NATIONAL TECHNICAL
UNIVERSITY OF ATHENS

«SUSTAINABILITY vs ARCHITECTURAL DESIGN»

Regenerative architecture: technological design for future

innovative materials and "cradle to cradle" approach

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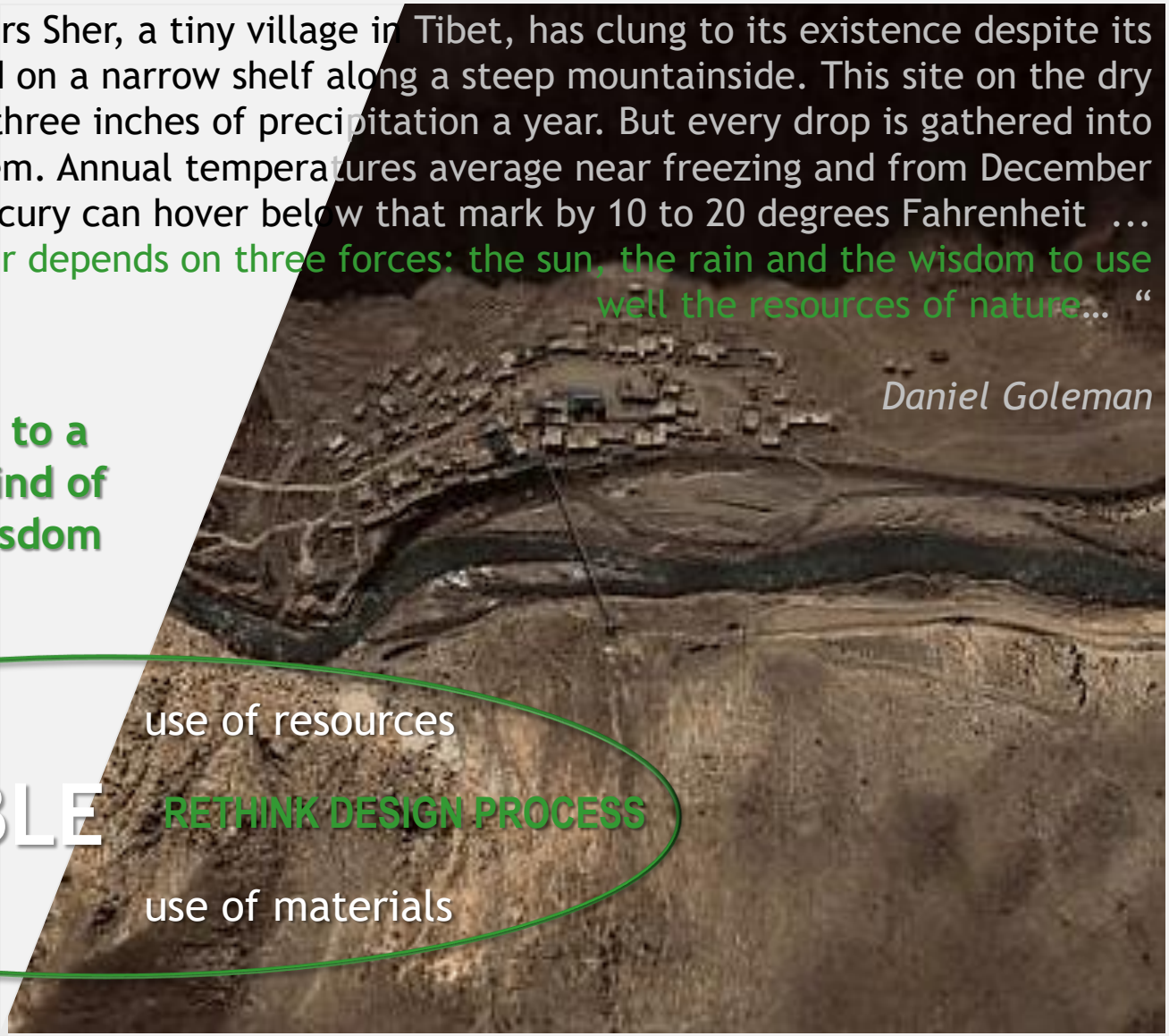
"For over a thousand years Sher, a tiny village in Tibet, has clung to its existence despite its dire location, perched on a narrow shelf along a steep mountainside. This site on the dry Tibetan plateau gets just three inches of precipitation a year. But every drop is gathered into an ancient irrigation system. Annual temperatures average near freezing and from December through February the mercury can hover below that mark by 10 to 20 degrees Fahrenheit ... The little village of Sher depends on three forces: the sun, the rain and the wisdom to use well the resources of nature... "

Daniel Goleman

Modern life leads to a decrease of this kind of ability and this wisdom



RESPONSIBLE

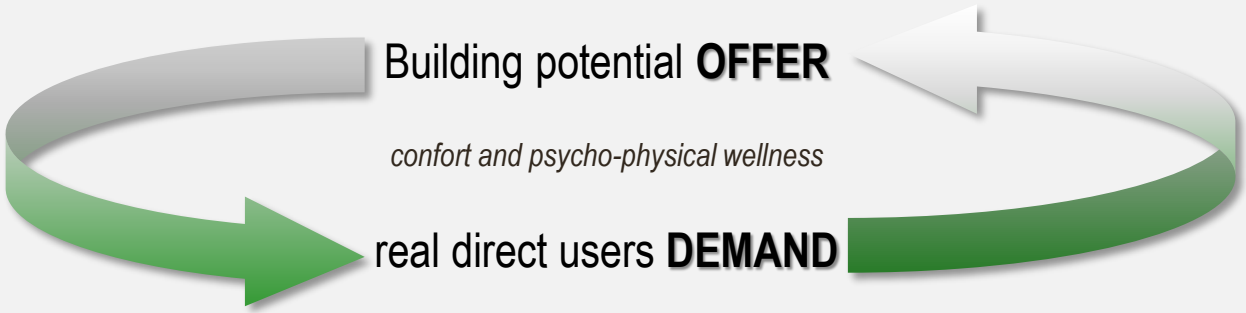
use of resources

RETHINK DESIGN PROCESS

use of materials

Design, before being a transformation instrument, is a knowledge instrument

Building construction requires the creative interpretation of direct users' needs:
a wise balance between technological innovation, research and possible quality.



objective

POSSIBLE QUALITY

- resources
- needs
- eco-friendly transformations
- innovation
- efficiency

wise combination of compositive knowledge and constructive knowledge

Goal

SYMBIOSIS
between
built environment
material science
natural systems

➢**The technological design is a decisional iter:**
What decisions impact the sustainability of the technological design?

➢**The technological design is an interdisciplinary work:**
What tools and information you need to make better informed decisions?

➢**Making decisions, in the design process, can help deliver significant results in the efficient use of land, energy, water and materials:**
What are the impacts of the human transformation on the air, soil and water systems?

➢ **The construction process is articulated in phases:**
When to make those decisions?

The false myths of sustainable architecture

- A building that saves energy is a sustainable building
- A sustainable building is not architecturally "beautiful"
- A building in A grade consumes low energy
- The plants are an important aspect of sustainable architecture
- A wooden building sustainable
- A sustainable building is more expensive

Greenwashing

NOT ALWAYS

Sustainability is not just about energy aspects but also the environmental use of the site, climate, water, sun, daylight, natural ventilation, recycled materials, innovative technological solutions. These must be integrated!

FALSE

We can design sustainable architecture with beautiful

FALSE

the evaluation of the class depends on a balance between the need for primary energy for lighting, ventilation, heating, cooling and domestic hot water and consumption. If the requirement is provided by renewable energy sources, the building is a Class A

NOT ALWAIS

only choice of materials is not a guarantee of eco-compatibility. It is necessary to assess all energy, environment, thermal aspects in its LCA

NOT ALWAIS

the cost evaluation must be made not only by considering the construction costs but also those of management. If the building is properly designed and natural resources are actually elements of architectural design the management becomes economical and initial costs are reduced

ARCHITECTURE

search for harmony

- MAN
- NATURAL ENVIRONMENT
- BUILT ENVIRONMENT

SYMBIOSIS
between
built environment
material science
natural systems

«cradle-to-cradle» sustainable design

This approach uses natural resources in order to restore the compromised ecological cycles

experimental technological design
assessment of traditional, natural and grown materials

HOUSE LIKE A TREE

OBJECTIVE → **SYMBIOSIS**
between
built environment
material science
natural systems

Our research evaluates
four models of architecture

Traditional Architecture

Sustainable Architecture ... without eco-oriented meta-design choice

Sustainable Architecture ... with eco-oriented meta-design choice

Regenerative Architecture

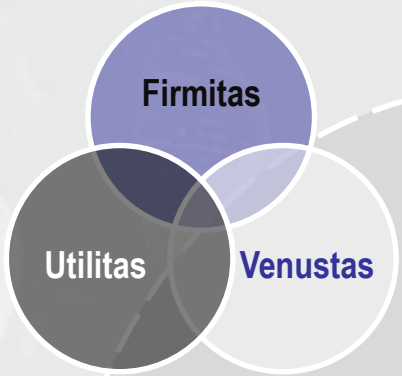
aiming at the only performance optimization in the operational phase

making also eco-oriented design choices, that have had a positive impact on the environmental balance in the cradle and grave phases

The traditional architecture follows

Past approach (here and now)

OPERATIONAL PHASE



CRADLE PHASE

GRAVE PHASE

Buildings

energy consume for
Heating, Cooling, Hot Water, Light, Ventilation

towards the present

In Europe after the 2002/91/EC Directive

In Italy after the Law Decree 192/2005

Current approach (cradle-to-grave)

OPERATIONAL PHASE

In Europe 2010/31/EU Directive

In Italy Law Decree 90/2013

CRADLE PHASE

15-20%

NetZeroEnergy Buildings

consume less energy than they produce
they are comfortable and smart

GRAVE PHASE

15-20%

towards the future

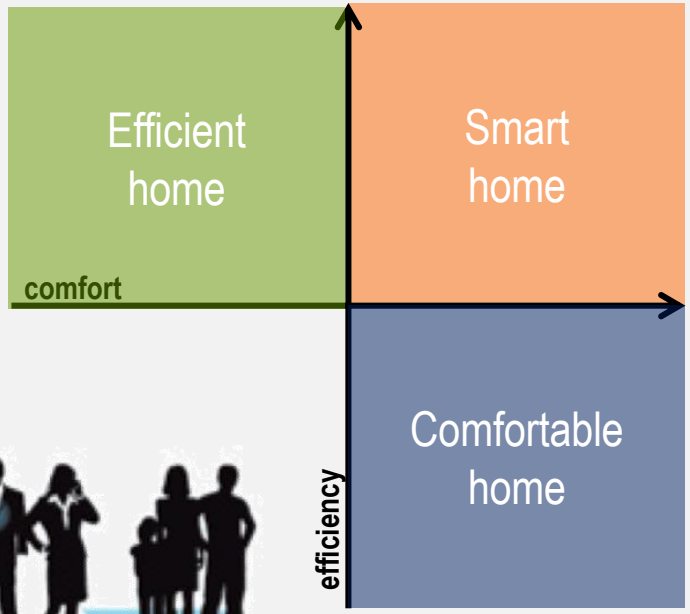
GREY ENERGY
is increasingly
important

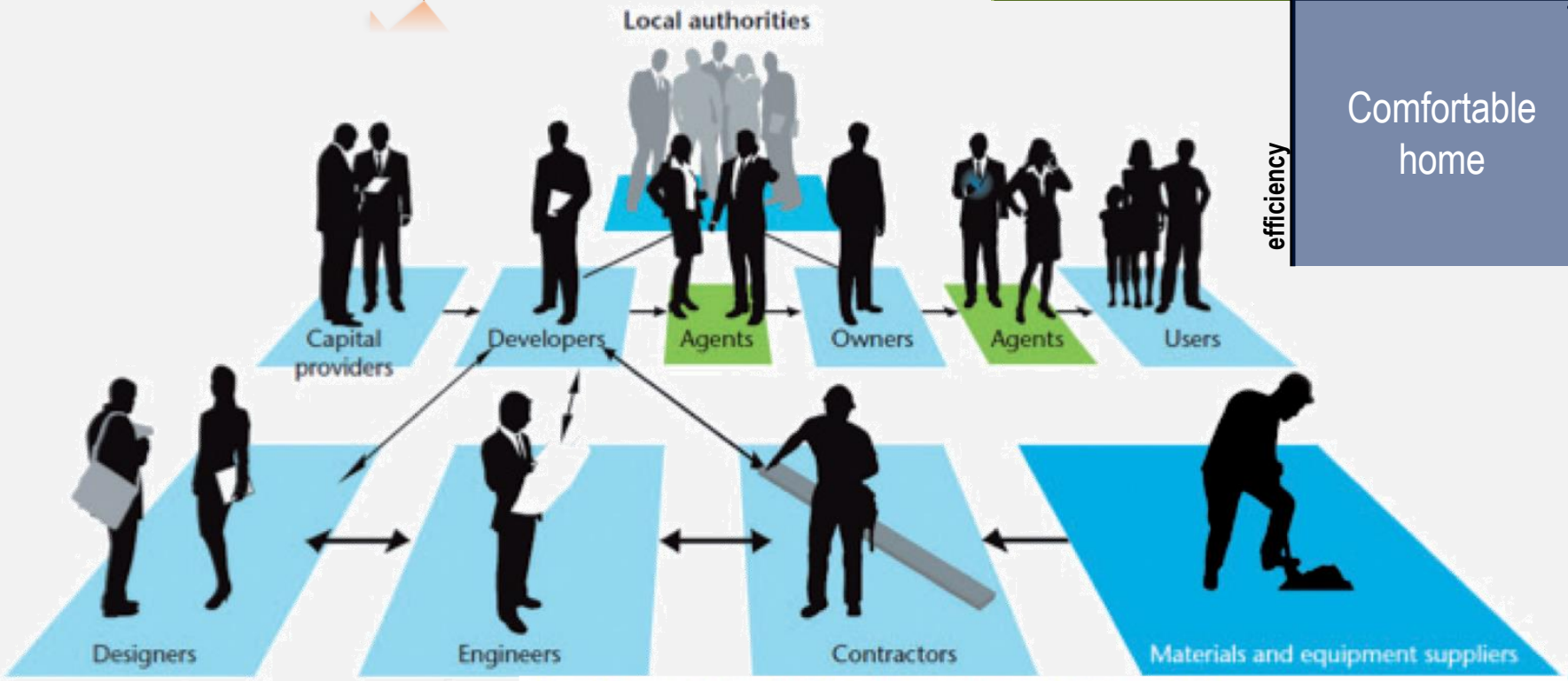
The future construction procedure are increasingly characterized by designing of buildings,
which will have the least impact on the environment, consume less energy than they produce, are comfortable and smart.

APE is not the end of the design ... is the tool!

- a building can be **EFFICIENT** consume low energy but be uncomfortable
- a building can be **COMFORTABLE** but consume a lot of energy
- a building is **SMART** if it consumes low energy and is very comfortable

This is our goal



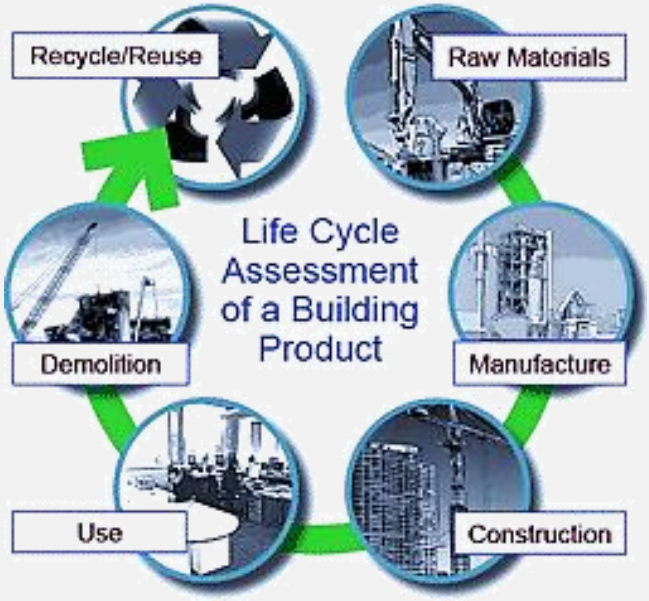


"Energy Efficiency in Buildings", World Business Council for Sustainable Development, 2008
Fonte "A GUIDE TO DEVELOPING STRATEGIES FOR BUILDING ENERGY RENOVATION" Buildings Performance Institute Europe (BPIE).

CONSTRUCTION MARKET IS MATURE

A solar panel does not
make sustainable a building

a thermal insulator is not sufficient
in order to create the comfort conditions



OBJECTIVE

decrease our consumption of
non-renewable resources (materials and energy)

do more with less

Total energy use
during the life cycle

EMBODIED ENERGY

EMBODIED ENERGY

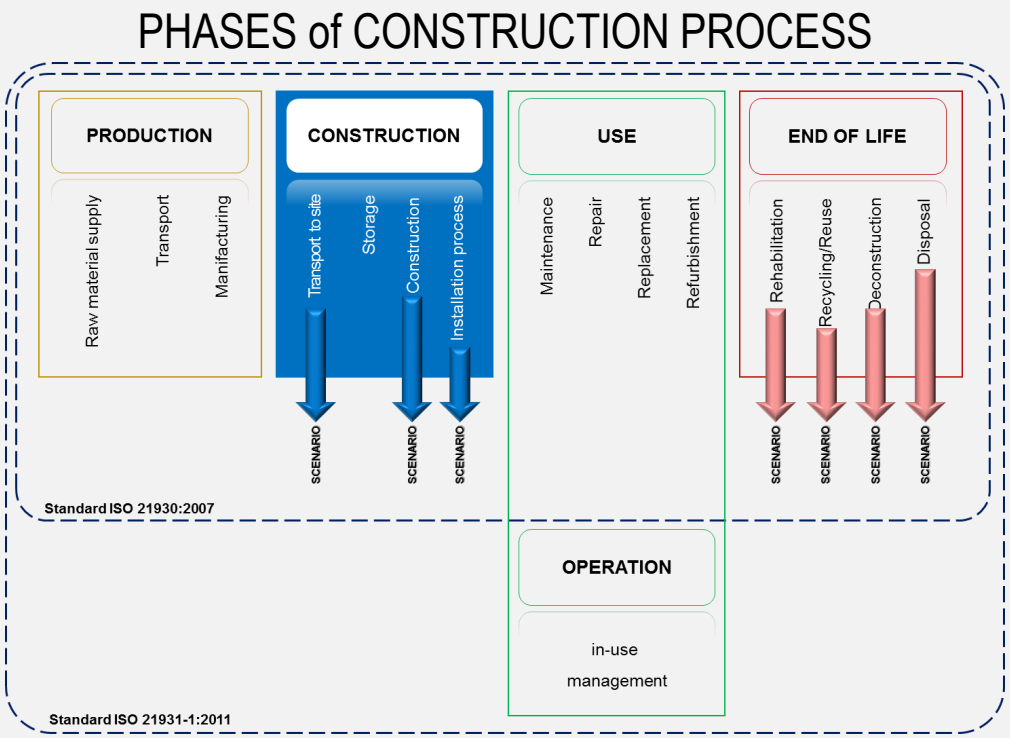
In the building industry, the energy consumption of the life cycle consists of two components:

- **Operating Energy**
- **Embodied Energy**

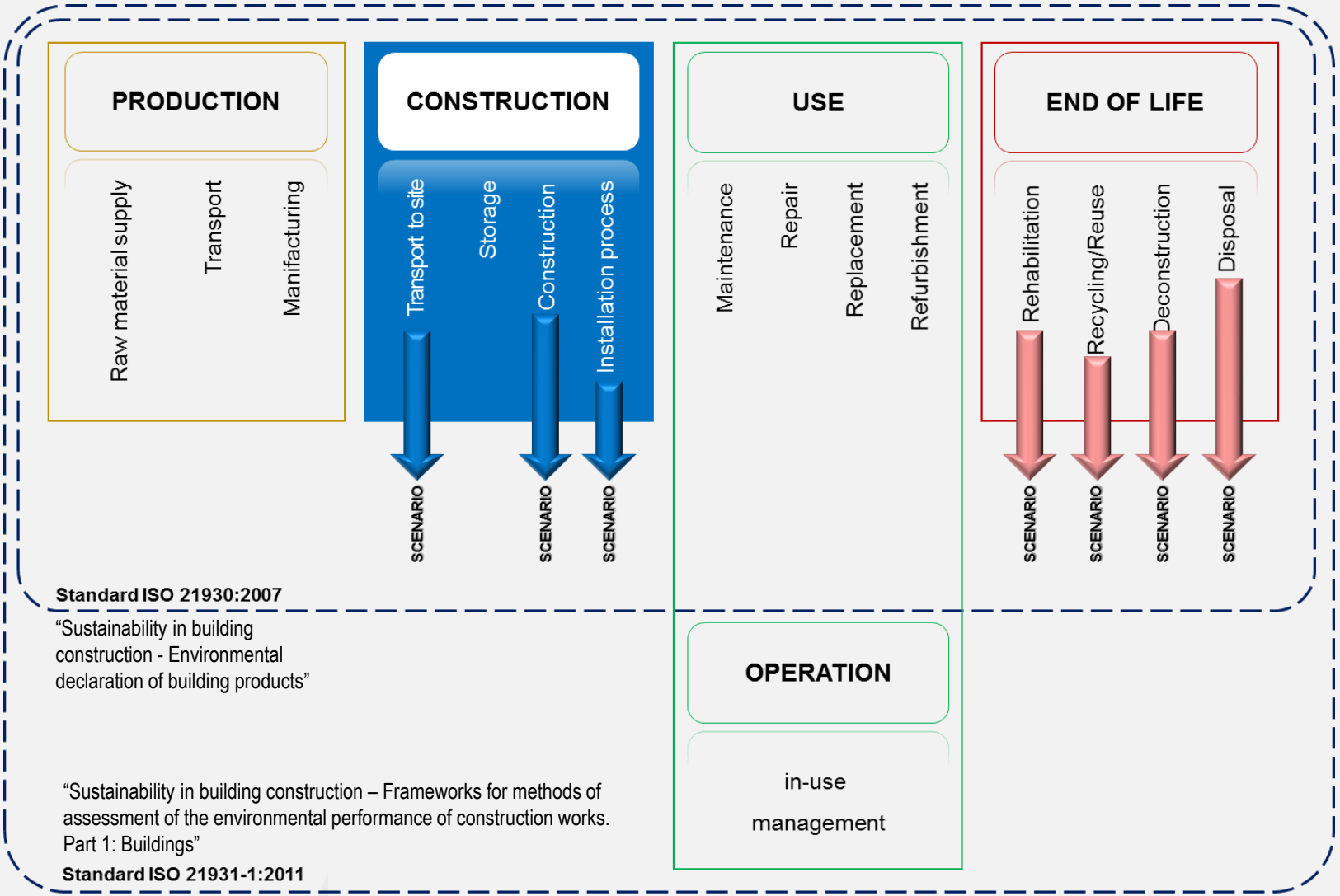
DURING OPERATING PHASE

non-renewable energy for heating, cooling lighting, ventilation and domestic hot water

The embodied energy is non-renewable energy required for the production phase, construction and end of life



EMBODIED ENERGY



LIFE CYCLE STAGE/PHASE

PRODUCTION

Refurbishment

Design

CONSTRUCTION

USE

Operation (in-use)

Maintenance

END OF LIFE

ASSET RATING (predicted values)

MEASUREMENT

ENQUIRIES (e.i. user satisfaction)

OPERATIONAL RATING

Performance aspect

material

product

system

Operational indicators

Asset indicators

Location-related indicators

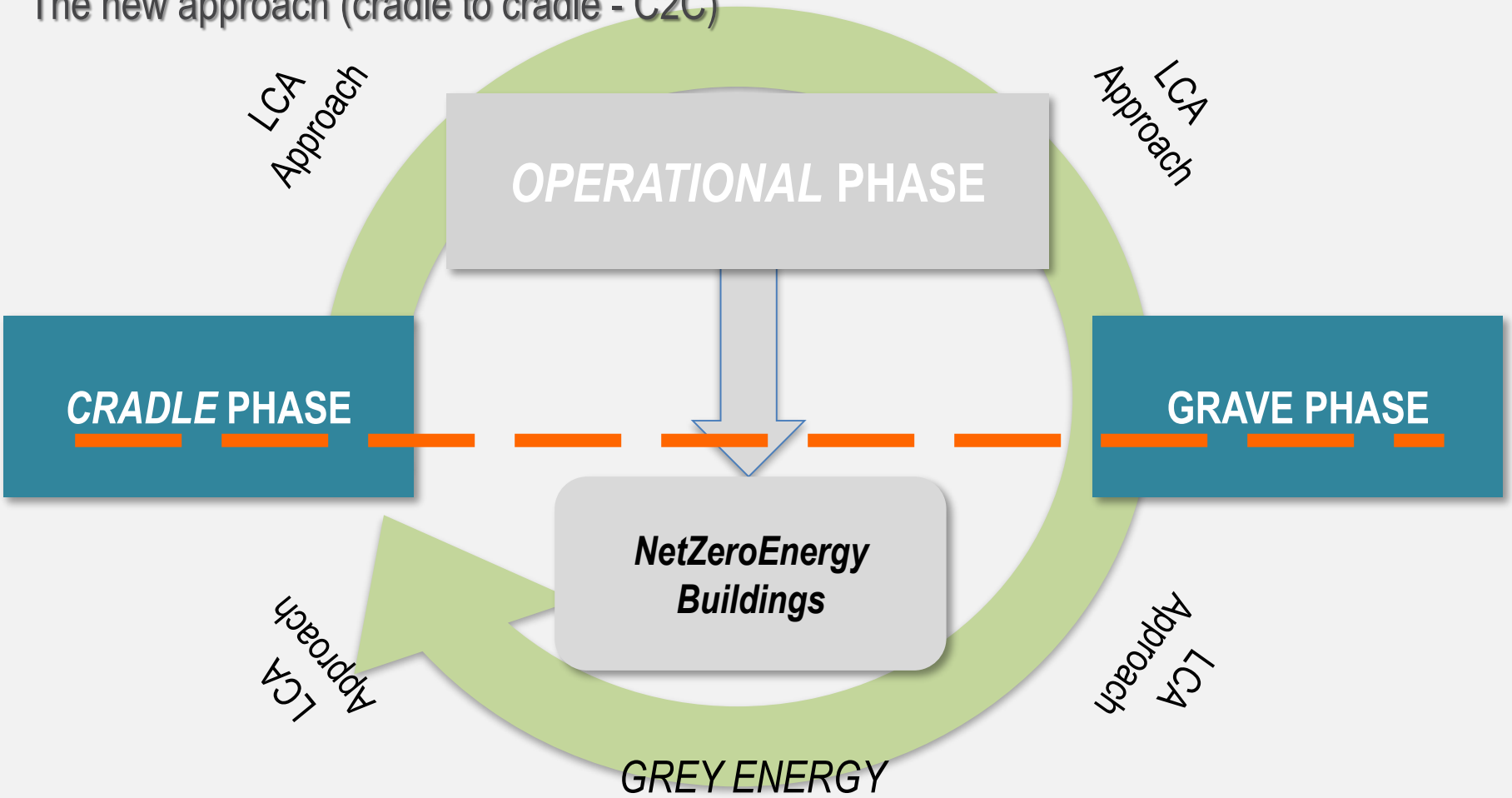
Site-related indicators

Building-related indicators

Process-related indicators

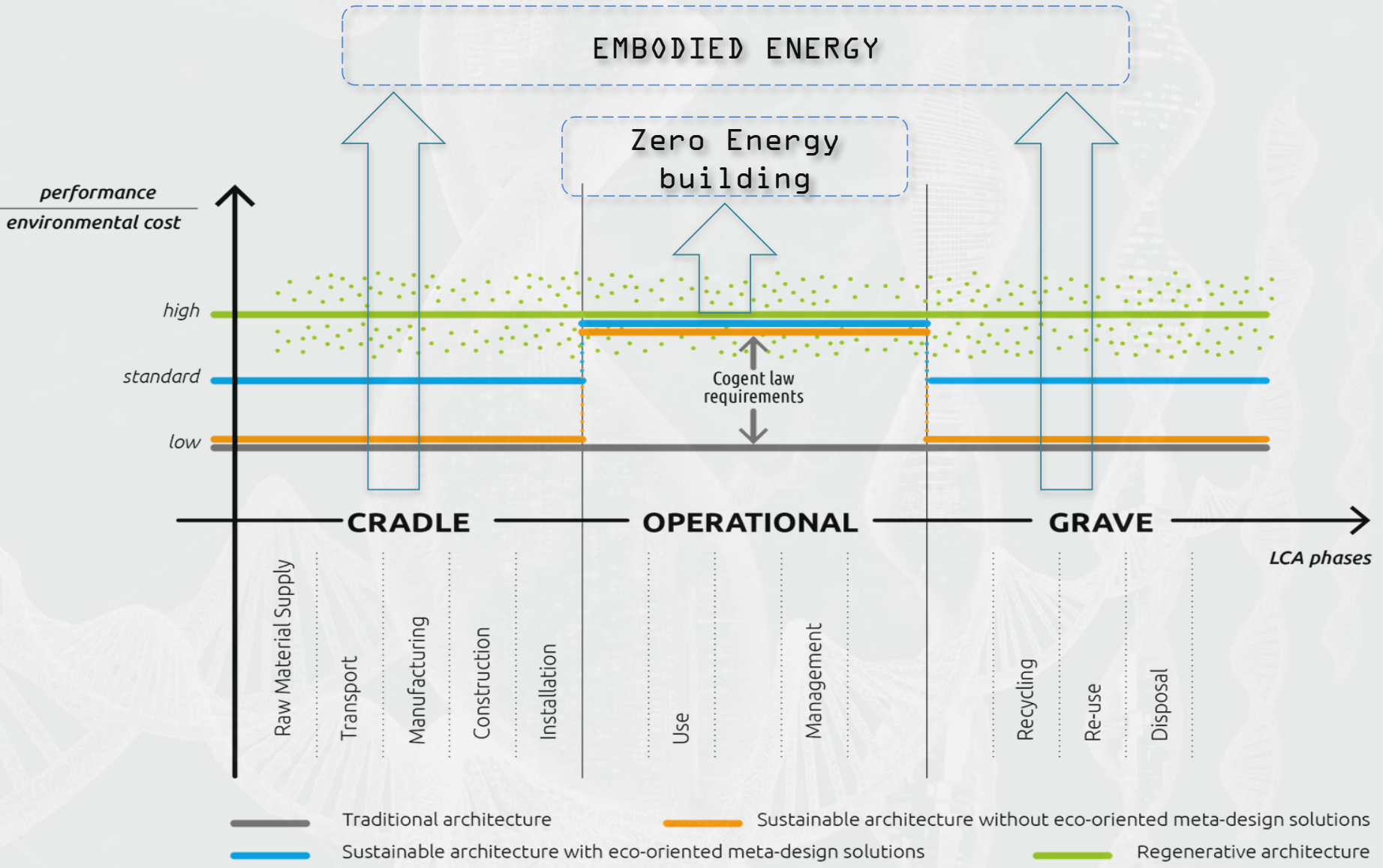
Recommendations
Technical solutions
Best Practices

The new approach (cradle to cradle - C2C)



GREY ENERGY
is increasingly important

Integrating the building in the life cycle of the ecosystem


EMBODIED ENERGY
Zero Energy building
performance
environmental cost
high
standard
low
Cogent law requirements
CRADLE
OPERATIONAL
GRAVE
LCA phases
Raw Material Supply
Transport
Manufacturing
Construction
Installation
Use
Management
Recycling
Re-use
Disposal
Traditional architecture
Sustainable architecture without eco-oriented meta-design solutions
Sustainable architecture with eco-oriented meta-design solutions
Regenerative architecture

From Sustainability to Regerenative approach

the Global Footprint Network created

SPEEDOMETER

which examines the percentage of biocapacity humans have required over the years.

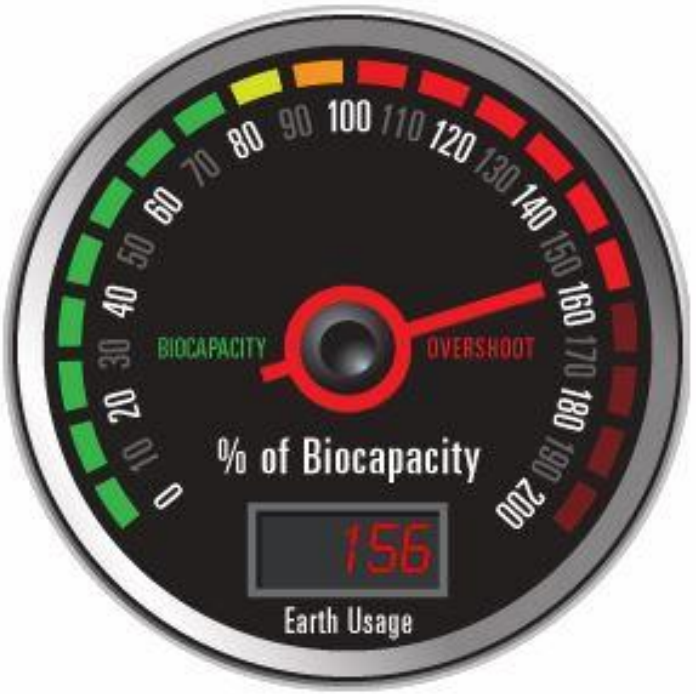
REGENERATIVE

=

returning energy to the source

applying the principles of living systems to the business and development fields

Regenerative development is centered around the idea that the earth can be healed and regenerated through human development.

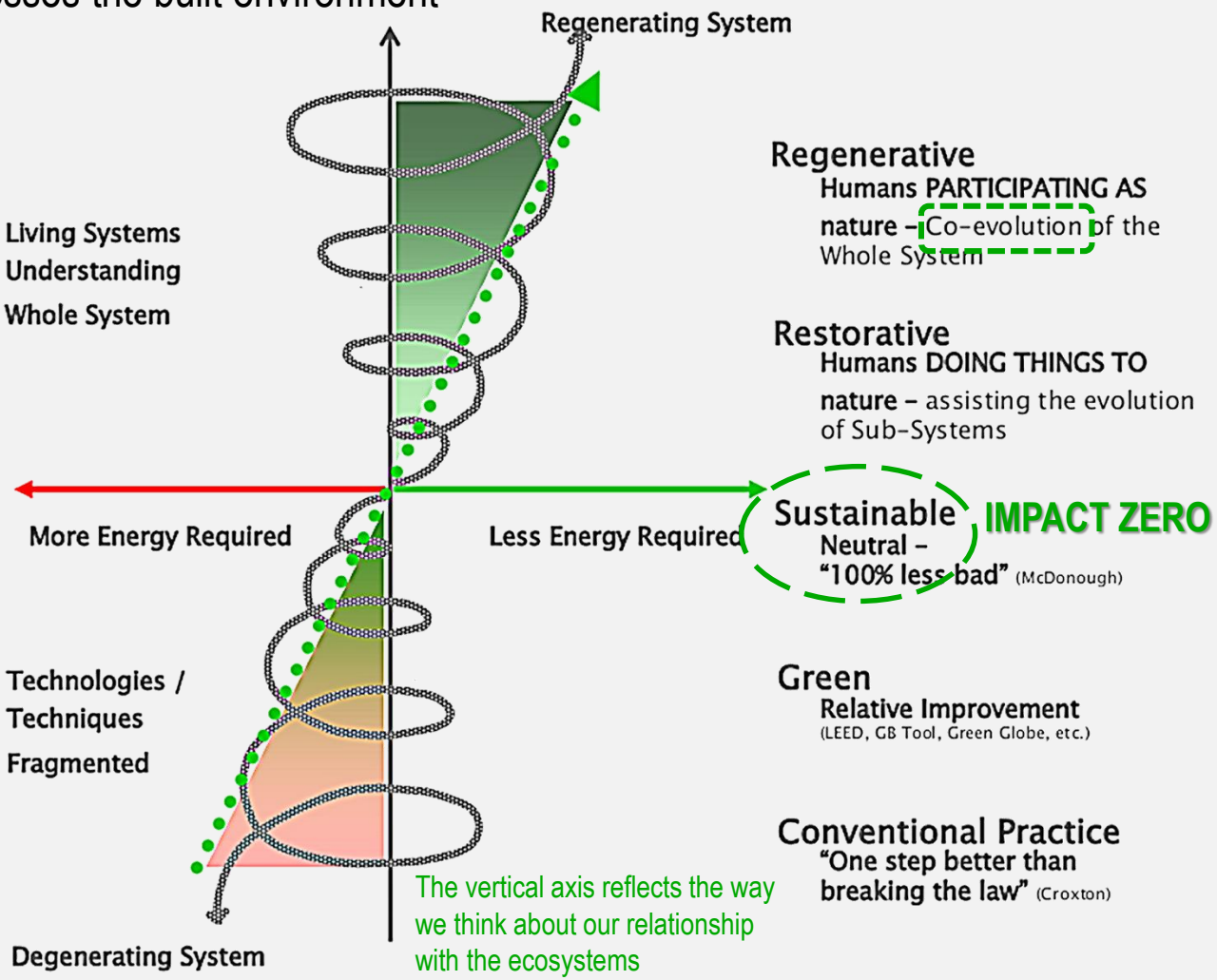


SOURCE: http://www.urbanthriving.com/news/what-is-regenerative-development/

this approach primarily addresses the built environment

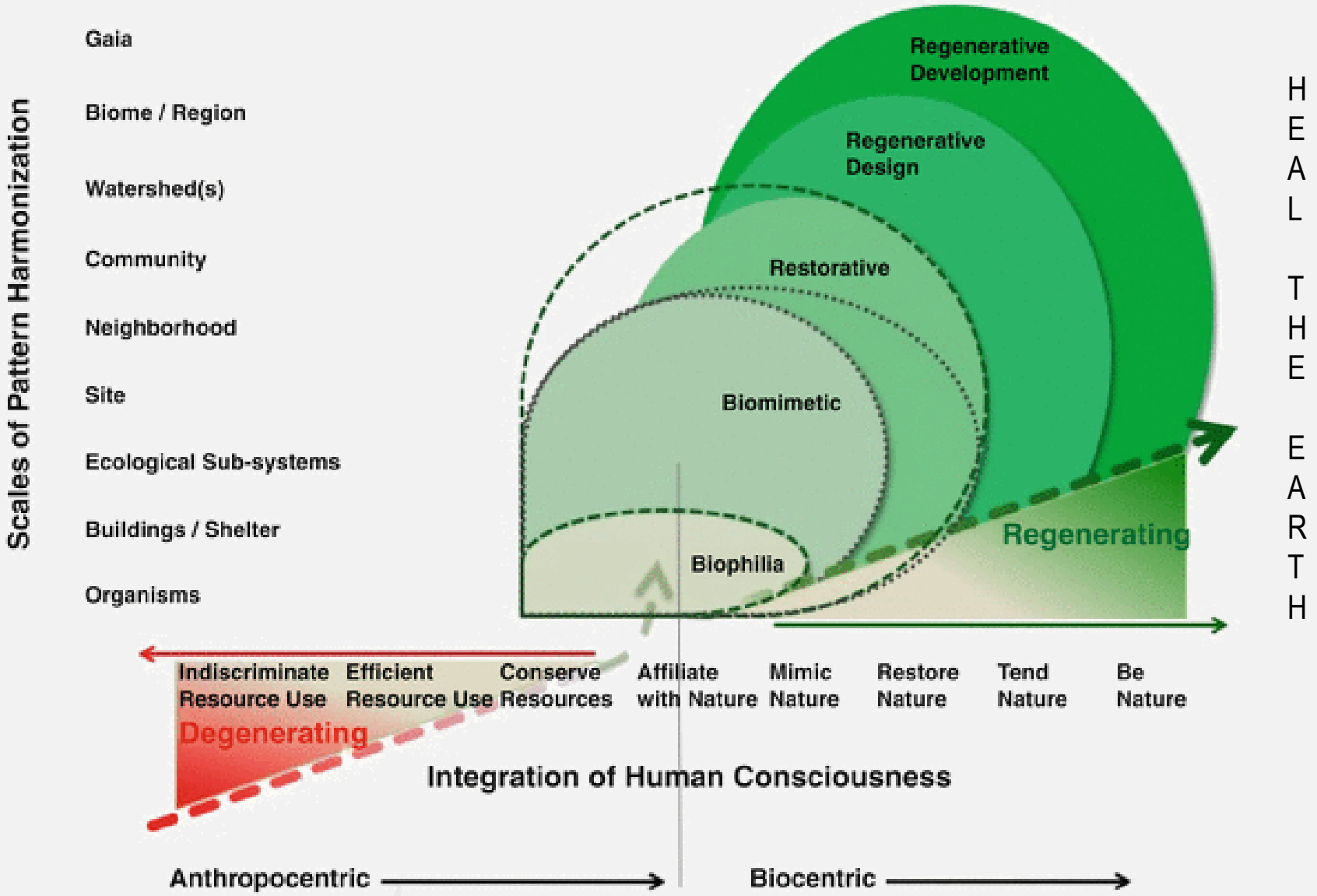
The horizontal axis reflects the emerging changment in the technologies that we use to make the products and services we use

bio-based technologies that process renewable materials



Trajectory of Environmentally Responsible Design

See more at: http://balance3.com.au/sustainable-restorative-regenerative-whats-in-a-name/#sthash.DjUmjMnH.dpuf


Scales of Pattern Harmonization
Gaia
Biome / Region
Watershed(s)
Community
Neighborhood
Site
Ecological Sub-systems
Buildings / Shelter
Organisms
Regenerative Development
Regenerative Design
Restorative
Biomimetic
Biophilia
Regenerating
HEAL THE EARTH
Indiscriminate Resource Use
Efficient Resource Use
Conserve Resources
Affiliate with Nature
Mimic Nature
Restore Nature
Tend Nature
Be Nature
Degenerating
Integration of Human Consciousness
Anthropocentric
Biocentric

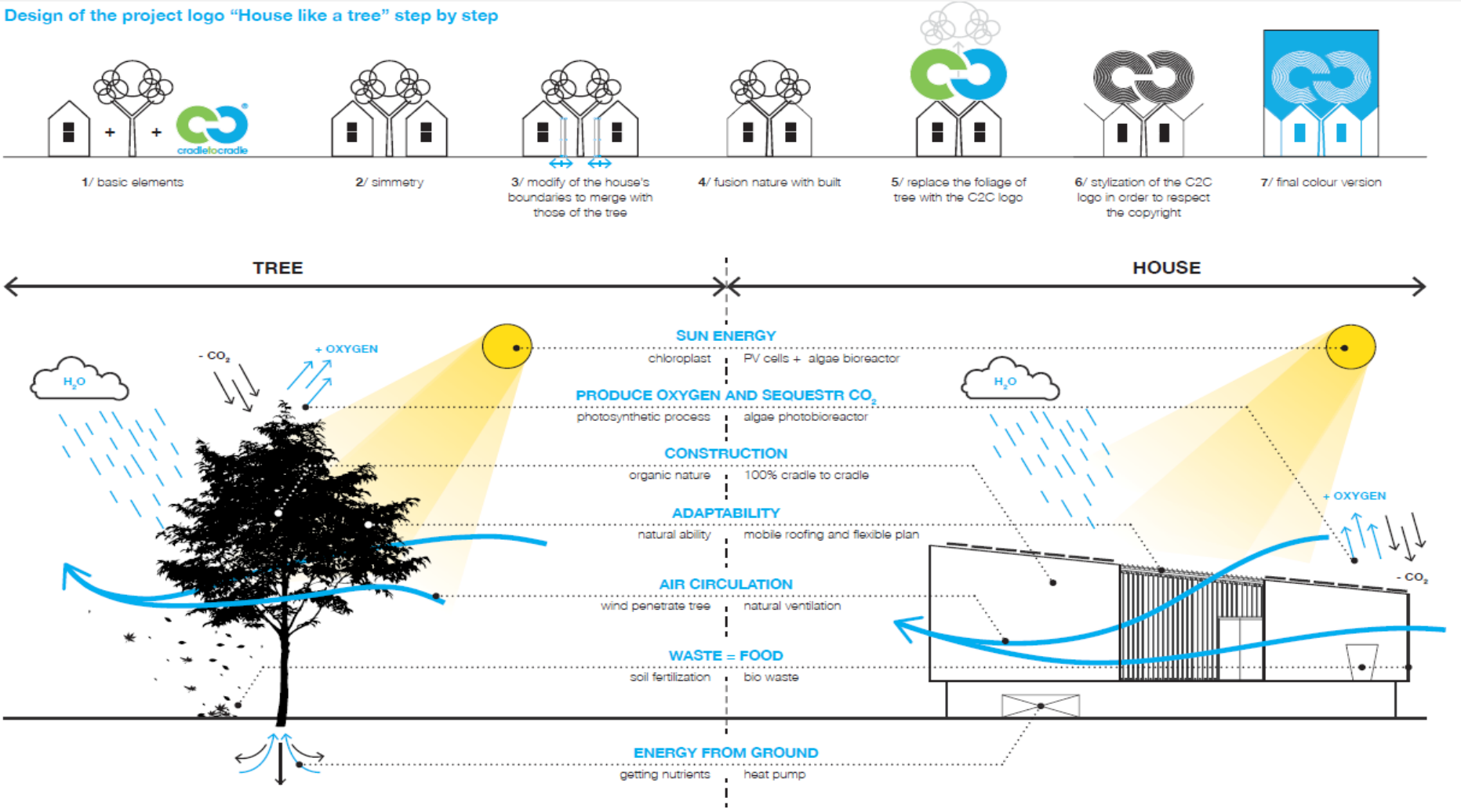
Stages of a regenerative development process

In the article *Green to the Power of Three*, Regenesis Group's Ben Haggard outlined a set of six distinctive stages of a regenerative development process, which uses Place as a fulcrum for transformation.

1. Elucidating place as a living system into which the project must integrate.
2. Envisioning the higher order potential that exists in that system, and how integration of project and place can bring that into being.
3. Generating a concept for the project, based on this understanding of place and potential.
4. Enabling stakeholdership in what could be.
5. Generating an aim for the project, the project team and the system as a whole.
6. Translating this vision into reality without collapsing into automatic patterns.

SOURCE: http://www.urbanthriving.com/news/what-is-regenerative-development/

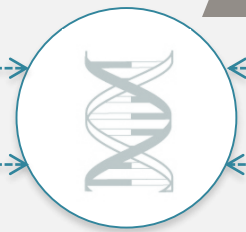
The design is not only a process but a “place” of reciprocal relationship



developing an innovative "ecology of space“ implies a new "ecology of behaviour"

Genetic engineering

Biotechnology



Electrical engineering

Biophysics

Synthetic biology

will be able to imagine and build new living systems (which display functions that do not exist in nature) for useful purposes

Architectural

fields

Building

BIO-SENSORS

Es.. microbes that change color when detecting toxins or find and heal cracks in concrete

Energy

BIO-FUELS

derived from converting of readily available solar energy and natural or waste materials

Environment

BIO-REMEDIATION

based on the design and modification of microorganisms such as fungi or bacteria to eliminate toxic substances and pollutants from soil or contaminated water

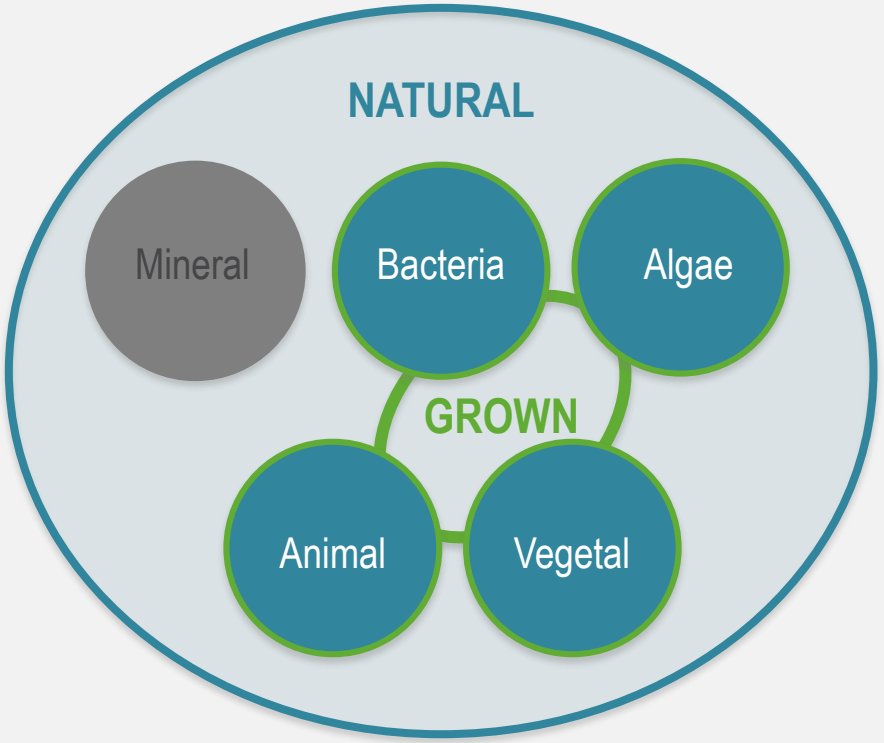
Grown materials

**BIO-BASED BUILDING MATERIALS:
A REGENERATIVE ALTERNATIVE**

"**Grown** is any raw material, product, technology and/or process that is based upon natural growing cycles in the plant, animal, fungal and bacterial kingdoms. […]"

Proprieties

- **Minimal environmental impact during production process**
- **High recyclability**
- **Minimal hazardus**
- **High productivity**
- **High environmental purification efficiency**



The grown materials: applications in architecture

the **biotic-processed** that collects the materials generated by an actively participation of living organisms in the process of creating the final product

the **biotic-processing** that collects the materials in which the living organisms are integrated into the final product to extend the service life.

Bacteria-based materials

BioMason

Bio-On

Bio cement

Fungi-based materials

Ecovative

Algae based materials and systems

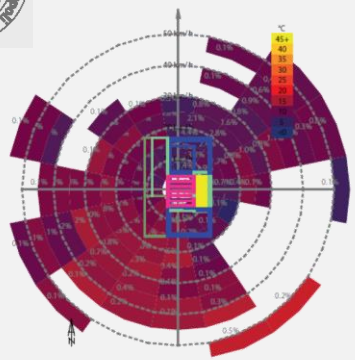
EdiMare

Urban algae façade

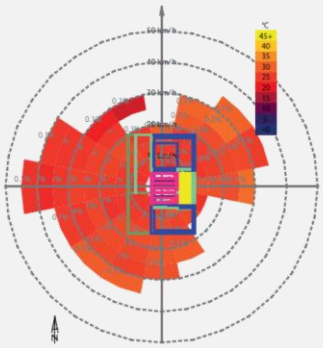
Solar*Leaf*

The role of the microorganism ends at the time when the construction product is made.

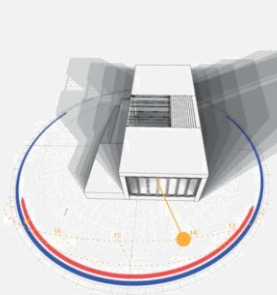
microorganisms co-evolve with the building and their living process continue during the operational phase



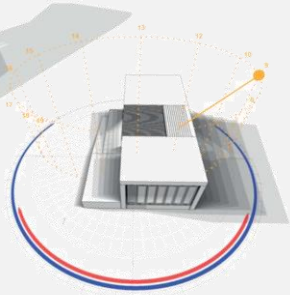
Venti prevalenti Inverno



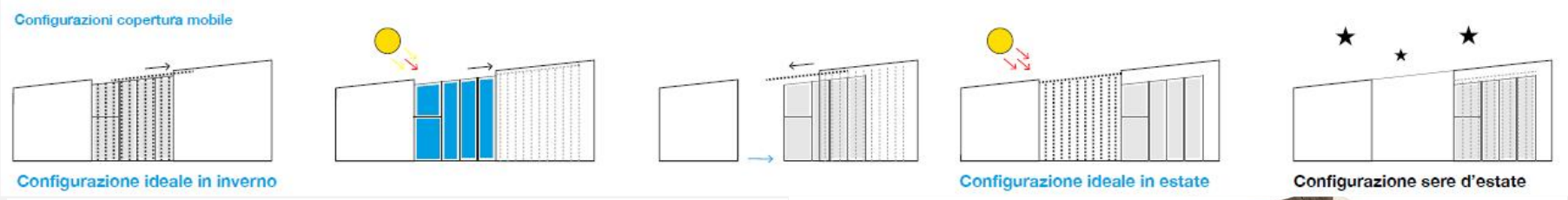
Venti prevalenti Estate

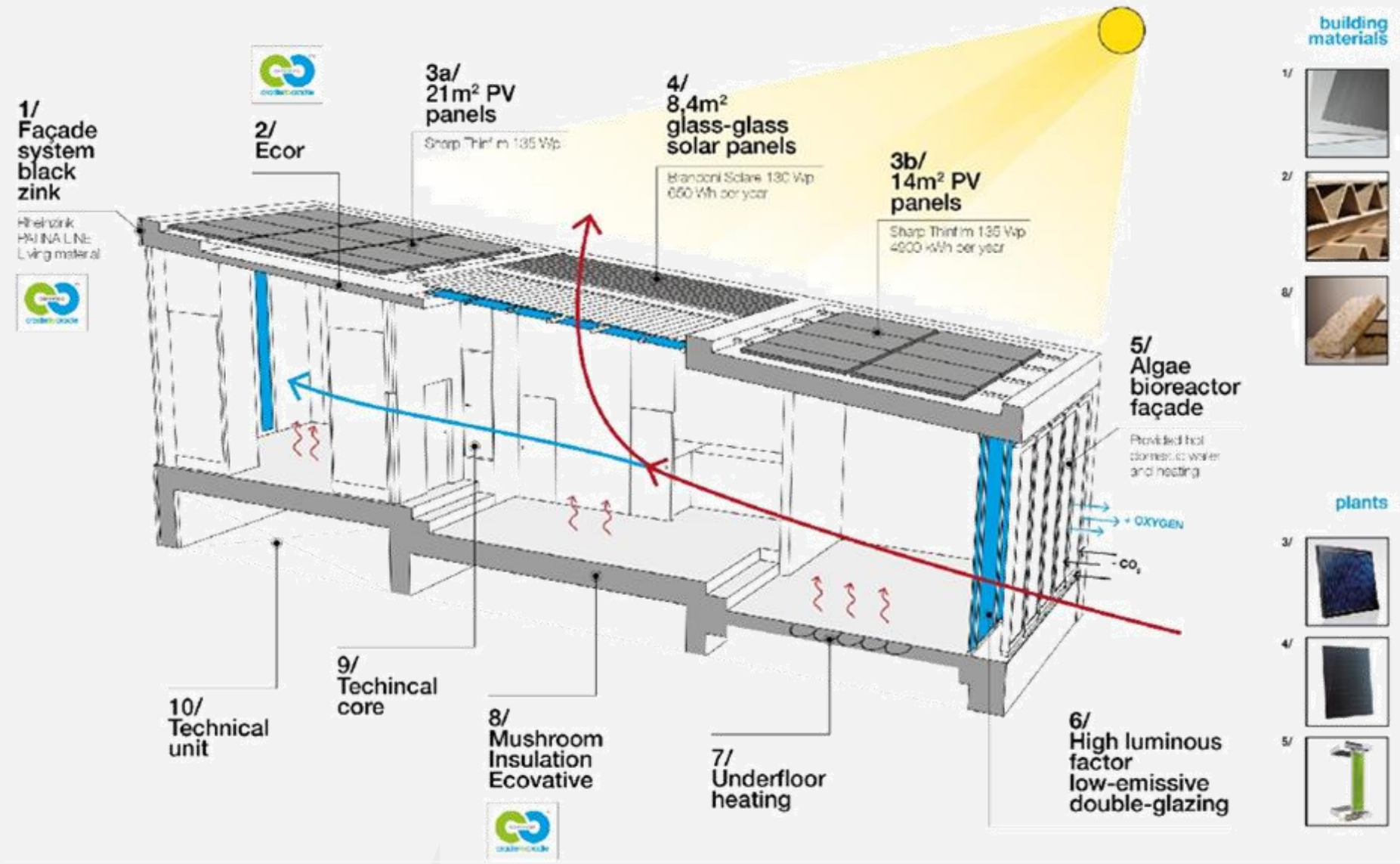


Range ombre Inverno



Range ombre Estate

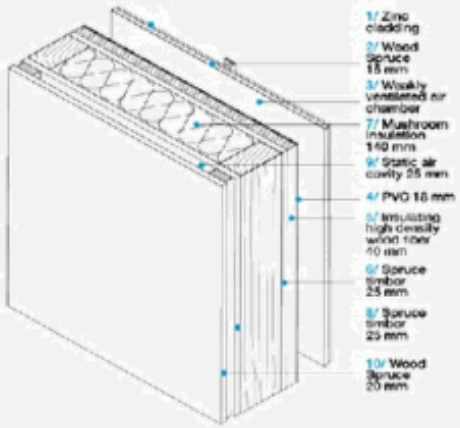



1/
Façade system black zink
2/
Ecor
3a/
21m² PV panels
4/
8,4m² glass-glass solar panels
3b/
14m² PV panels
5/
Algae bioreactor façade
6/
High luminous factor low-emissive double-glazing
7/
Underfloor heating
8/
Mushroom Insulation Ecovative
9/
Techincal core
10/
Technical unit
+ OXYGEN
- CO2
building materials
plants

The structural resilience is formally realized through different design solutions, regarding first of all the envelope, but also plants systems, furniture and materials.

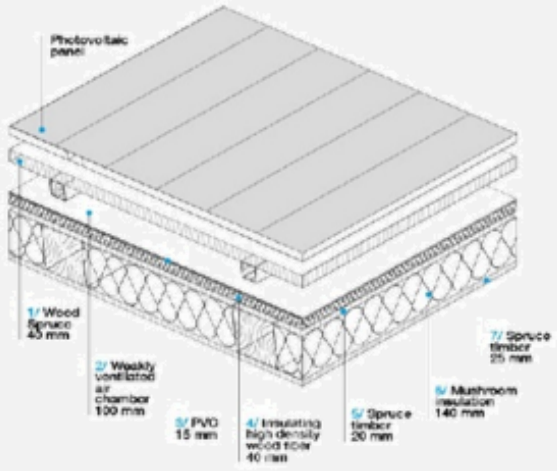
External wall

Total layers	10
Total thickness	392,8 mm
Thermal resistance	5,7094 m²K/W
Thermal transmittance	0,1751 W/m²K
Attenuation	0,1647
Time shift (ext-int flux)	12h 35'



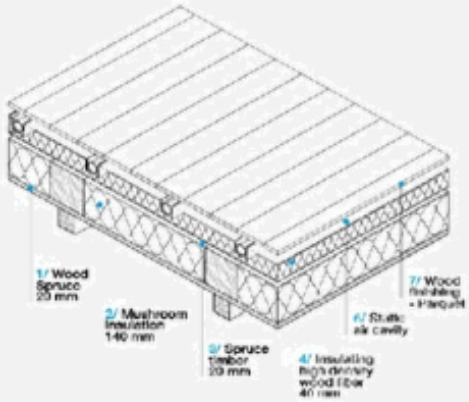
Living area roof

Total layers	7
Total thickness	361,5 mm
Thermal resistance	5,5158 m²K/W
Thermal transmittance	0,1813 W/m²K
Attenuation	0,2518
Time shift (ext-int flux)	11h 14'



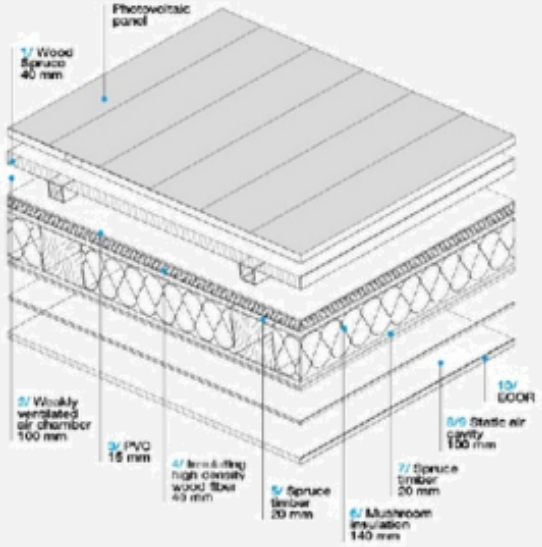
Floor

Total layers	7
Total thickness	261 mm
Thermal resistance	5,8175 m²K/W
Thermal transmittance	0,1719 W/m²K
Attenuation	0,2648
Time shift (ext-int flux)	9h 48'



Night area roof

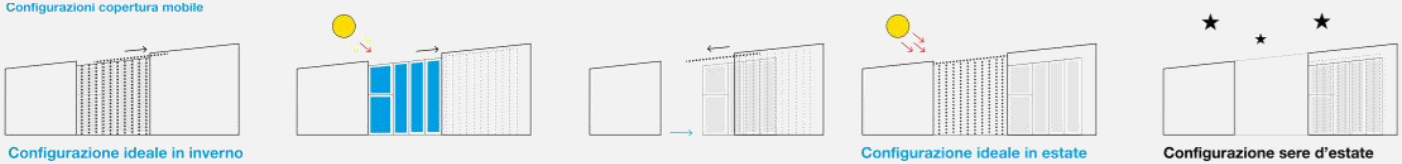
Total layers	10
Total thickness	581,5 mm
Thermal resistance	6,1835 m²K/W
Thermal transmittance	0,1617 W/m²K
Attenuation	0,1492
Time shift (ext-int flux)	13h 17'



Vista esterna Ovest/ Configurazione con copertura vetrata

Vista esterna/ Configurazione sere d'estate

Configurazioni copertura mobile



Configurazione ideale in inverno

Configurazione ideale in estate

Configurazione sere d'estate

PLUS VALORE

Doppia copertura mobile a scomparsa per un maggiore benessere termoigrometrico

Vista interna/ Configurazione con copertura vetrata

Vista esterna Sud-Ovest/ Configurazione con copertura vetrata

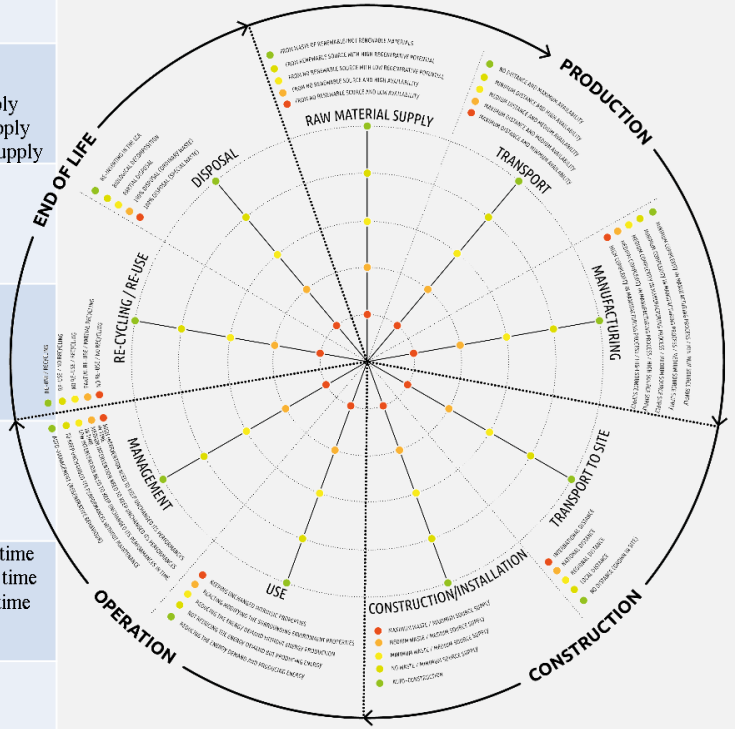
Vista interna/ Patio chiuso

Vista interna/ Patio chiuso

	Criteria	Range
PRODUCTION	Raw material supply	1. From no renewable source and low availability 2. From no renewable source and high availability 3. From no renewable source with low regenerative potential 4. From renewable source with high regenerative potential 5. From waste of renewable/not renewable materials
	Transport [Distance/ Availability]	1. Maximum distance and minimum availability 2. Maximum distance and medium availability 3. Medium distance and medium availability 4. Minimum distance and high availability 5. No distance and maximum availability
	Manifacturing [Complexity manufacturing process / Source supply]	1. High complexity in manufacturing process / High source supply 2. Medium complexity in manufacturing process / High source supply 3. Medium complexity in manufacturing process / Medium source supply 4. Minimum complexity in manufacturing process / Medium source supply 5. Minimum complexity in manufacturing process / Minimum source supply
CONSTRUCTION	Transport to site	1. International distance 2. National distance 3. Regional distance 4. Local distance 5. No distance (grown in site)
	Construction / Installation process [Waste/Source supply]	1. Maximum waste / Maximum source supply 2. Medium waste / Medium source supply 3. Minimum waste / Medium source supply 4. No waste / Minimum source supply 5. Auto-construction
OPERATION	Use [Reactivity]	1. Keeping unchanged intrinsic properties 2. Reacting modifying the surrounding environment properties 3. Reducing the energy demand without energy production 4. Not reducing the energy demand but producing energy 5. Reducing the energy demand and producing energy
	Management [Manteinance of performances during time]	1. High intervention need to keep unchanged its performances during time 2. Medium intervention need to keep unchanged its performances during time 3. Low intervention need to keep unchanged its performances during time 4. To keep unchanged its performances without maintenance 5. Auto-management (regenerative behaviour)
END OF LIFE	Recycling / Re-use	1. No re-use / No recycling 2. Partial re-use / Partial recycling 3. No re-use / Recycling 4. Re-use / No recycling 5. Re-use / Recycling
	Disposal	1. 100% disposal (special waste) 2. 100% disposal (ordinary waste) 3. Partial disposal 4. Biological decomposition 5. Re-inserting in the LCA

RESEARCH COMPARES

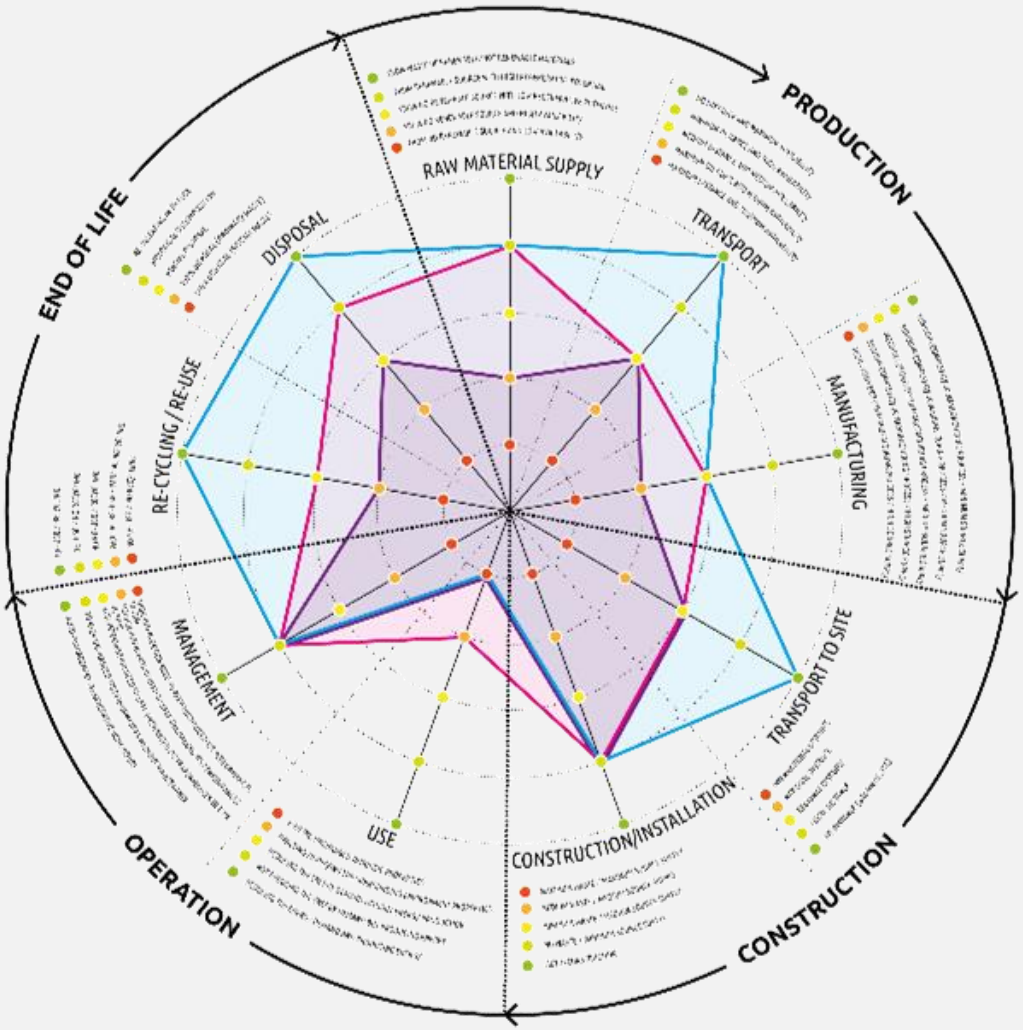
- **bio-based materials**
  grown materials
- **natural materials**
- **traditional materials**



The research highlights the added value of the regenerative approach.

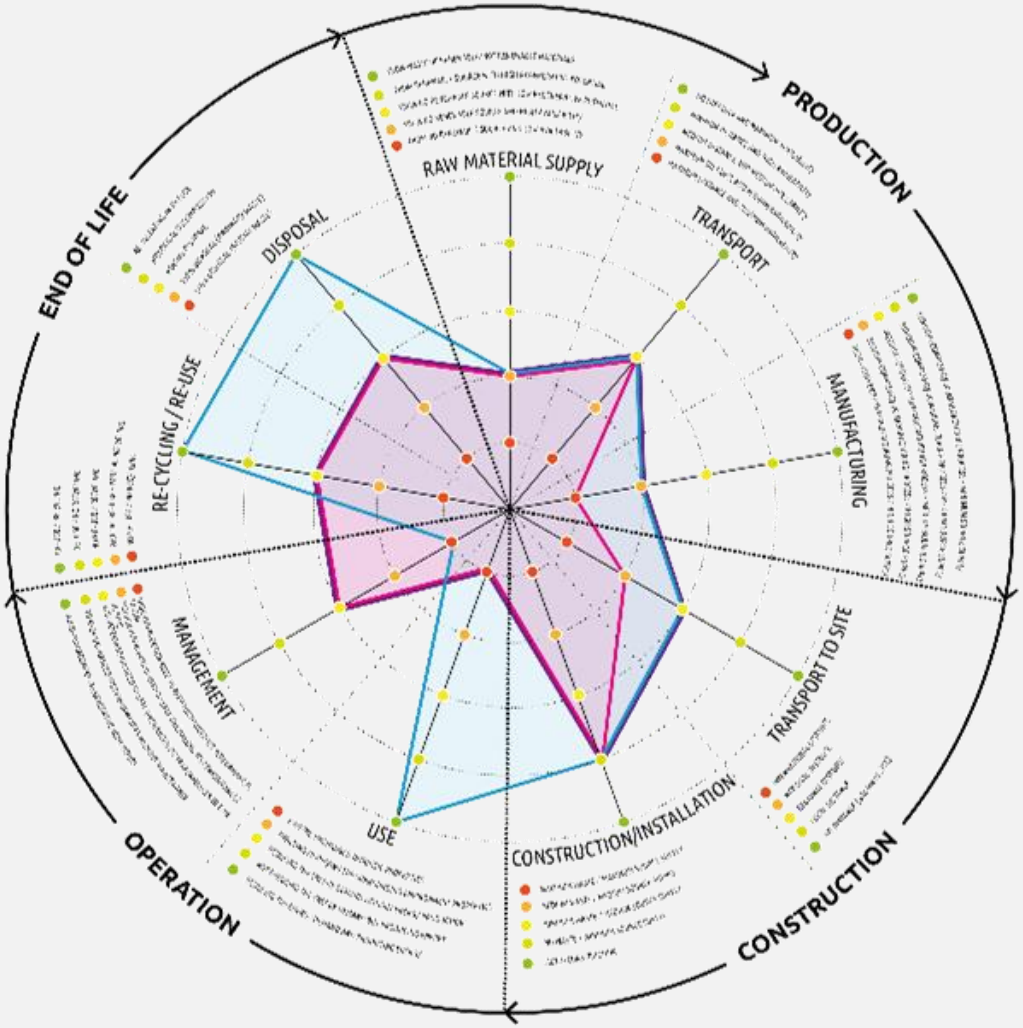
Diagram of opaque envelope

The results, obtained about the opaque envelope (ad example) demonstrate that the regenerative solution is the best, because in operational phase, we have an increase in terms of ratio performance/environmental costs during the cradle-to-gate phase, because it has a lower embodied energy. Moreover, we have an add value in construction phase because it grows directly on site, and finally, in the end of life it returns safely to nature with a positive environmental impact.



GROWN MATERIAL	NATURAL MATERIAL	TRADITIONAL MATERIAL
Bacteria-based brick 46	Hemp-lime brick 31	Clay brick 22

Diagram of transparent envelope

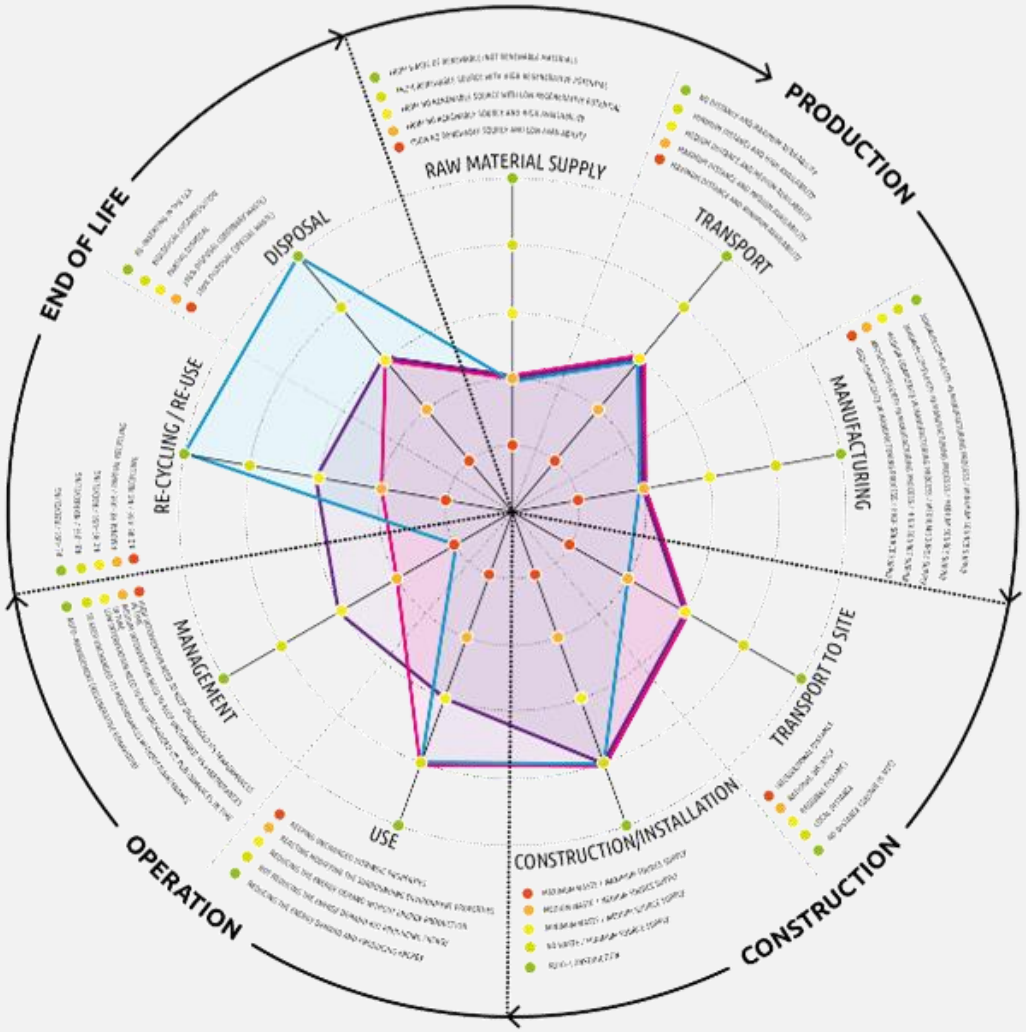


GROWN SYSTEM	BIO-INSPIRED SYSTEM	TRADITIONAL SYSTEM
Bioreactor façade 30	Homeostatic façade 21	Energy-efficient glass 19

Diagram of plant systems

Instead, for the plant system we have not a too diversified score. These systems are constituted by a massive technological component, which requires for the Raw Material Supply or even for Construction, a similar use of resources, materials, and processes.

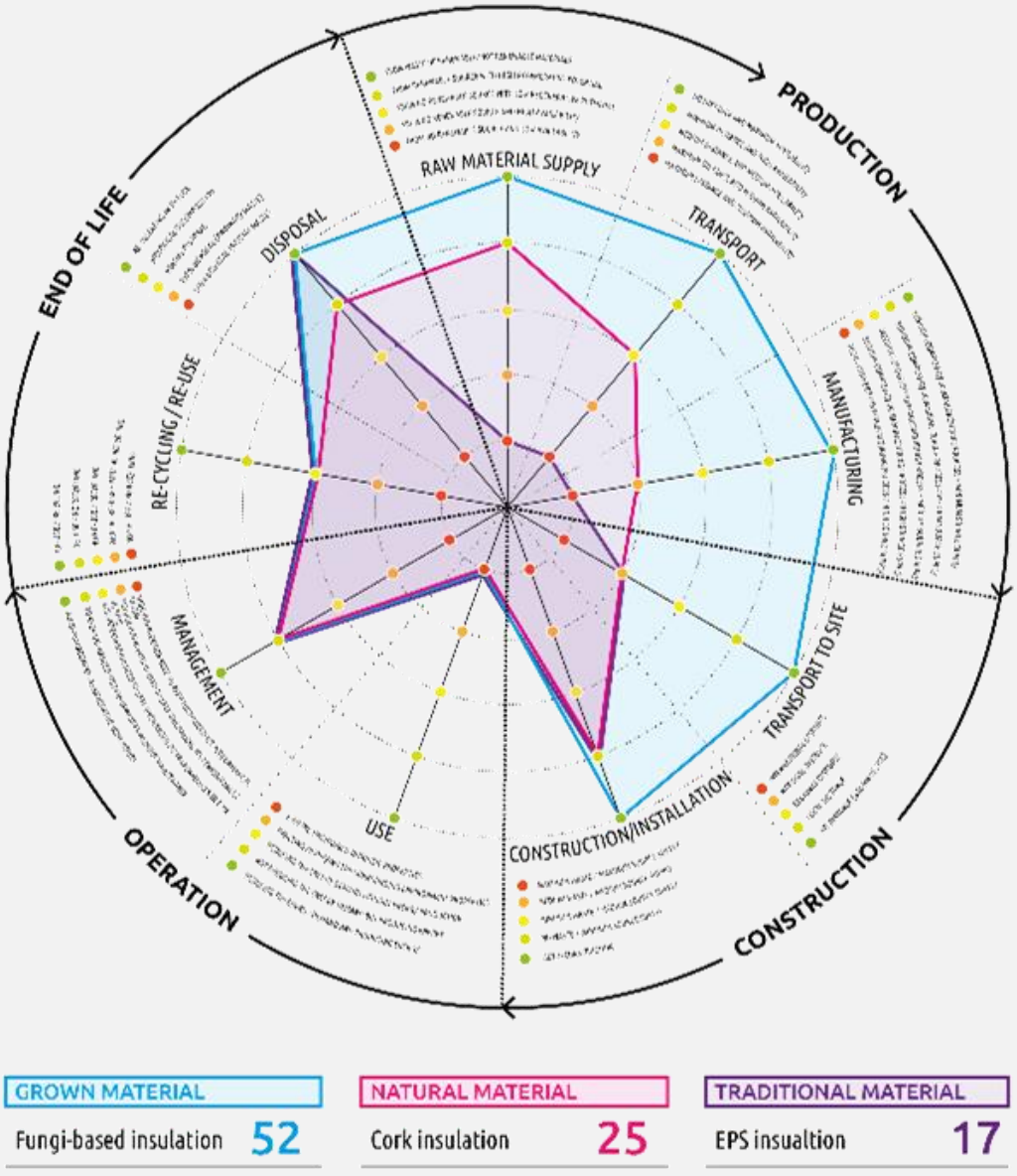
The added value of the bio-reactive façade is in the “use phase”, where they have a high quality score.



GROWN SYSTEM	BIO-INSPIRED SYSTEM	TRADITIONAL SYSTEM
Bioreactor system 29	Solar glass 24	Tradional boiler 26

Diagram of insulation materials

In conclusion, a regenerative approach means moving forward and imagine future scenarios in which buildings live in symbiosis with their inhabitants and the environment of which they are part.



"Understanding how objects and Nature work means to recognise and to understand the many ways in which man-made systems interact with natural ones, which implies what I call ecological intelligence".
Daniel Goleman

Sustainability will never achieve its needs if we do not change our behaviour, culture and way to work.
… this is the new frontier of architecture
… this is the mental and behaviour innovation that asks to the technicians:

let us cultivate ecological intelligence
let us change our way to design!

Nature always wins