SUSTAINABLE DESIGN OF VEGETATED STRUCTURES: BUILDING FRESHNESS

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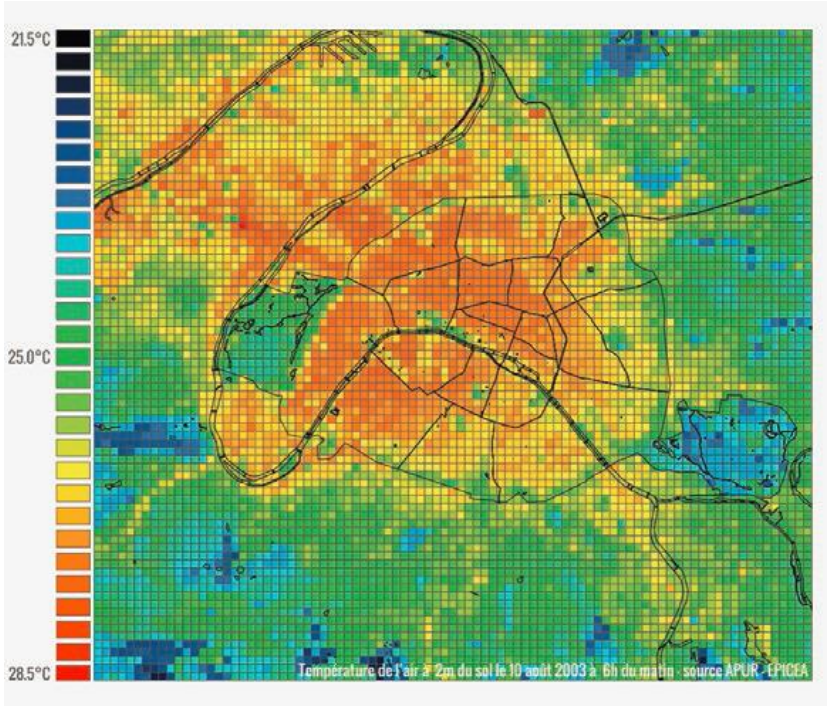
Credits: Urban Canopee

Urban heat island

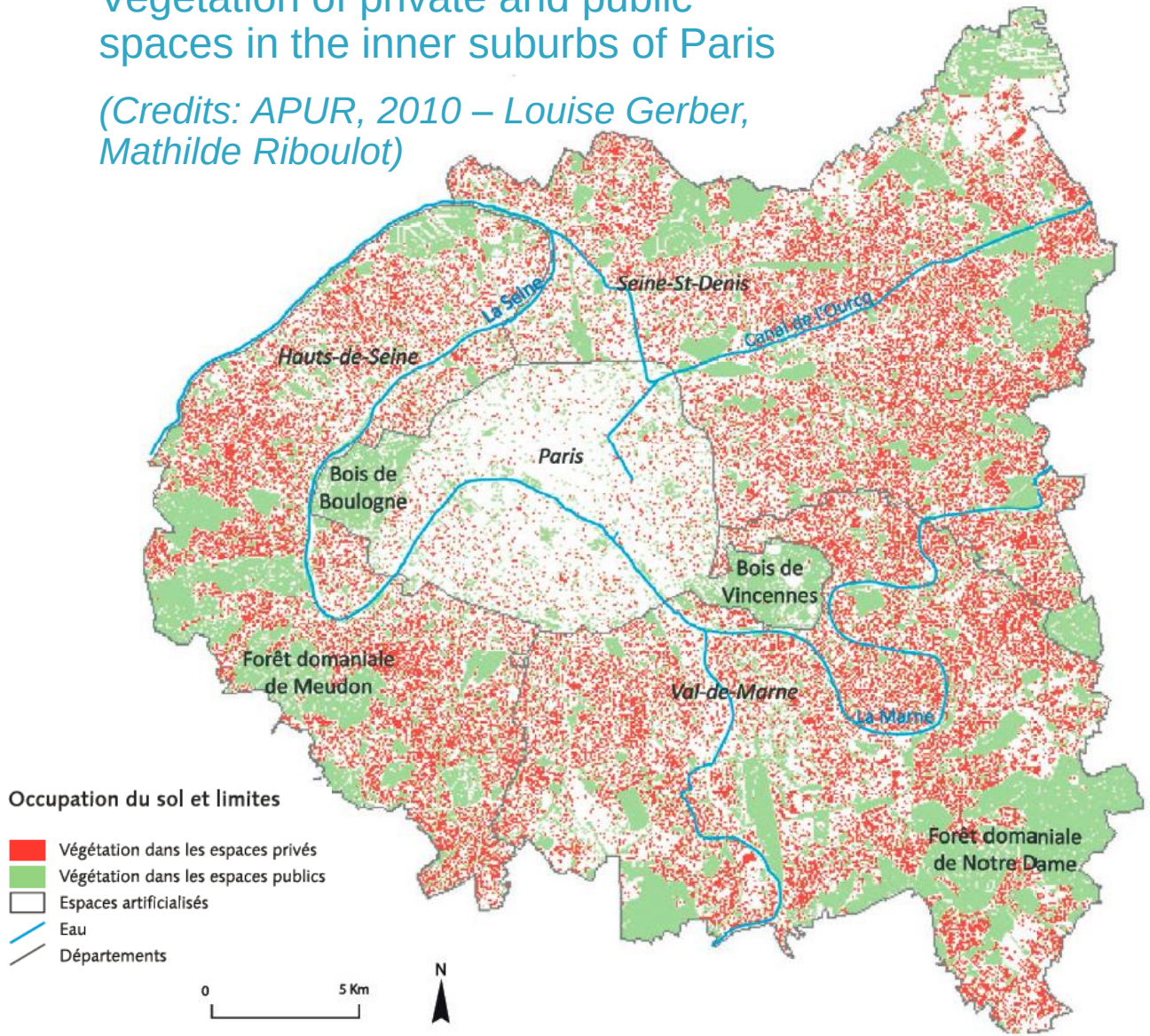
Air temperature at 2m height on 10 Aug. 2013 at 6am

(Credits: APUR|EPICEA, 2014)



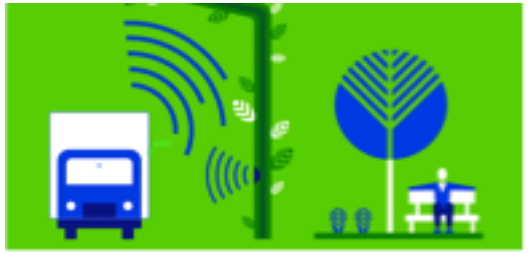
Vegetation of private and public spaces in the inner suburbs of Paris

(Credits: APUR, 2010 – Louise Gerber, Mathilde Riboulot)



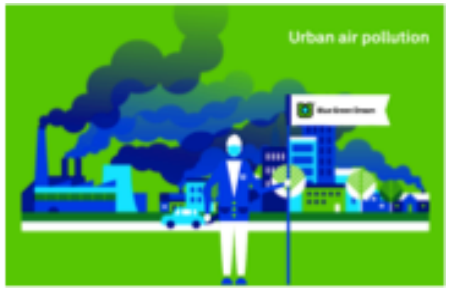
Blue-green solutions

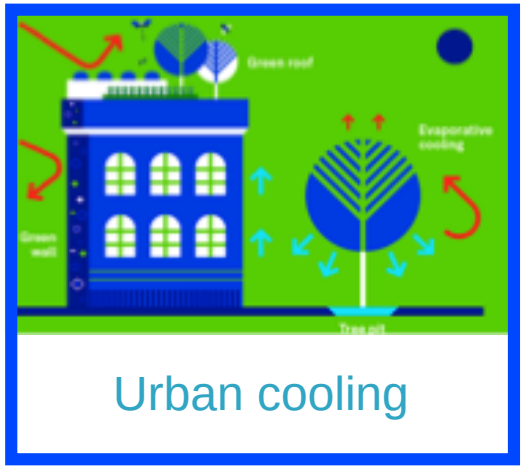
Acoustic insulation



Well-being

Air purification





Urban cooling

Urban vegetation

Thermal insulation

Stormwater management

Biodiversity

An urban planning issue

- Issues for convincing stakeholders

  (ecosystem services are not properly quantified – i.e. the real « performance » of blue-green solutions is unclear)

- Dense cities: lack of space

- Issues related to retrofitting existing buildings

  (technical regulations, costs, long-term consequences)

How to enhance greening of cities?

Vegetated elastic gridshells

Credits: Urban Canopee

Research questions

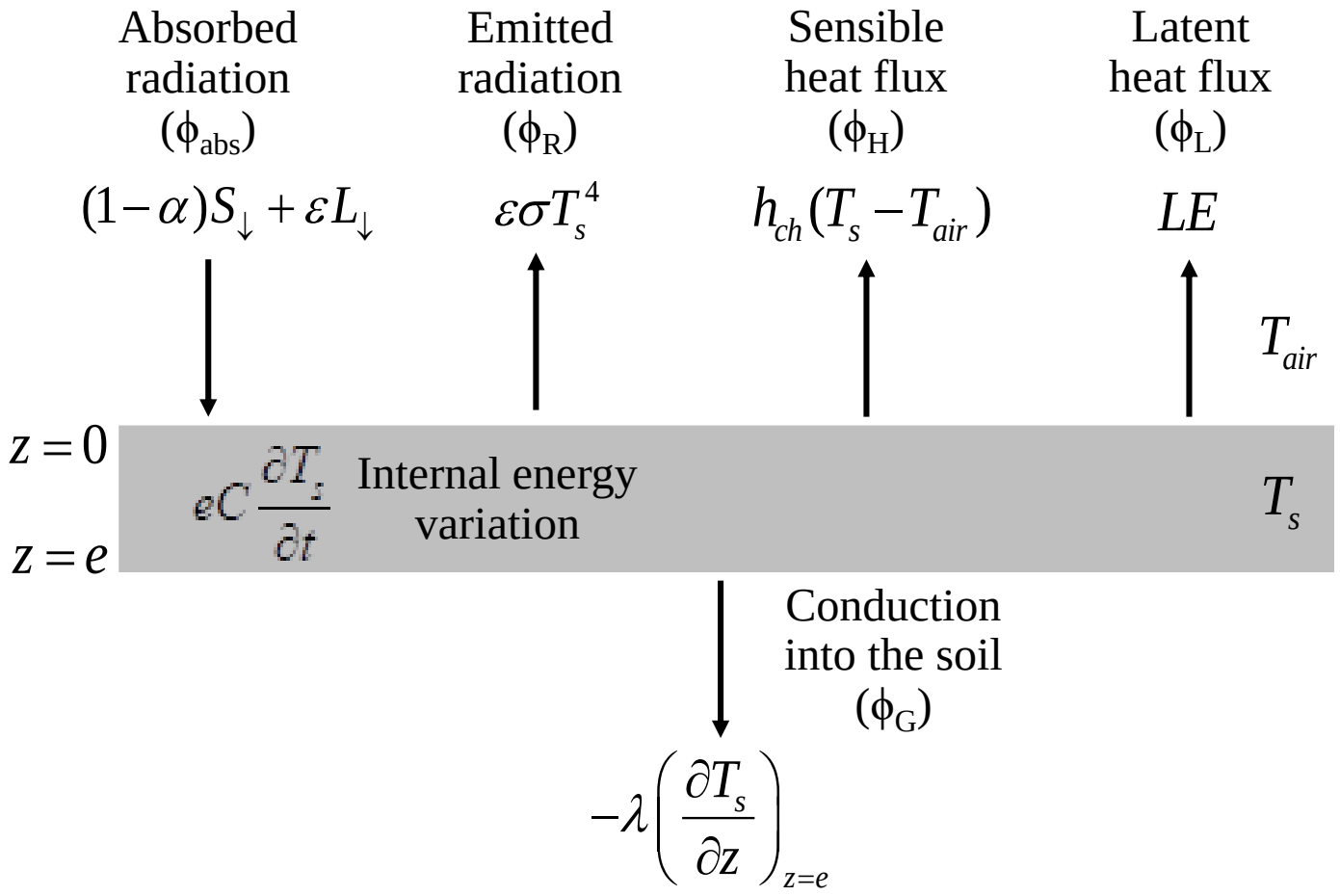
- How is vegetation relevant for urban cooling?

→ What are the main mechanisms for mitigating urban heat island effects?

→ How does the spatial arrangement of blue-green solutions influence geophysical fields/human comfort at different scales?

- What are the costs (e.g., material resources, polluting processes) and benefits (ecosystem services, biodiversity) of implementing urban vegetation?

Energy balance and cooling mechanisms



Energy balance: $\phi_{abs}=eC\frac{\partial T_s}{\partial t}+\varepsilon\sigma T_s^4+h_{ch}\left(T_s-T_{air}\right)+LE-\lambda\left(\frac{\partial T_s}{\partial z}\right)_{z=e}$

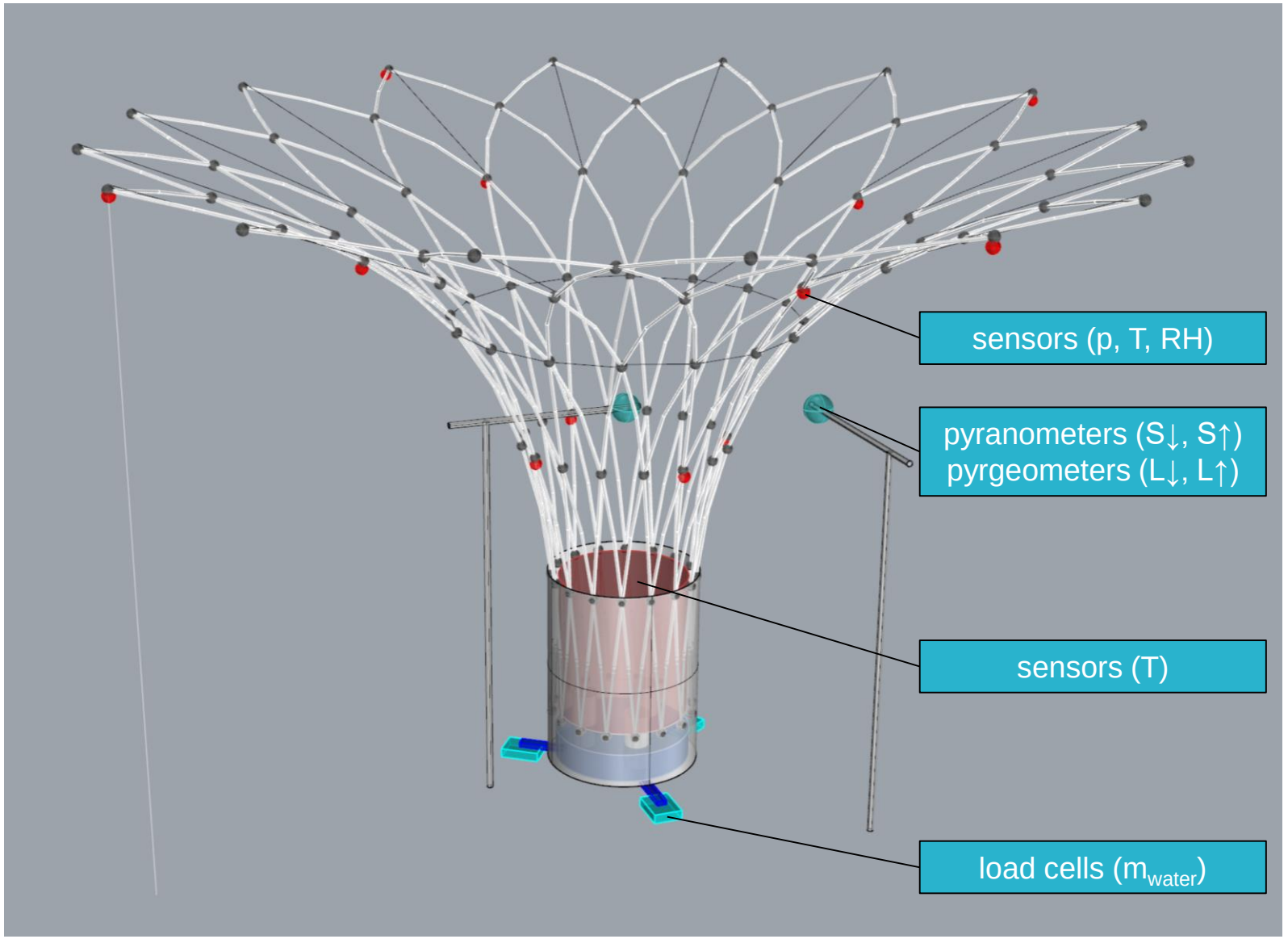
Energy balance and cooling mechanisms

$$\Phi_{H,vegetation} + \Phi_{H,shade} \overset{?}{\leq} \Phi_{H}$$

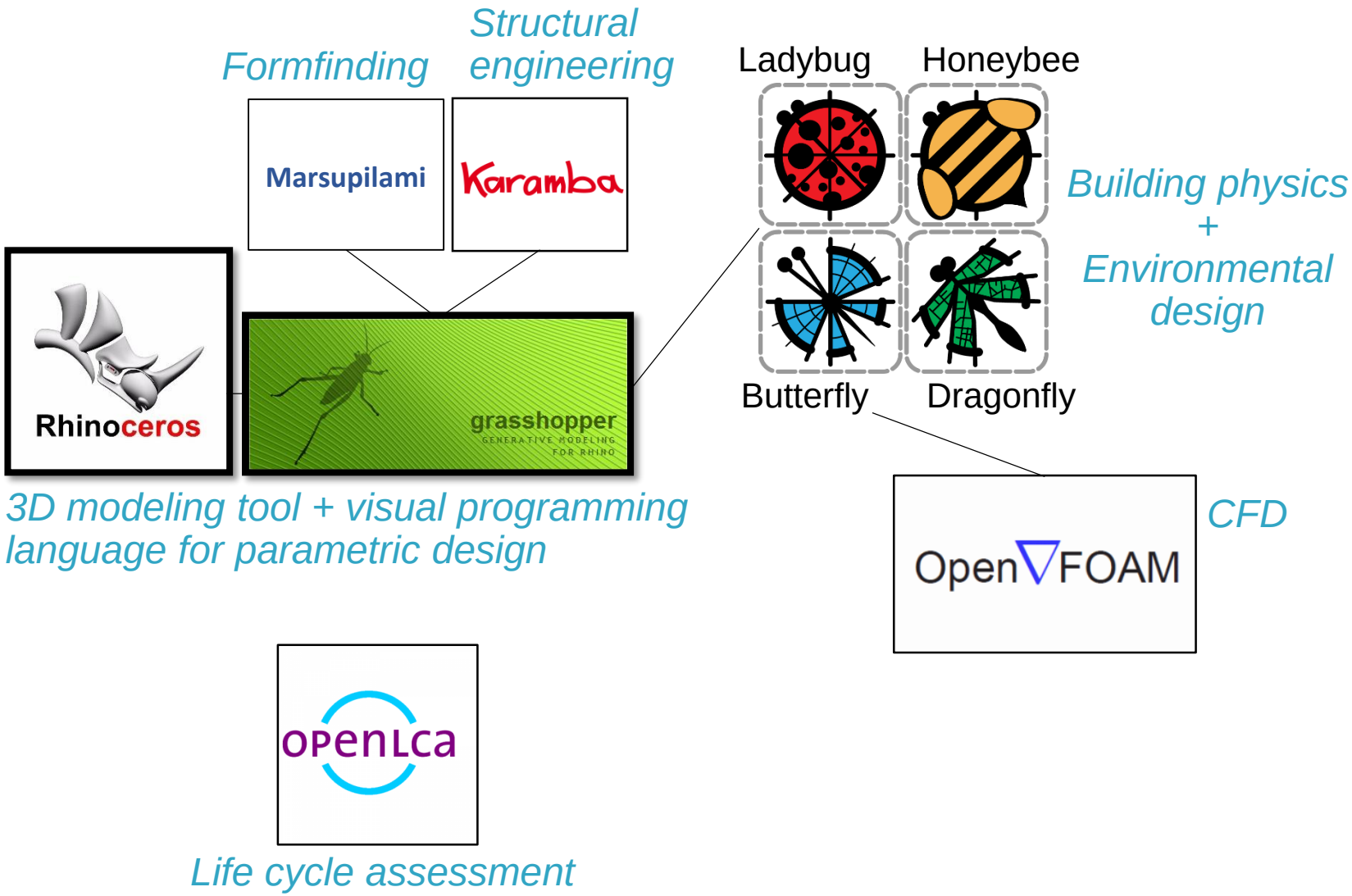
Elastic gridshells in composite materials: Construction process

Elastic gridshells in composite materials: Construction process

Instrumentation plan

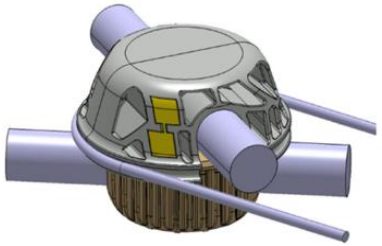


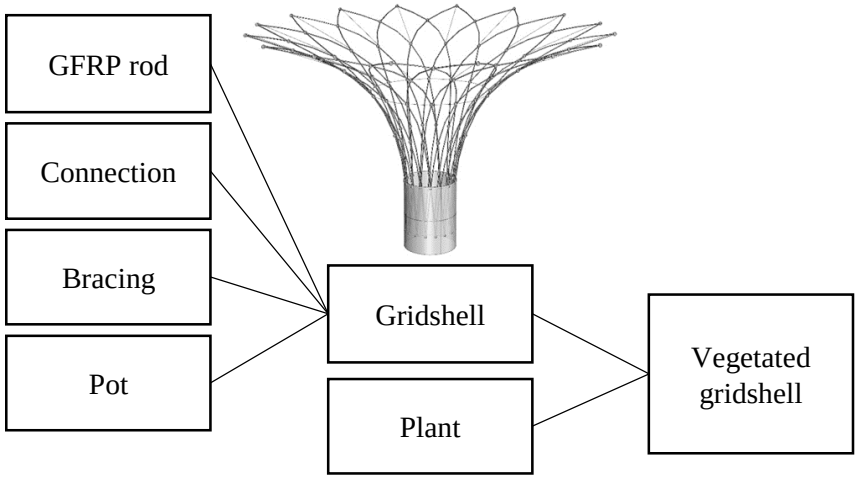
Connecting models

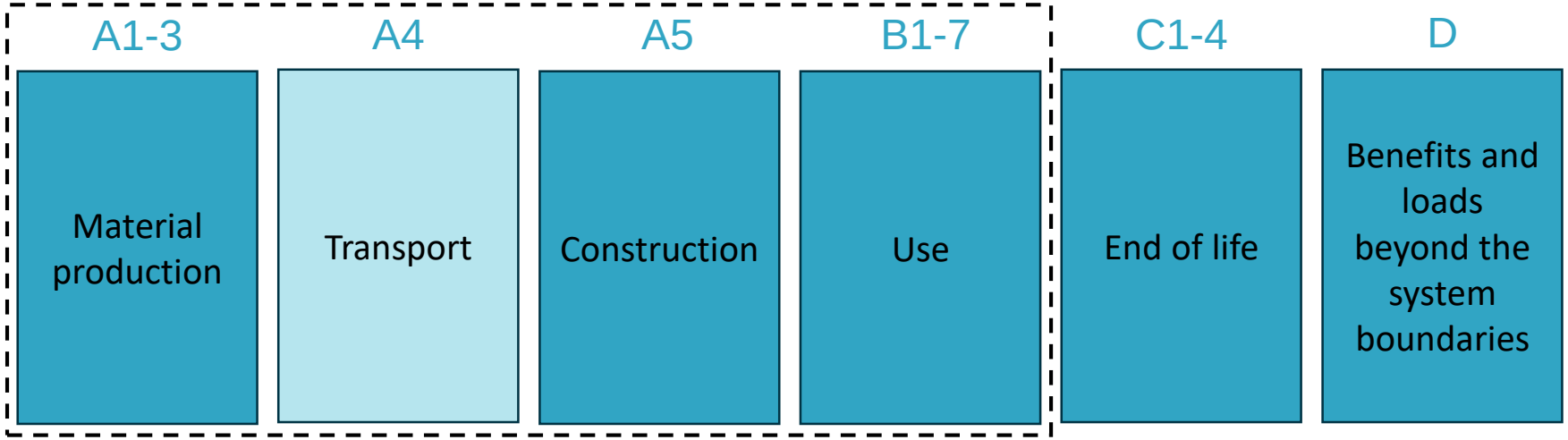


Life cycle assessment

OpenLCA + Ecoinvent 3.2



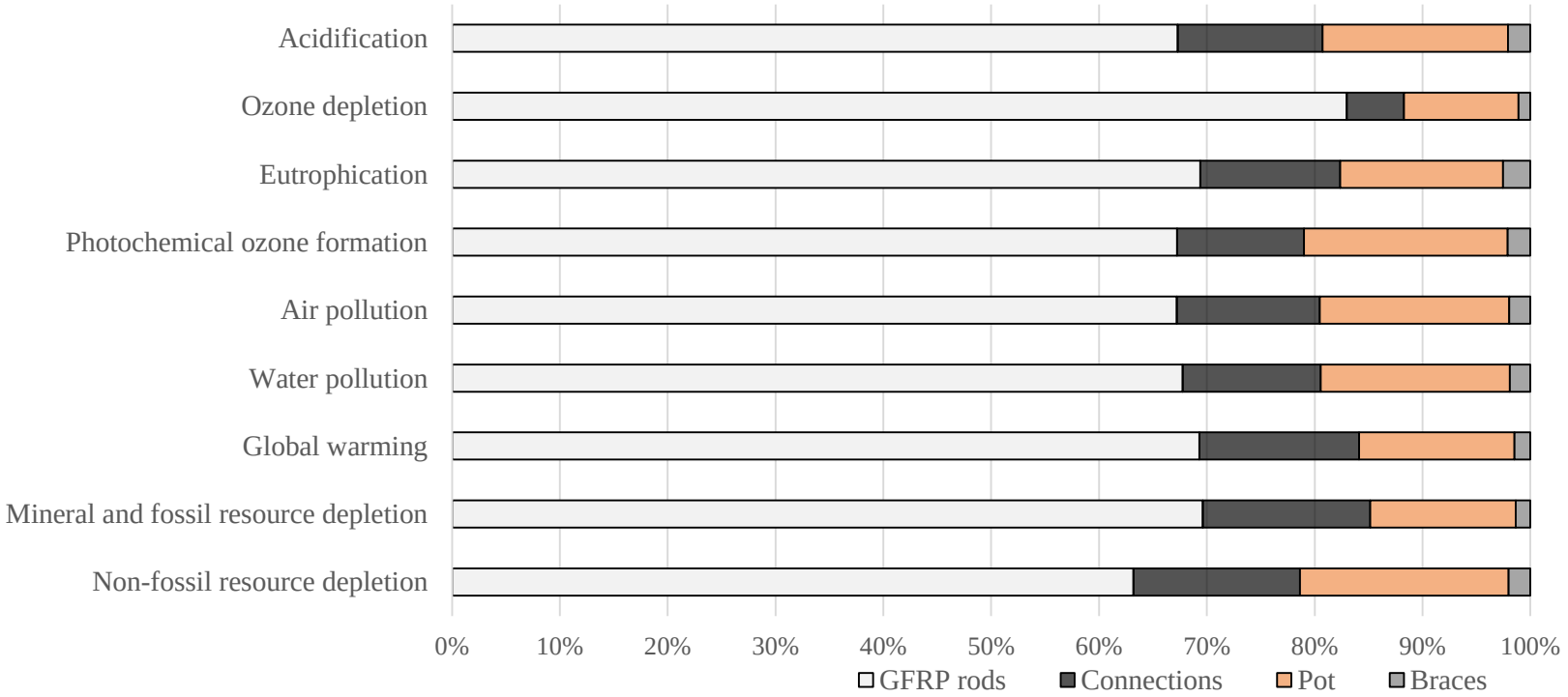




System boundaries as per NF EN 15804 standards

Life cycle assessment

Impact category	Gridshell	Vegetated gridshell (30 years)
Acidification of soils and water (kg SO_2 eq.)	2.9	3.0
Ozone depletion (kg CFC-11 eq.)	$6.3 \cdot 10^{-5}$	$6.3 \cdot 10^{-5}$
Eutrophication (kg PO_4^{3-} eq.)	0.46	0.47
Photochemical ozone formation (kg ethylene eq.)	0.17	0.17
Air pollution (m^3)	1700	1700
Water pollution (m^3)	$4.8 \cdot 10^{5}$	$4.9 \cdot 10^{5}$
Global warming (kg CO_2 eq.)	690	40
Mineral and fossil resource depletion (MJ)	$1.0 \cdot 10^{4}$	$1.0 \cdot 10^{4}$
Non-fossil resource depletion (kg Sb eq.)	$1.4 \cdot 10^{-8}$	$1.4 \cdot 10^{-8}$



Perspectives

- Assessing experimentally the urban cooling provided by one kind of vegetated urban furniture
- Evaluating the geophysical fields by means of CFD models
- Refining costs and benefits attributed to these vegetated structures through their whole life cycle so that this data can be used to establish trade-offs between outdoor thermal comfort and environmental impacts

https://hmco.enpc.fr/

https://navier-lab.fr/

http://thinkshell.fr/en/

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