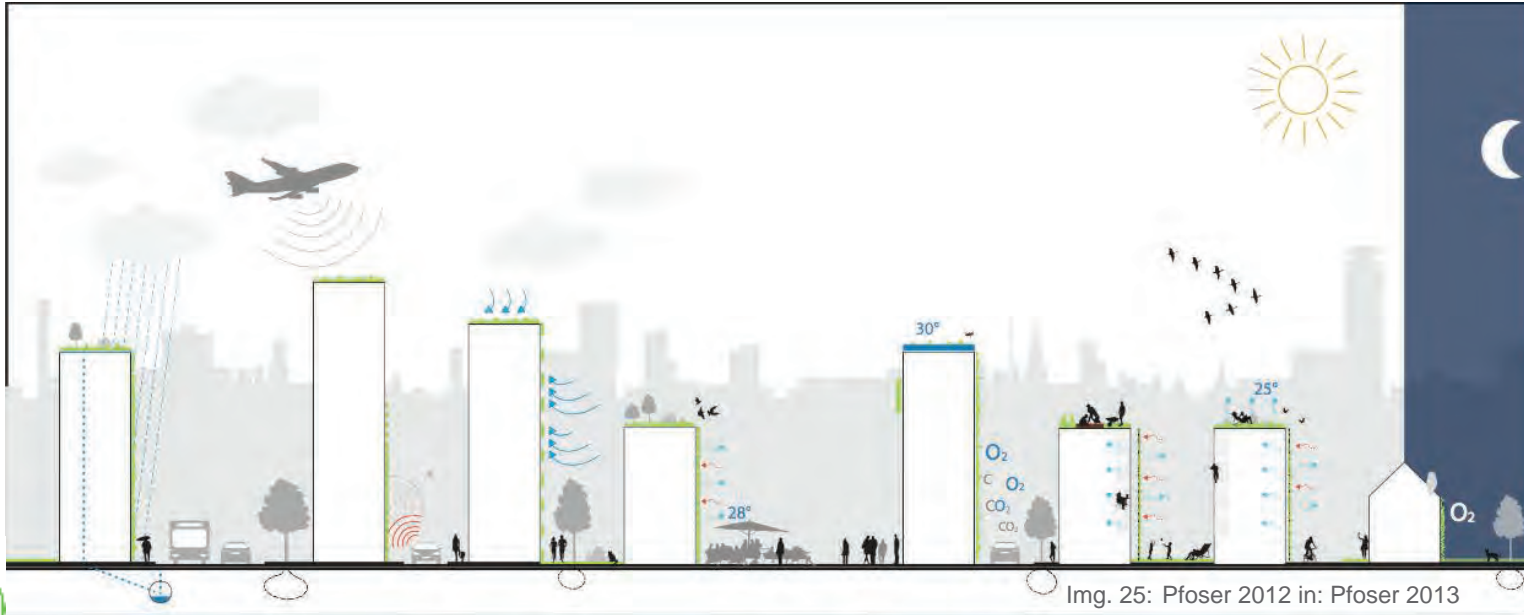


**BUT:**

there is more space than just the ground

about **50% of the sealed surface**  
(in Vienna) are

**Roofs**



Img. 25: Pfoser 2012 in: Pfoser 2013







# Greenroofs

plants have no contact to earthbond soil

mostly heat, dry and sunnstress  
(but also shady ones)

**in Cities a lot of „ greenroofs“  
are on the ground**  
(f.e. parking garage etc.)



Img. 27: garage in Vienna

Img. 26: Highline New York

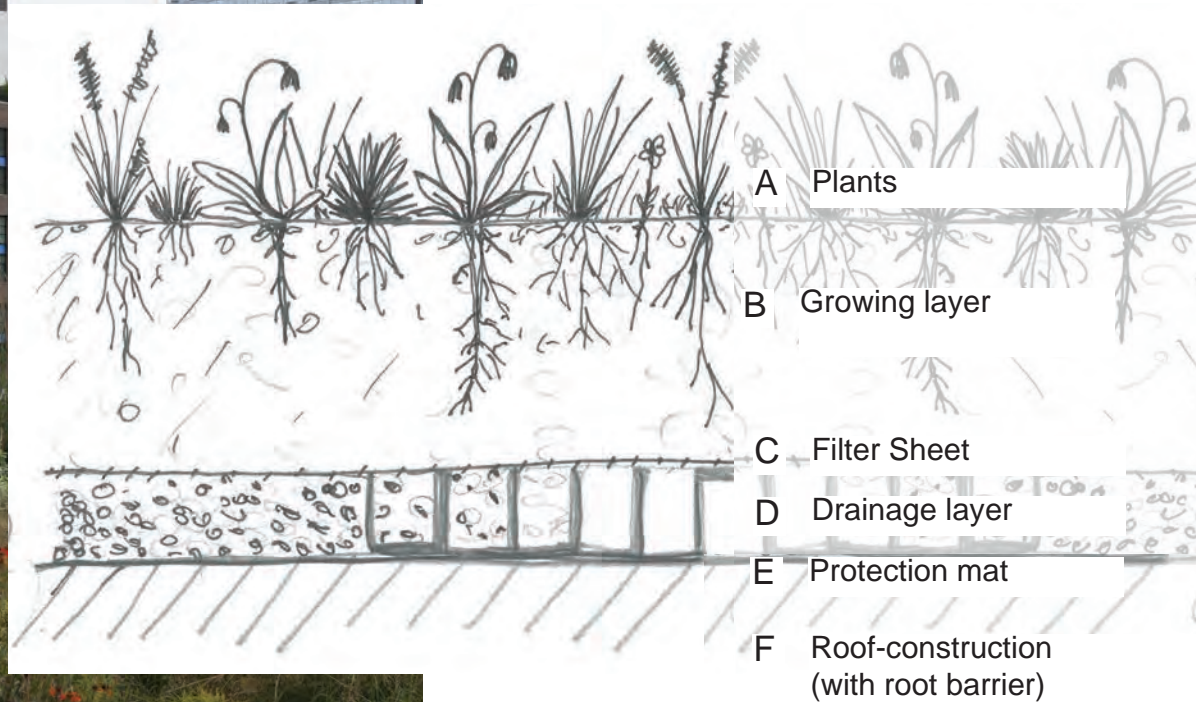






# Greenroofs

Excurs: how to build a greenroof?



Img. 28: Scheme of layers of a green roof







## Greenroofs

### Extensive greenroofs

height of substrate: 4 to 8 cm  
not irrigated

low maintained

### Semi intensive greenroofs

height of substrate about 15 cm  
irrigated and maintained



Img. 30: extensive greenroof London

Img. 29: semi intensive greenroof New York

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# Greenroofs

## intensive greenroofs

### „Roofgardens“

height of substrate: minimum 20cm  
 irrigated  
 maintainance needed



Img. 32: intensive greenroof in Winter

Img. 31: Roofgarden in Paris (source:Anja, [www.pixabay.com](http://www.pixabay.com))







# Walkways

Excursion: **High Line New York**  
„Roofpark - Walkway“

from 1934 to 1980 rails to support industry in New York's Meat district

revitalized as a park opened in 2009



Img. 33: +34 High Line New York

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## Excursus: **Highline New York**

Project raised by „Friends of Highline“  
then donated to New York city

about 5 mio visitors/year in 2014

example how green infrastructure create a benefit  
for the whole district



Img. 36: South end of the Highline  
(source: Robin Stevens, cynic.org.uk)

Img. 35: High Line New York

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**Intensive  
greenroofs  
need  
a proper  
irrigation !!!**

Img. 37: to 40: High Line New York





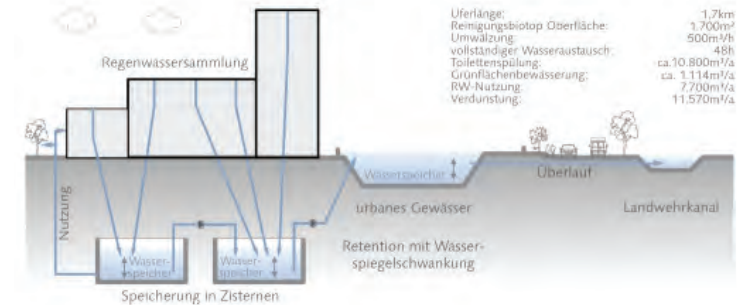


Img. 41: Water basin in London

# Rainwater Collection in public basins and cisterns

used for irrigation

Excurs: Potsdamer Platz  
Konzept: Artelier Ramboll, Dreiseitl



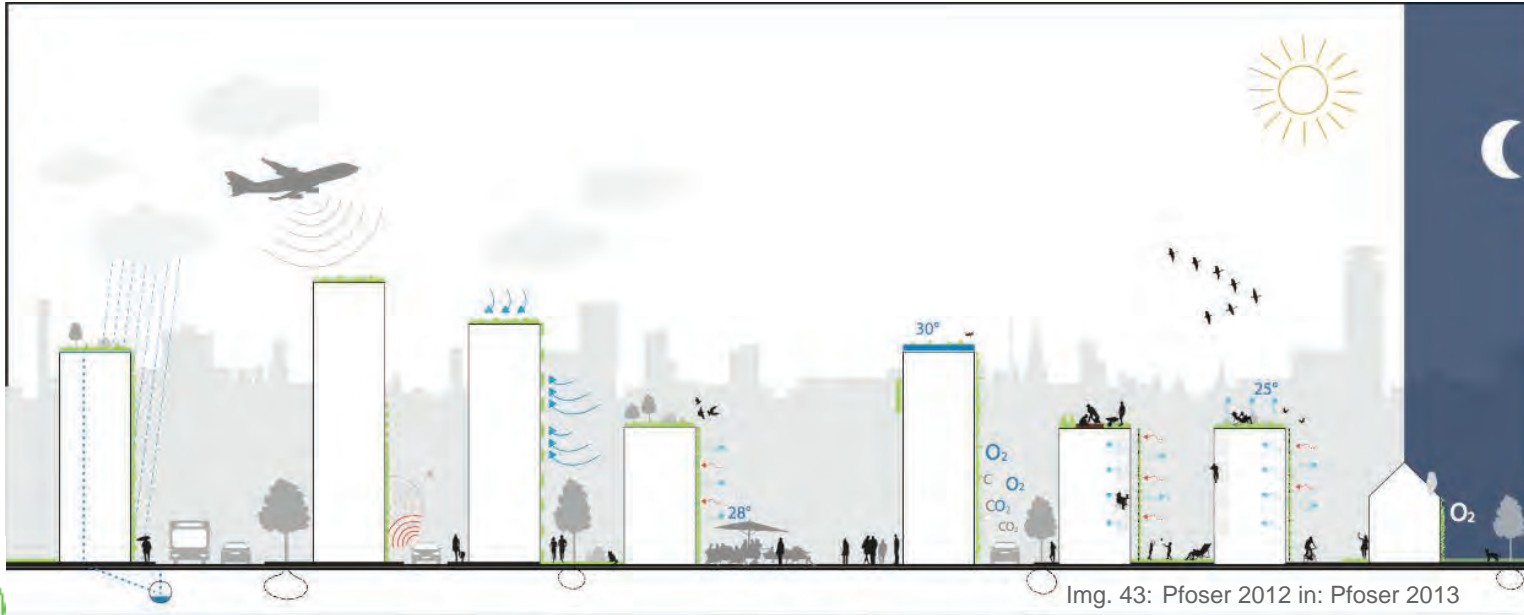
Img. 42: Rainwater-collection system Potsdamer Platz  
source: Grundlagen des Ökologischen Bauens, Bauhaus-Universität Weimar, Prof. Dr.-Ing. D. Glücklich  
[www.ecobine.de](http://www.ecobine.de)





# AND: Facades

can provide **2-3 times** of the basal **area**  
(in Vienna) **additionally**







3rd dimension

## Facade earthbond Climbers

need enough space on the ground for their roots

some climb by themselves  
others need climbing support



Img. 44: + 45: *Parthenocissus tricuspidata* (Ivy wine)







3rd dimension

## Facade

**Klimbers in pots on the wall**

irrigation is a must



Img. 46: Facade with climbers in Vienna „Hängende Gärten“

Img. 47: Integrated concrete pot for plants







## 3<sup>rd</sup> Dimension

Excursus: **Bosco Verticale, Milano**

Scyscraper with big trees on Balconies (2014)



Img. 48: to 50: Bosco Verticale, Milano





## 3<sup>rd</sup> Dimension Facade Balconies



Img. 52: Balcony in Vienna (Majolika Haus)

Img. 51: Balcony in Milano







3rd dimension

**Facade**

**Perennials**

**in special Systems**

big number of different fabricates,  
very little space for the roots,  
difficult to handle because low resilience  
irrigation (and fertilisation) is a must



Img. 53: Element on Galeries lafayette in Berlin

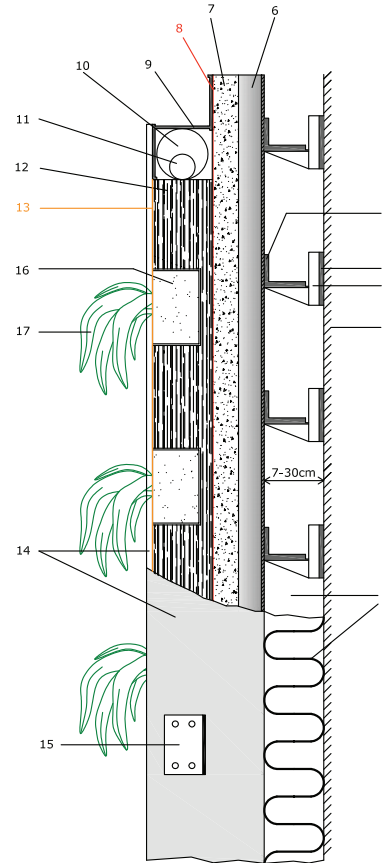
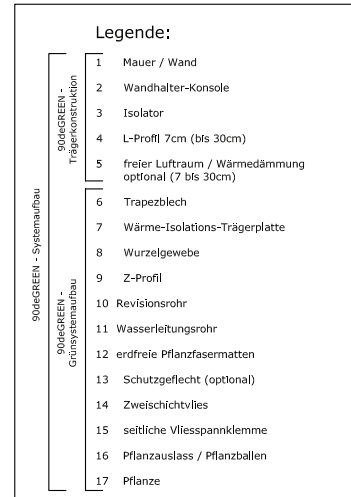
Img. 54: Le mur végétal by Patrick Blanc (Musée du quai Branly)  
(source: Jean-Pierre Dalbéra <https://commons.wikimedia.org>)

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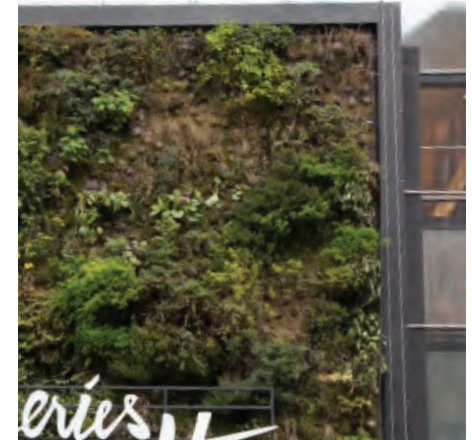




on

## 'stems

ent fabricates,  
he roots,  
cause low reseilience  
ation) is a must



es lafayette in Berlin

Img. 56: Example of a facade-greening-element  
(source: [www.90-degreen.at](http://www.90-degreen.at))

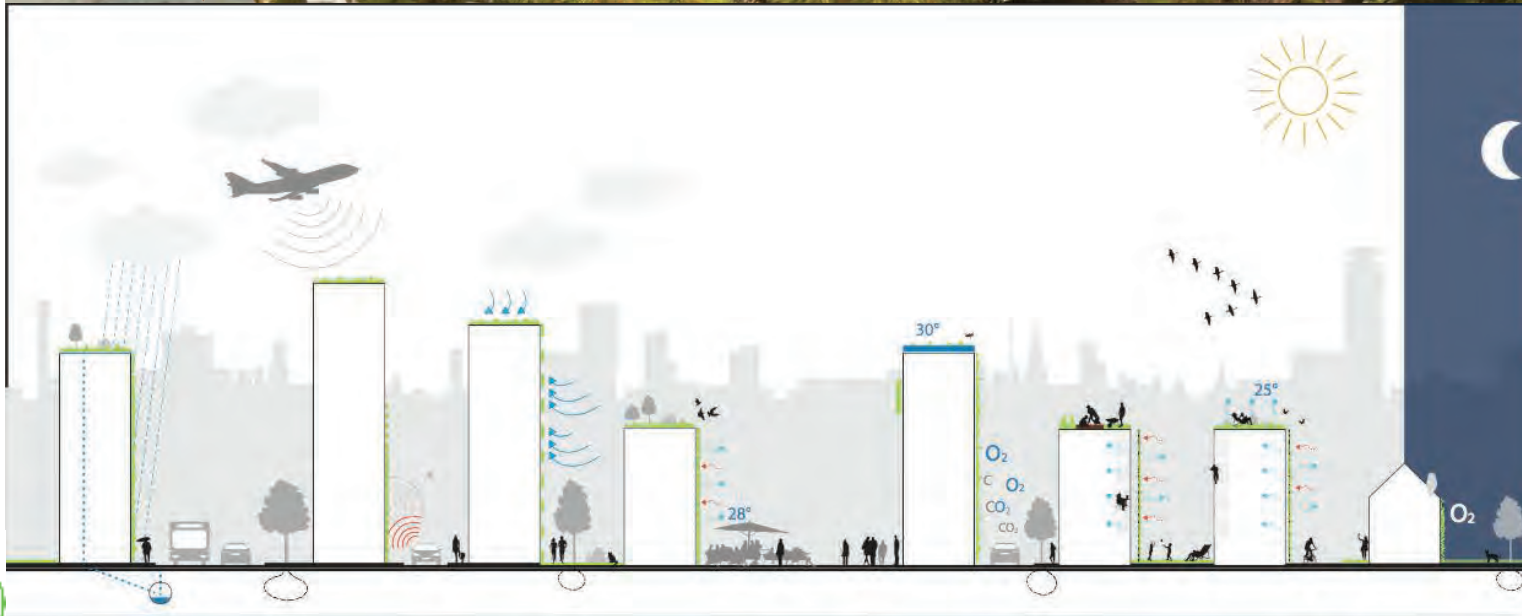
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# Examples for the benefits of green infrastructure Case Studys



Img. 57: Pfoser 2012 in: Pfoser 2013

provide  
O<sub>2</sub>  
Shadow  
habitats for animals  
space for humans to be

reduce  
noise  
CO<sub>2</sub>  
wind  
heat

filter fine particles  
hold rainwater back







case study 1

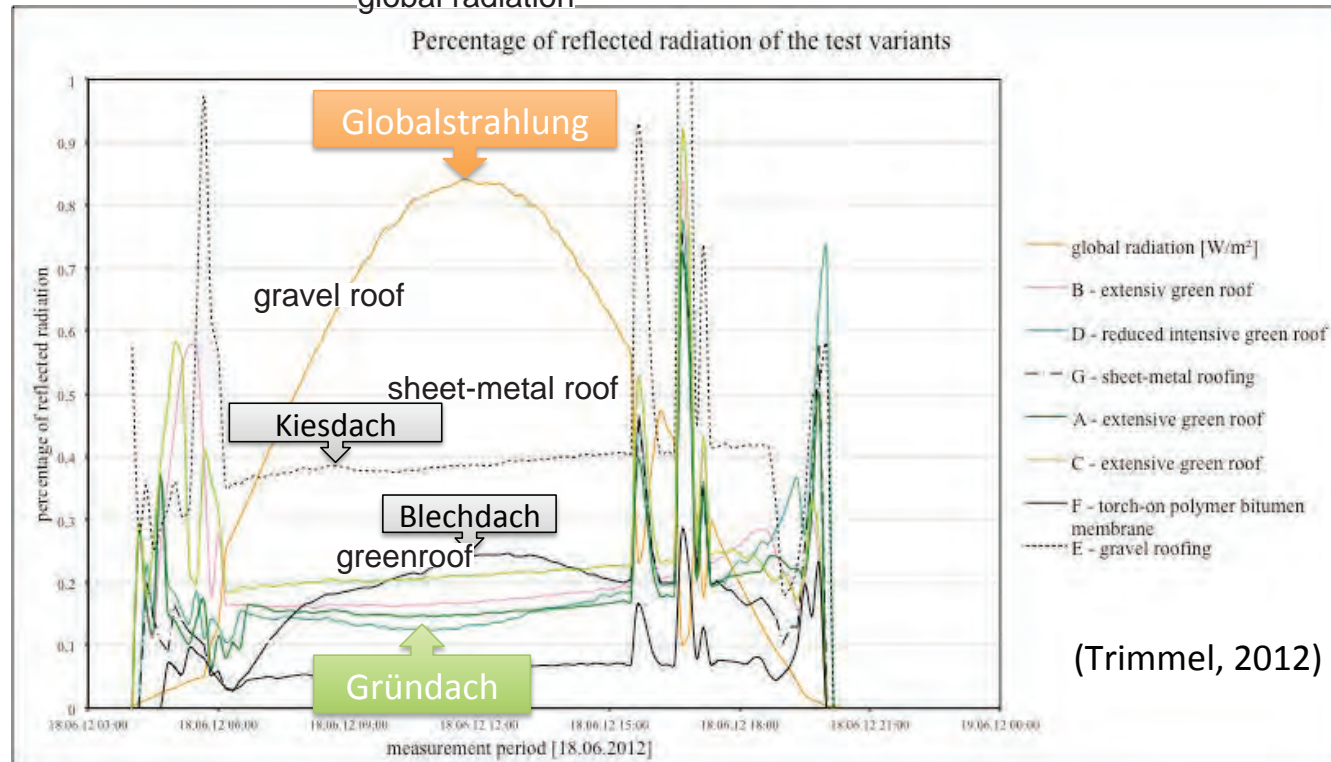
# Research Project: Green City

Img. 58: Greenroofs for GrünStadtKlima-Project  
(source: Vera Enzi)





global radiation



Percentage of reflected radiation:

greenroof 13% to 21% –  
sheet metal roof: 24%  
gravel roof: 38%

Img. 59: Percentage of reflected radiation of different roofs  
GrünStadtKlima-Project  
(source: Trimmel, 2012)







## Case Study 2

# Research Project: Rooftop-Garden in combination with Pho- tovoltaics



Img. 60: Potential areas for Greenroofs [www.wien.gv.at](http://www.wien.gv.at)).







Situation:

## Greenroof vs. photovoltaics



Img. 63: Potential areas for greenroofs([www.wien.gv.at](http://www.wien.gv.at)).

Img. 62: Potential areas for photovoltaics([www.wien.gv.at](http://www.wien.gv.at)).

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Situation:

## Greenroof vs. photovoltaics vs. space for people



Img. 66: Potential areas for greenroofs([www.wien.gv.at](http://www.wien.gv.at)).

Img. 65: Potential areas for photovoltaics([www.wien.gv.at](http://www.wien.gv.at)).

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<-- **Photovoltaics  
on the top**  
(for producing green energy)

<-- **Recreation area  
for people**  
(to have extra  
space in town)

<-- **green layer  
at the bottom**  
(to profit from all benefits  
a green roof provides)







Img. 67: Constructon in wood as a test site

**Test Site@Boku 54 m<sup>2</sup>**



Img. 68: naked Terrasse

**How do people feel under the photovoltaic shelter?**  
**Which plants will grow in which light zone?**





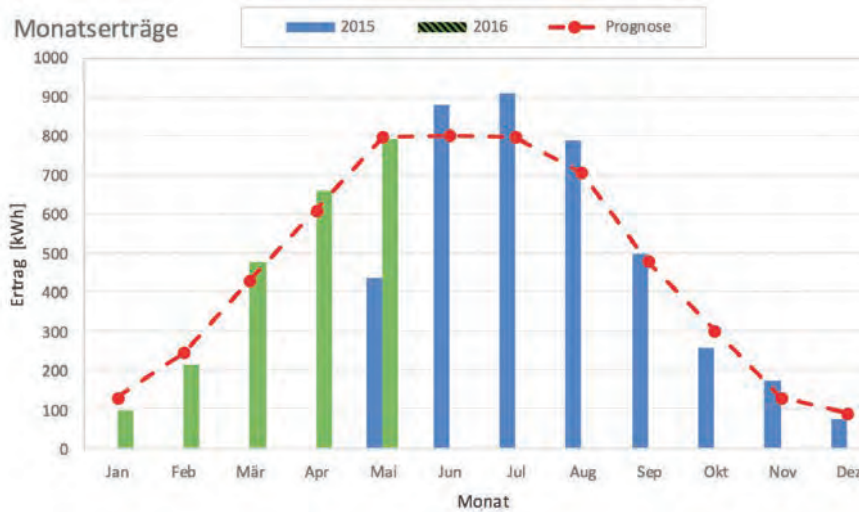


Results:

## Water demand and energy production

Water demand in one year: 6,6 m<sup>3</sup>  
(spring, summer, autumn) no irrigation  
in Winter

next investigation steps: providing  
water in winter and integration of  
rainwater



Energy production over one year:  
5816 kWh  
(about one household)

Monthly energy production in 2015/16 in the PV-Rooftopgarden  
test site (source: ATB-Becker)





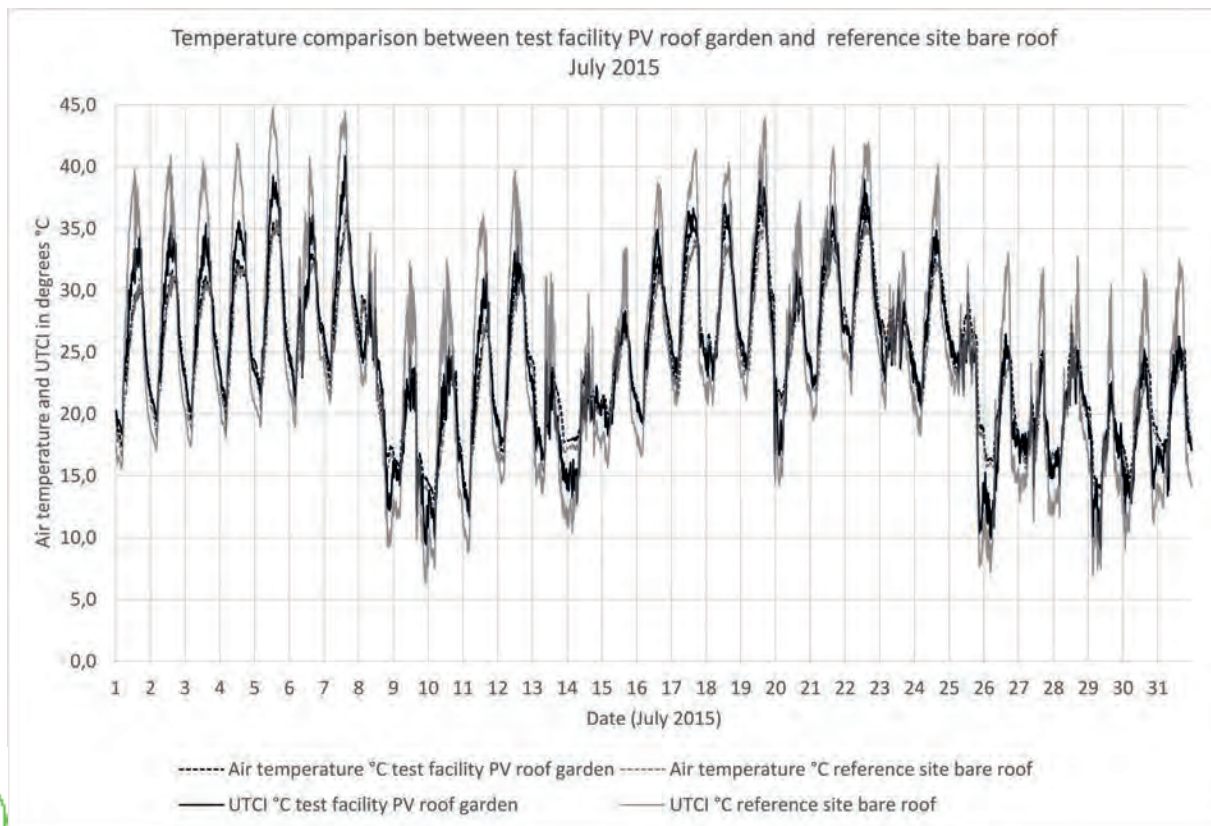
Results:

## Thermal stress (UTCI)

### Sojourn quality in PV-Roofgarden test site

Example: very hot day: 5th of July 2015)

UTCI at reference point (bare flat roof): 44,8 °C  
UTCI under PV: 40,9°C



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case study 3

## Green facade on Office Building, Vienna



Img. 69: Building of MA 48 before greening  
(source: Enzi, Scharf (2012): Das Haus im „Grünen Pelz“)

Img. 70: Building of MA 48 with green facade (2016)

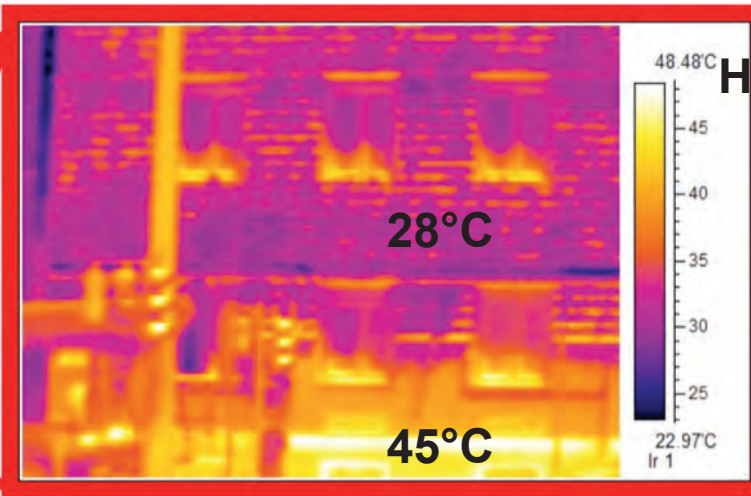
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Office Building of MA48 in Vienna:

## comparison: Surface temperature of green facade and plastered facade



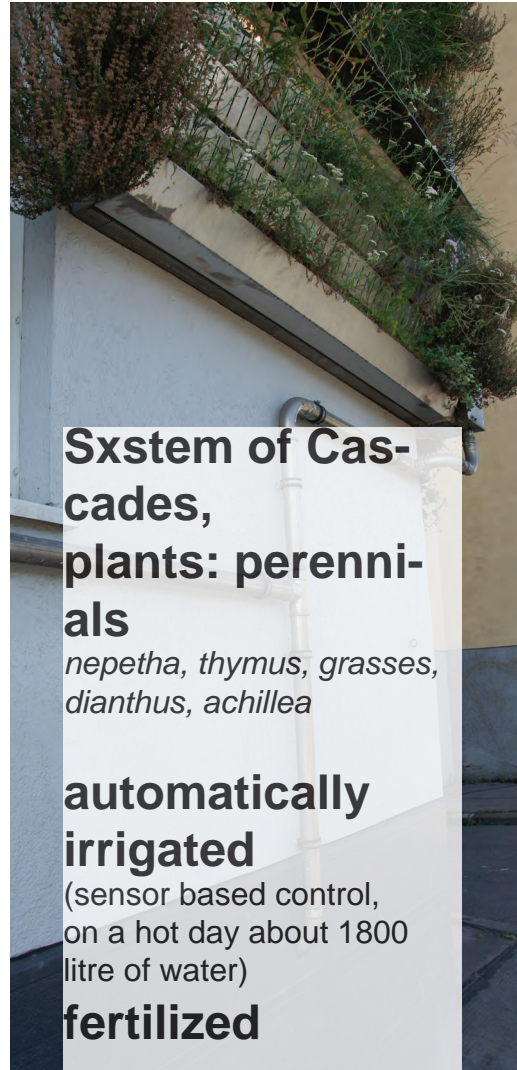
Heat transition coefficient  
greenfacade:  
 $0,57 \text{ W}/(\text{m}^2 \cdot \text{K})$

plastered facade:  
 $0,71 \text{ W}/(\text{m}^2 \cdot \text{K})$

Img. 71: Surface temperature in Summer on the office Building MA48 (Source: Scharf, Pitha, Enzi, 2013)







Office Building of MA48 in Vienna:

**850 m<sup>2</sup> green facade**

**Increased the green area of the  
 district about 0,85%**



Img. 72: to 6: details of office Building MA 48 in Vienna







case study 4

# Vertical farmers garden + grey water irrigation

BOKU-Test Site

linear tray system

10 m<sup>2</sup>

herbs and edible plants

testing of irrigation with greywater





## Summary

Urban green infrastructure  
is a **network** of  
**various patterns**  
in **different scales.**

providing

O<sub>2</sub>

Shadow

habitats for animals

space for humans to be

reducing

noise

CO<sub>2</sub>

wind

heat

filter fine particles

hold rainwater back

Irrigation (fertilisation), Storage (and reuse) of  
stormwater and maintenance are the challenges to  
work on.

Img. 74: Pfoser 2012 in: Pfoser

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# Thank you for listening

