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Backing visionary entrepreneurs

The European Innovation Council

Meeting with Member States 27.09.2022

Candidate topics for EIC Challenges in Architecture Engineering Construction

Franc Mouwen

"… And we all know, Europe is a powerhouse in science. Our new Horizon research programme is the largest ever. But we also face a big paradox: We, Europeans, are excellent in making science with money. But we are not so good in making money out of science. And the new European Innovation Council is there to help resolve this paradox." (18/03/2021)

EIC Launch Ceremony

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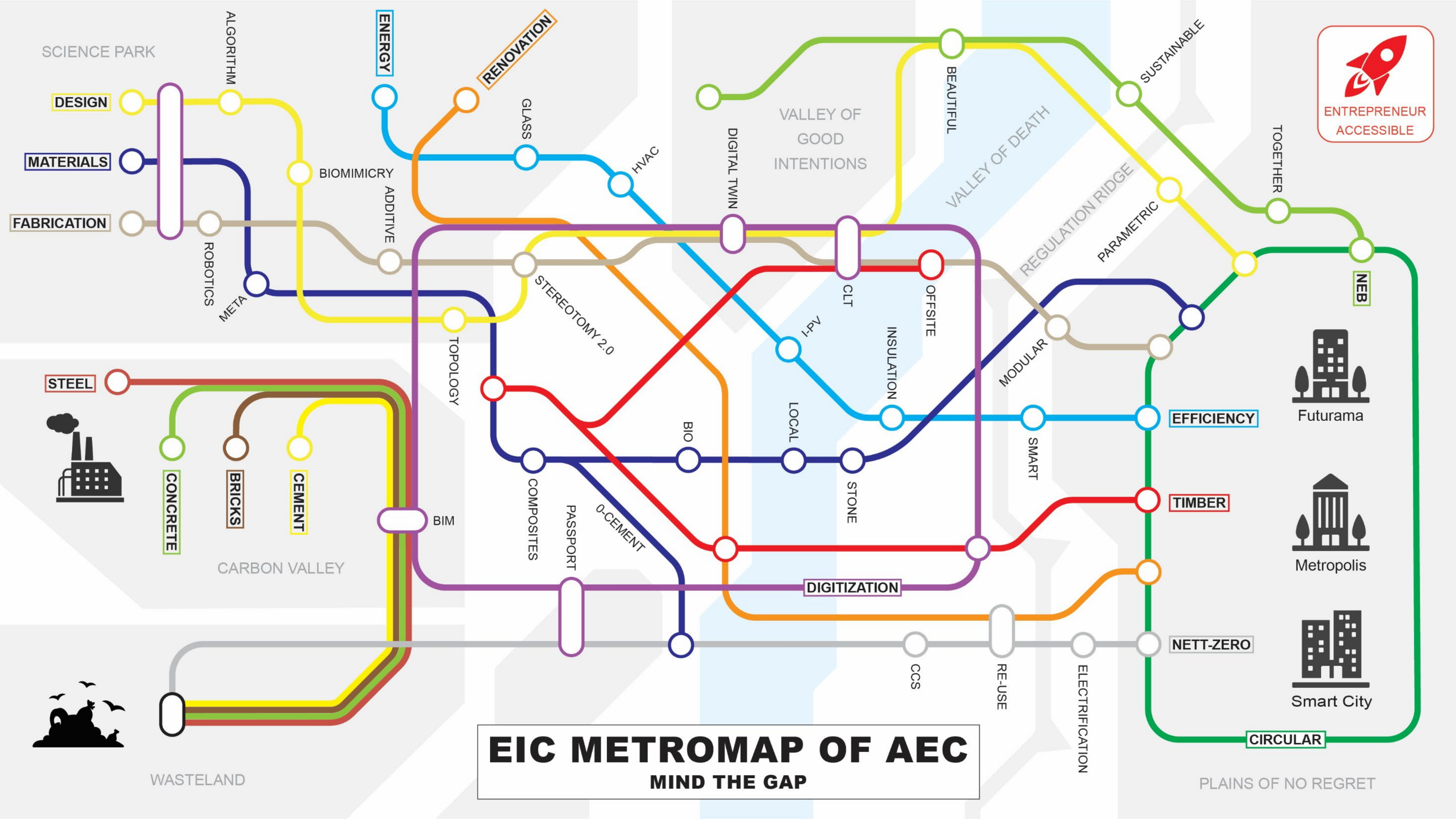

EIC METROMAP OF AEC
MIND THE GAP
SCIENCE PARK
DESIGN
MATERIALS
FABRICATION
ALGORITHM
BIOMIMICRY
ROBOTICS
META
ENERGY
RENOVATION
GLASS
HVAC
ADDITIVE
STEREOTOMY 2.0
TOPOLOGY
DIGITAL TWIN
VALLEY OF GOOD INTENTIONS
VALLEY OF DEATH
REGULATION RIDGE
BEAUTIFUL
SUSTAINABLE
TOGETHER
PARAMETRIC
NEB
ENTREPRENEUR ACCESSIBLE
CLT
OFFSITE
I-PV
INSULATION
MODULAR
EFFICIENCY
Futurama
STEEL
CONCRETE
BRICKS
CEMENT
CARBON VALLEY
BIM
COMPOSITES
PASSPORT
0-CEMENT
BIO
LOCAL
STONE
SMART
TIMBER
Metropolis
DIGITIZATION
NETT-ZERO
CCS
RE-USE
ELECTRIFICATION
Smart City
CIRCULAR
WASTELAND
PLAINS OF NO REGRET

Green Deal:
reduction of embedded carbon

The EU faces a monumental task to decarbonize and modernize the construction sector within 30 years

- The EU committed to net-zero by 2050 by law
- Emissions of the construction sector are estimated at 5-12% of EU's total
- Also, the construction sector accounts for 50% of EU extracted material …
- … and construction and demolition waste accounts for over 35% of EU's waste

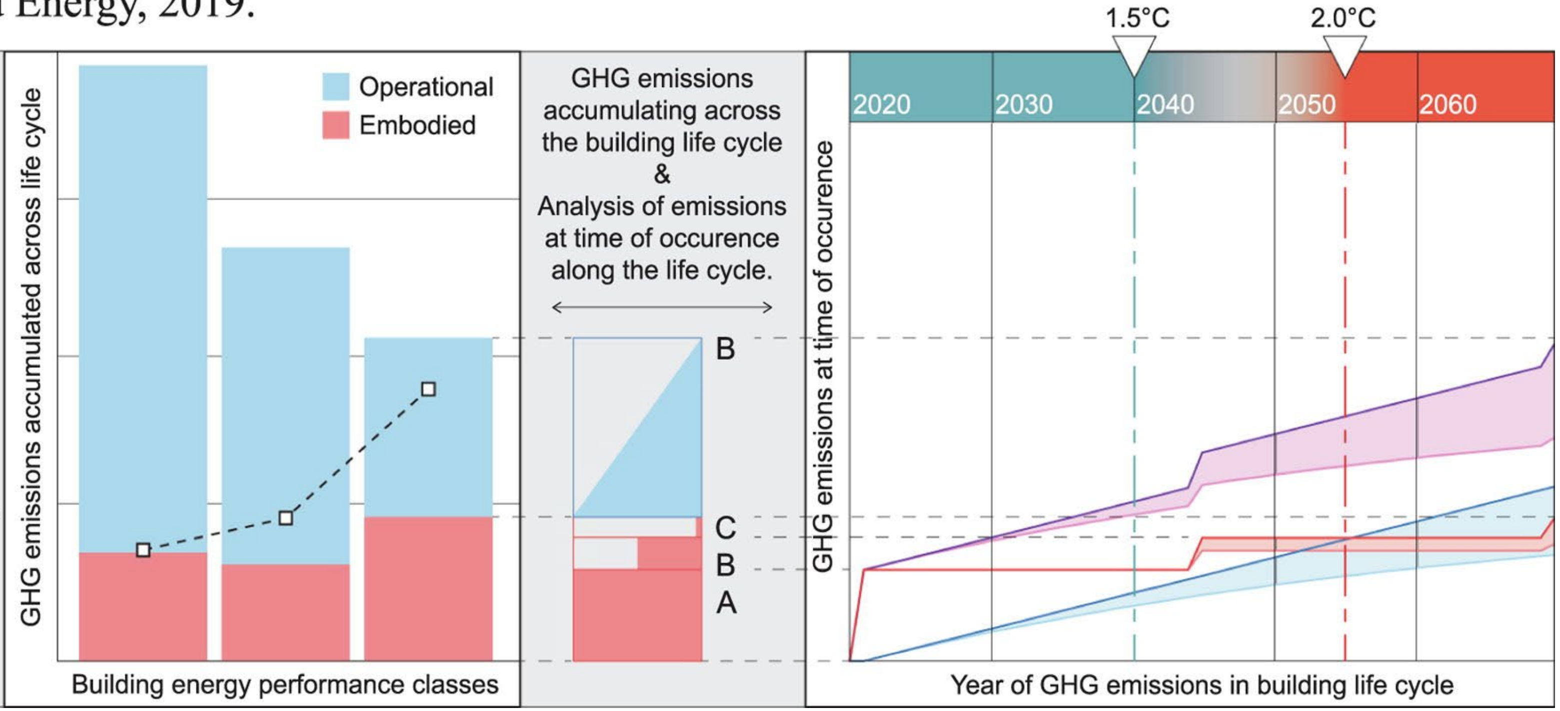
Global context: the world will add the equivalent of 1 New York City, per month, for the next 40 years:

Fossil fuels ugly fossil sister is embodied in our buildings and a climate change mitigation challenge

Embodied GHG emissions of buildings - the hidden challenge for effective climate change mitigation.
M. Röck et al., Applied Energy, 2019.

Highlights

- Systematic analysis of 650+ building LCA cases on life cycle greenhouse gas emissions.
- Buildings life cycle GHG emissions are reducing due to energy efficiency improvements.
- Meanwhile, embodied GHG emissions increased and are now dominating the life cycle.
- New building upfront GHG investments dominate timeframe for climate change mitigation.
- Improvements are needed to meet net-zero life cycle targets and avoid lock-in effects.



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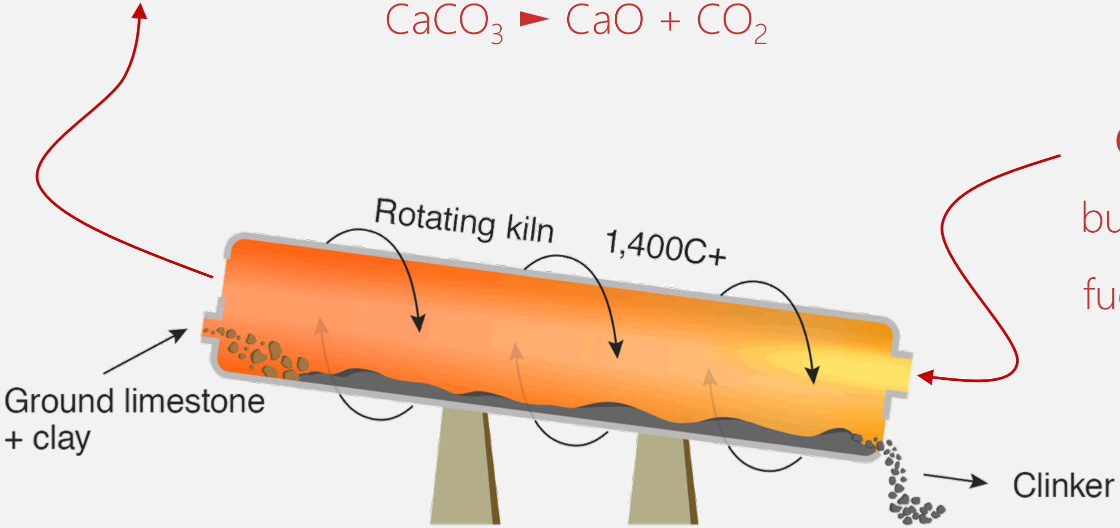
Problems to be solved: emissions from cement and steel and waste from demolished buildings, formwork

The calcination of limestone at high temperatures is the major source of embodied carbon emissions

The Problem

CO2 from calcination reaction of fossil limestone (50%)

$CaCO_3 \blacktriangleright CaO + CO_2$



CO_2 from burning fossil fuels for heat (>40%)

Solutions

- Use alternatives to cement
- Use less materials, cement
- Bury the CO_2 (CCS)
- Upgrade to electric kilns
- Re-use materials

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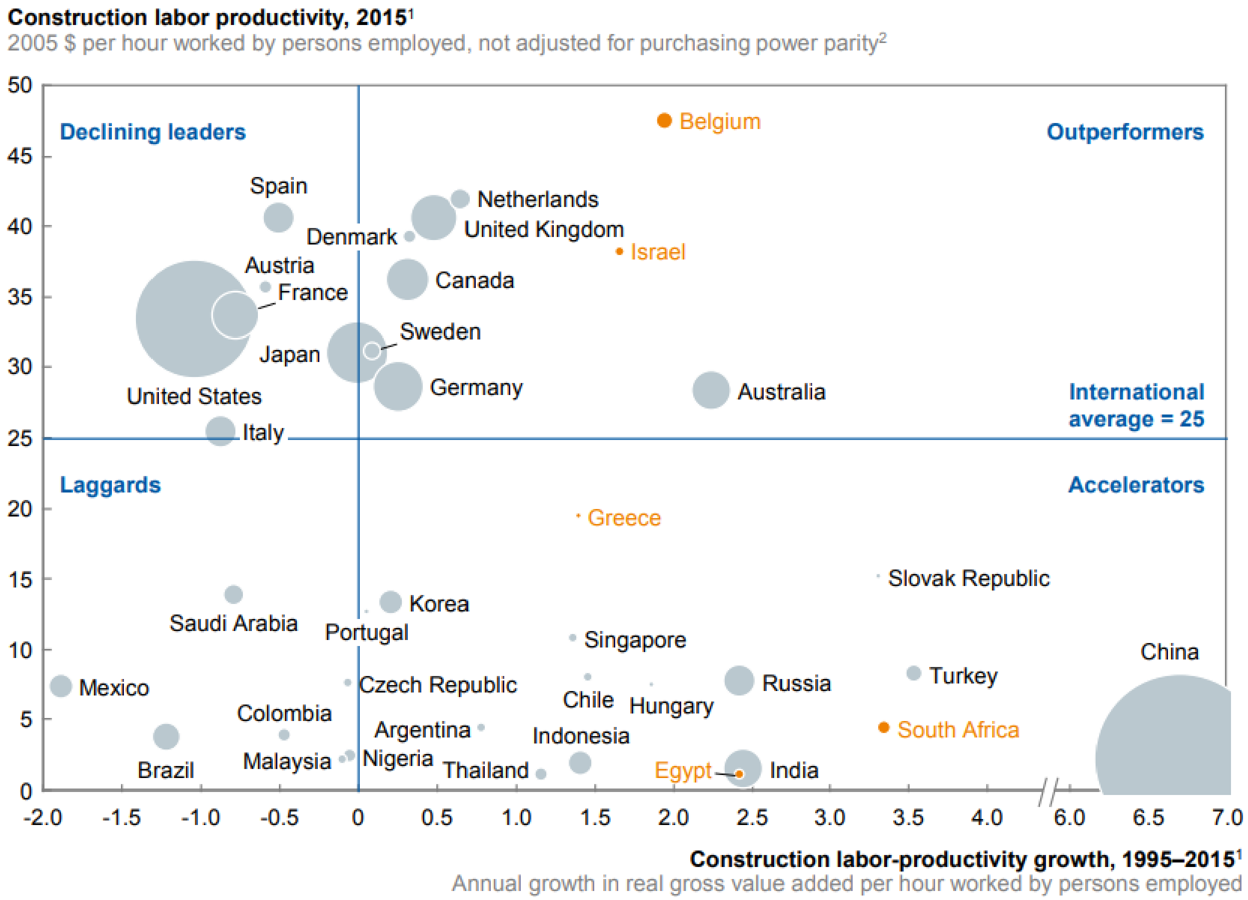
Contrasting all other sectors, the construction sector faces lagging productivity, e/g due to low digitization

The absolute value of productivity



Increase or decrease of productivity over a period of 10 years

Source: McKinsey Global Institute, Reinventing construction: a route to higher productivity, 2017

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Triad of computational design, digital fabrication and materials
(2023 Challenges)

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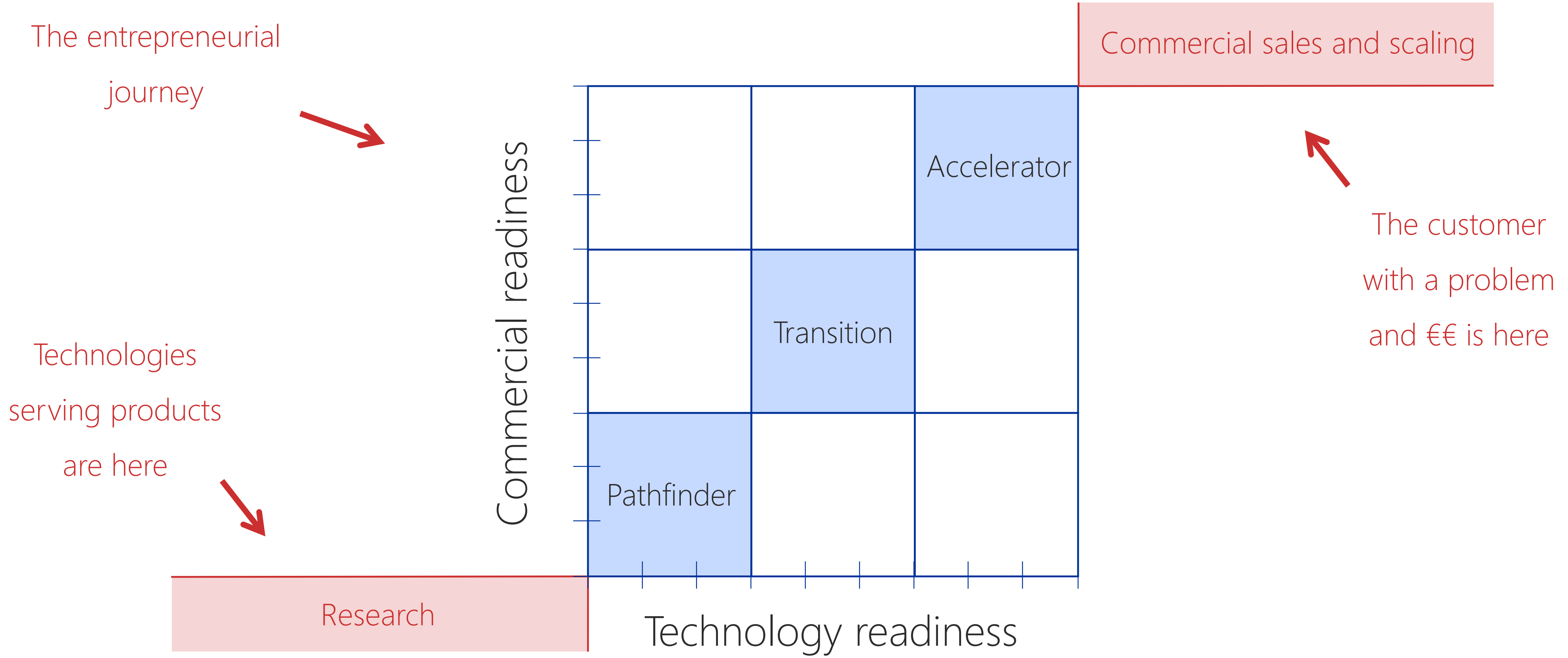
Mind the gap: the type of challenges match the TRL and CRL of pathfinder, transition and accelerator.



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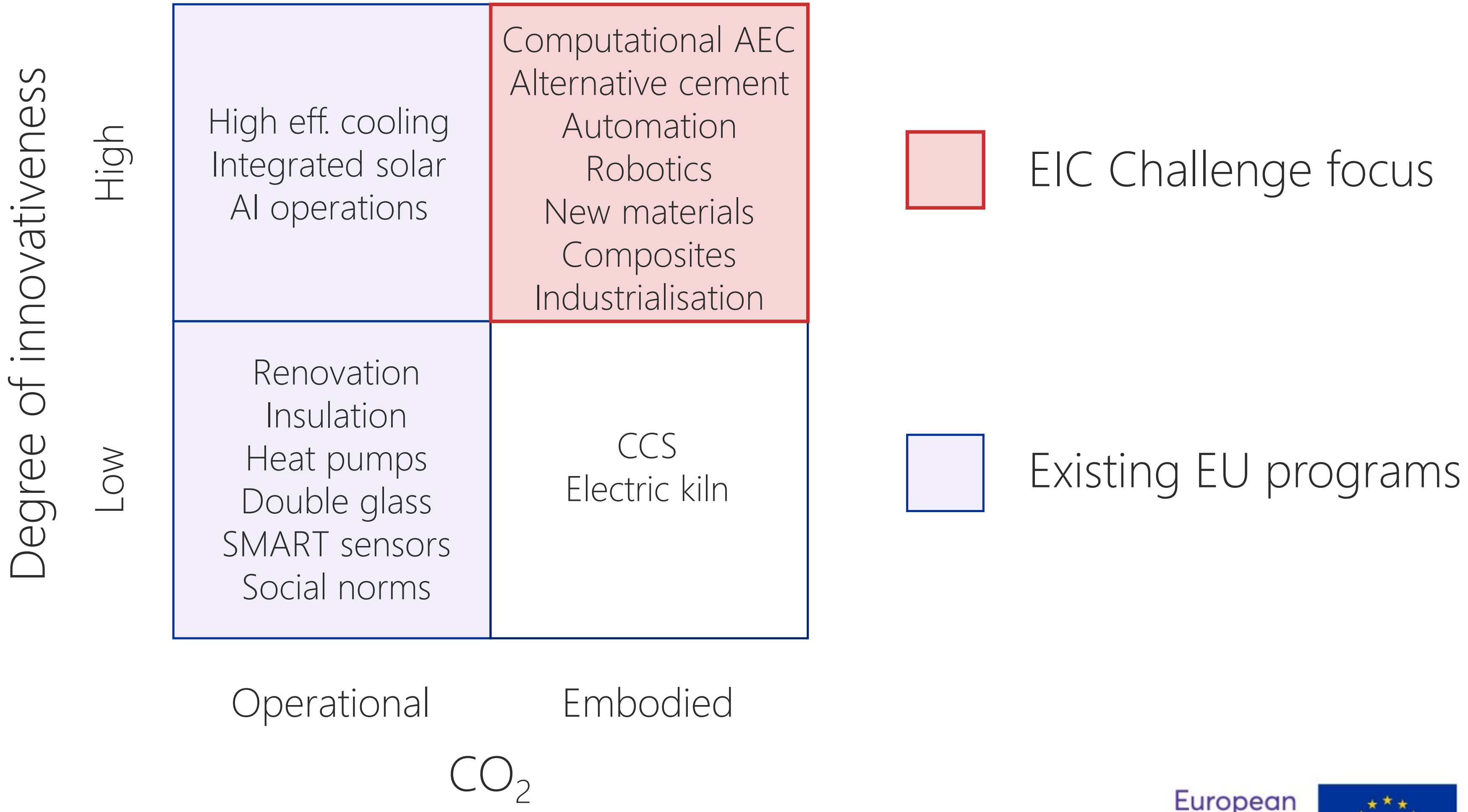
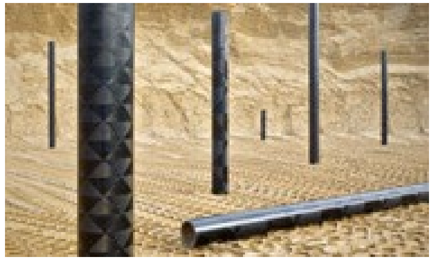
The EIC "AEC Challenges" aim to attack 2 problems: reducing embodied emissions, increasing productivity

The EIC Mission is to support deep-tech entrepreneurs



The "EIC AEC Challenges" are rooted in European RTD across the value chain with commercial potential

Densified wood + composites



Digital stereotomy local stone

Curved CLT timber

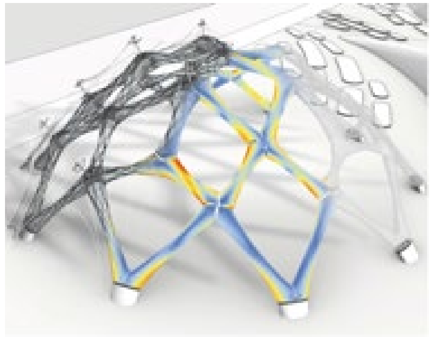
Suspended rapid concrete printing

Robotic fibre production

Biomimicry

Topology optimized concrete slab

Light weight AI computation



Flexible robotic production

Segmented robotic CLT construction

Moulded wood

3D thin shell fabric - no formwork

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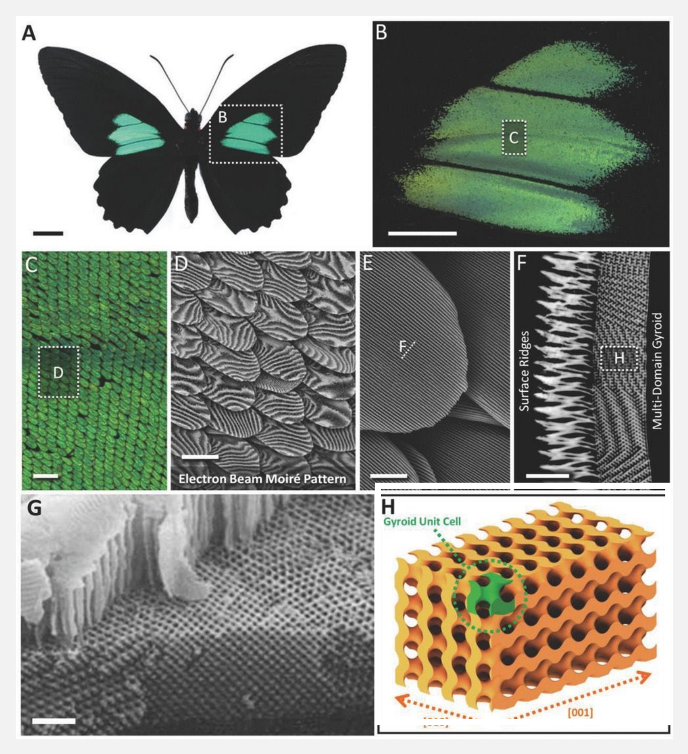
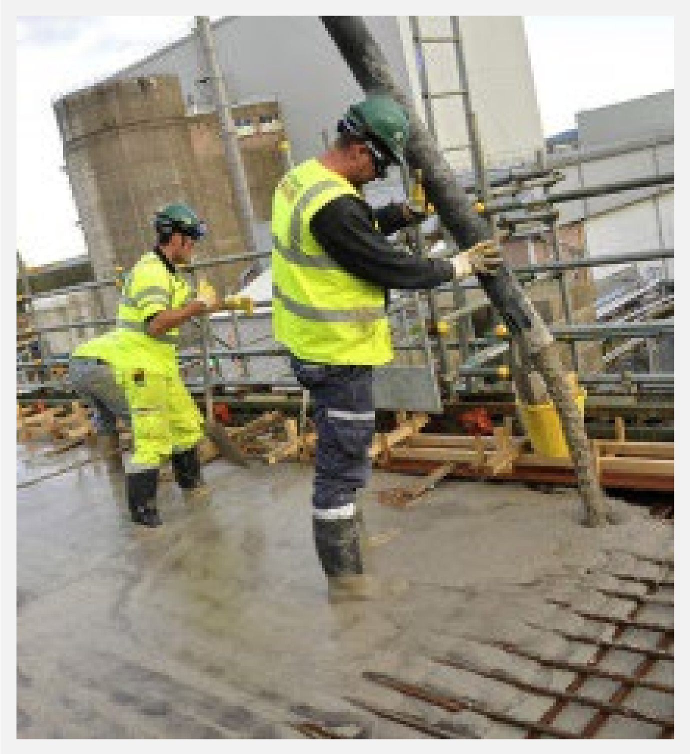
Nature uses few materials in endless complex ways; humans many materials in simplistic, wasteful ways

Gyroids at nanoscale in butterfly wing



Paradigm

In-situ concrete pouring and formwork



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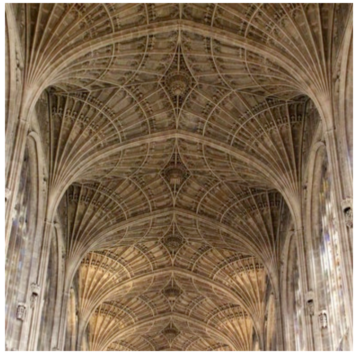
Rooted in EU legacy, computational digital AEC* offer pathways to use less ánd alternative materials

Once ...

Unreinforced
concrete
3D

Then ...



Stone
stereotomy
3D

Then ...

In-situ reinforced
concrete
2D+

... our logical digital future?

Computational design
Digital meta-concrete
3D+

* AEC: Architecture Engineering Construction

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AEC Challenges: deep chain digitalization to cut CO_2, push productivity, drive experience and sustainability

Digital workflow of: Design ▷ Engineering ▷ Fabrication ▷ Assembly ▷ Operation ▷ Re-use

Challenge

Under discussion

Scope

This Challenge aims to attract cutting-edge science and technologies that contribute to a deep digitization of the AEC value chain:

- **Computational design** scientific advances and new technologies that ultimately enable mass-adoption of parametric, generative and algorithmic design and physical simulation. The ultimate complexity of algorithmically designed objects may well approach the complexity of nature itself: biomimicry.
- **Alternative materials** enabled by computation, i.e. engineered, bio-, locally sourced, recycled, regenerative and meta-materials and alternatives to cement.
- **Digital fabrication** (3D print), industrialized manufacturing, assembly robotics.

Objectives and impact

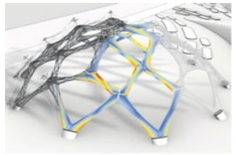
Objective is to transform the AEC sector into a **productive,** digitally enabled, **climate neutral sector**. Impacts include delivery of sustainable, inclusive and high quality building products in line with the **New European Bauhaus mission**.

Rationale

Horizon Europe's Strategic Plan 2021-2024: "Making Europe the first **digitally enabled**, circular, **climate neutral** and **sustainable** economy through the **transformation** of its mobility, energy, **construction** and **production** systems."

Mood board



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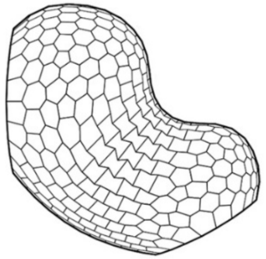
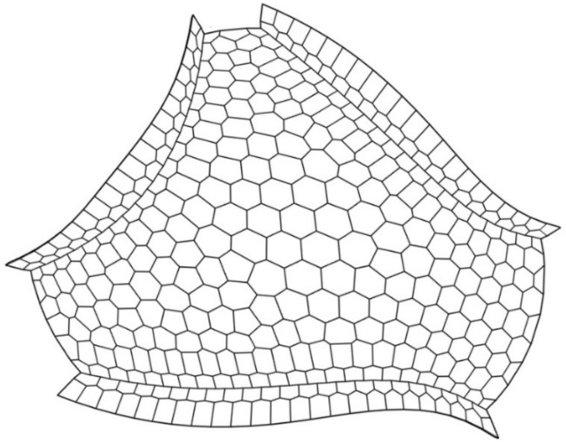
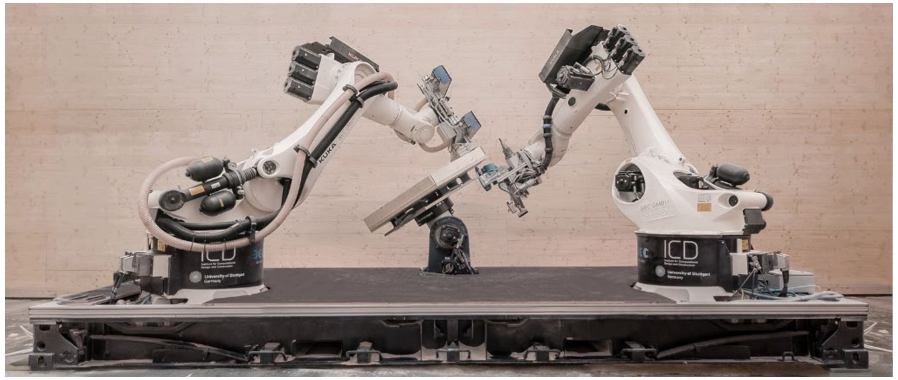
“Buga Pavilion” is an example of generative design, robotic CLT* fabrication, assembly and digital chain







* CLT: Cross Laminated Timber

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“We know that the construction sector can even be turned from a carbon source into a sink, if organic building materials like wood and smart technologies like AI are applied.

Ursula von der Leyen
President of the European Commission
State of the Union address, 9 Sep 2021

In the mean time ...

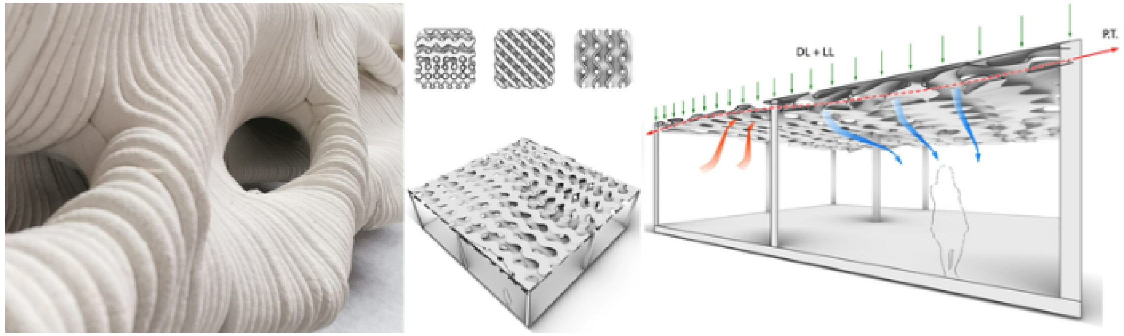

Image: Polyhedral Stuctures Laboratory at Penn

Penn Set to Receive $2.4M in Funding to Research Turning Buildings into Carbon Storage Structures

The University of Pennsylvania has been selected to receive $2.4M in funding from the US Department of Energy Advanced Research Projects Agency-Energy (ARPA-E). The funding is part of the ARPA-E HESTIA program, which prioritizes overcoming barriers associated with carbon-storing buildings, including scarce, expensive and geographically limited building materials. The goal of the HESTIA program is to increase the total amount of carbon stored in buildings to create carbon sinks, which absorb more carbon from the atmosphere than released during the construction process.

The University of Pennsylvania, in collaboration with Texas A&M University, The City College of New York, KieranTimberlake, and Sika, will design carbon-negative, medium-sized building structures by developing a high-performance structural system for carbon absorption and storage over buildings' lifespan.

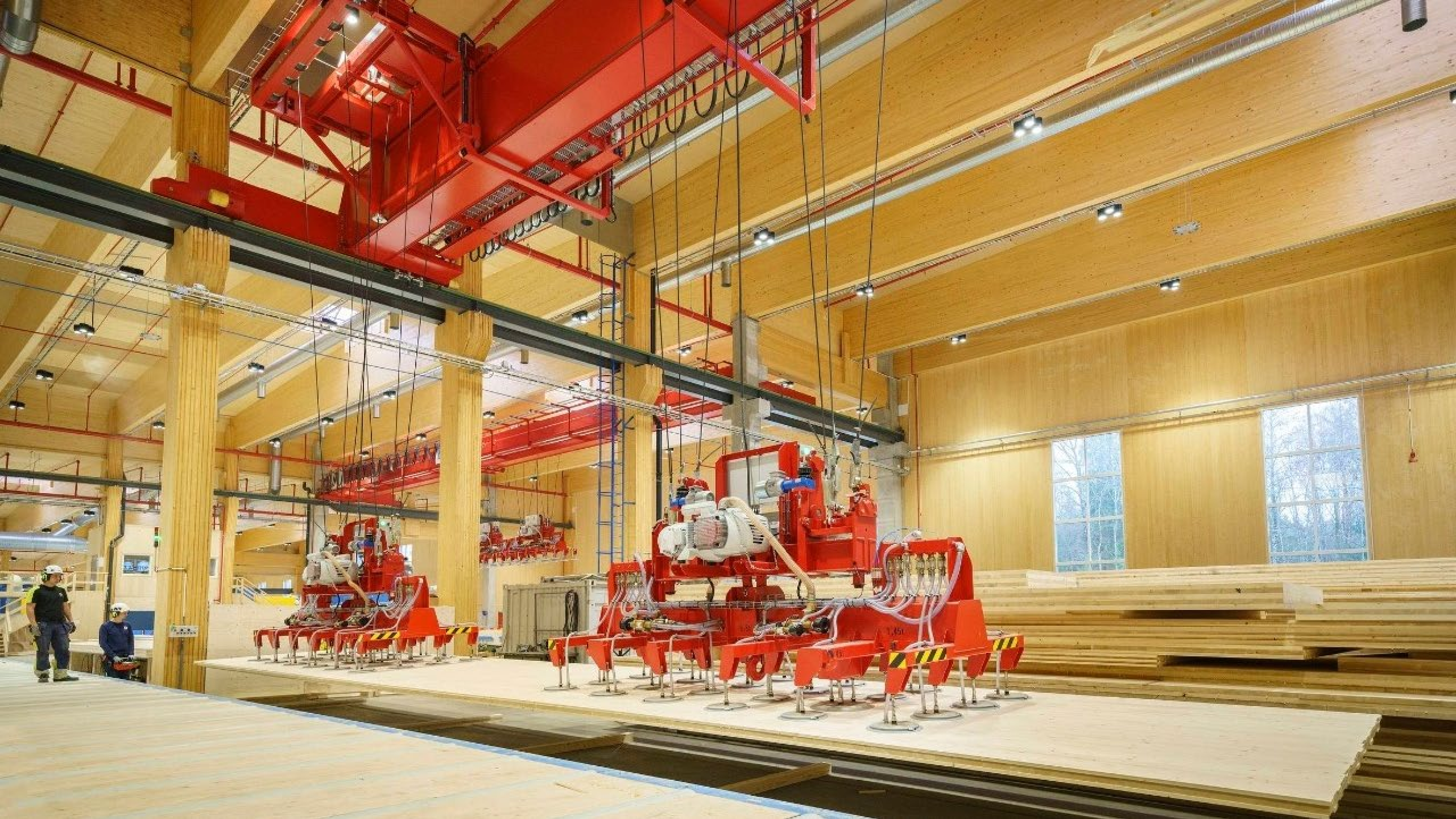

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ABB

Green Deal
Reduction of operational carbon

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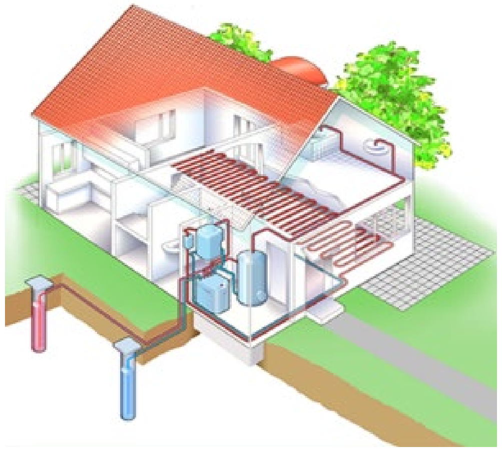
Operational carbon: electrification of HVAC (Heating, Ventilation, Air Conditioning) … of course + insulation



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ecodan
Stone

Operational carbon: "SMART buildings" use deep data tools to optimize building performance

The role of deep-tech in renovation, disassembly, re-use and recycling pathways

Problem to be solved: demolition waste, 35% of EU waste stream

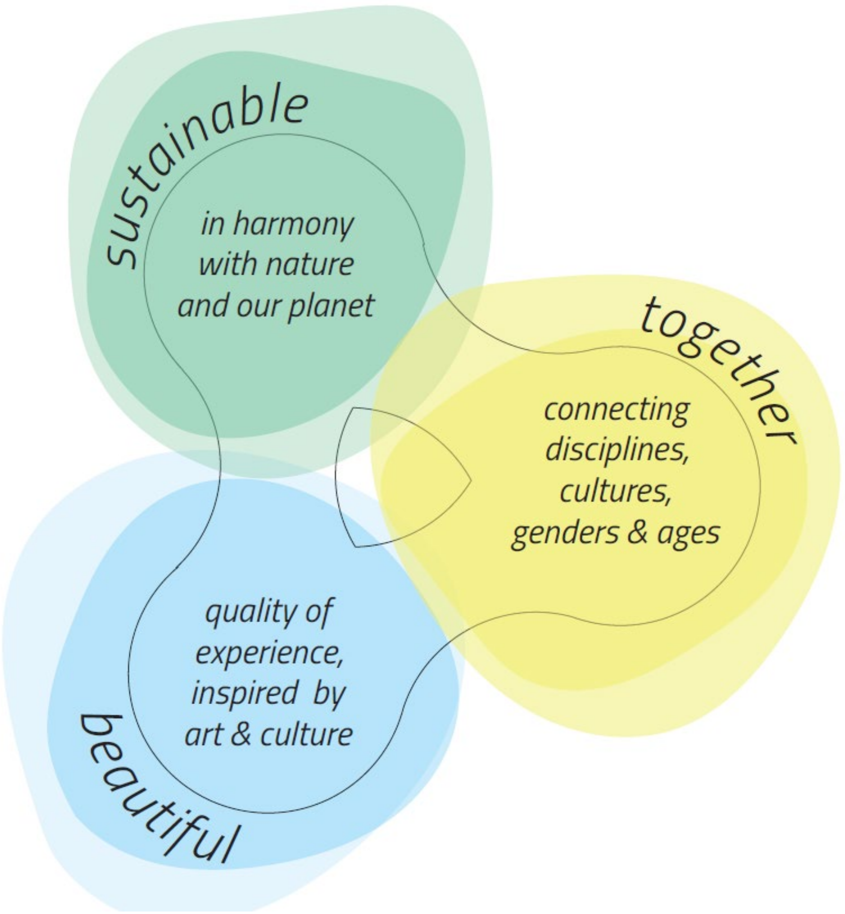
What is the role of deep-tech in disassembly, re-use and recycling pathways?

European Renovation Wave: what is the role of deep-tech in renovation?

New European Bauhaus

Problem to be solved: soul destroying ugliness. New European Bauhaus provides heart and soul to EGD.

New European Bauhaus



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New European Bauhaus

Sustainability

LEVEL I: Linear

LEVEL II: Circular

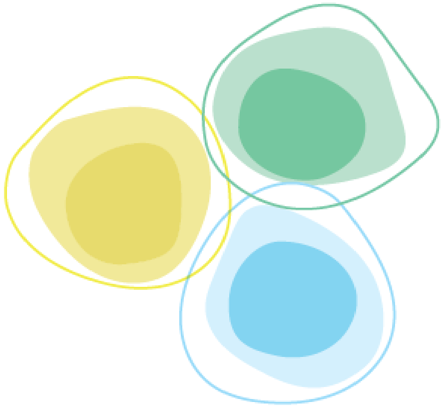
LEVEL III: Regenerative

Inclusion

LEVEL I: Embedded

LEVEL II: Consolidated

LEVEL III: Transformational



Quality of Experience

LEVEL I: Fragmented

LEVEL II: Connected

LEVEL III: Integrated

NEB **Compass**

References

Sustainability

	LEVEL 1: Conventional			LEVEL 2: Circular			LEVEL 3: Regenerative			
UNDERLYING DIMENSIONS →	Preservation	Repair Re-use Reduce	Change Upgrade	Lifecycle	Waste Reduction	Waste Transformation	Carbon Storing	Enhancing Biodiversity	Restoring / Expanding Natural Landscapes	Paradigm Shift / Behavioural Change

Quality of Experience

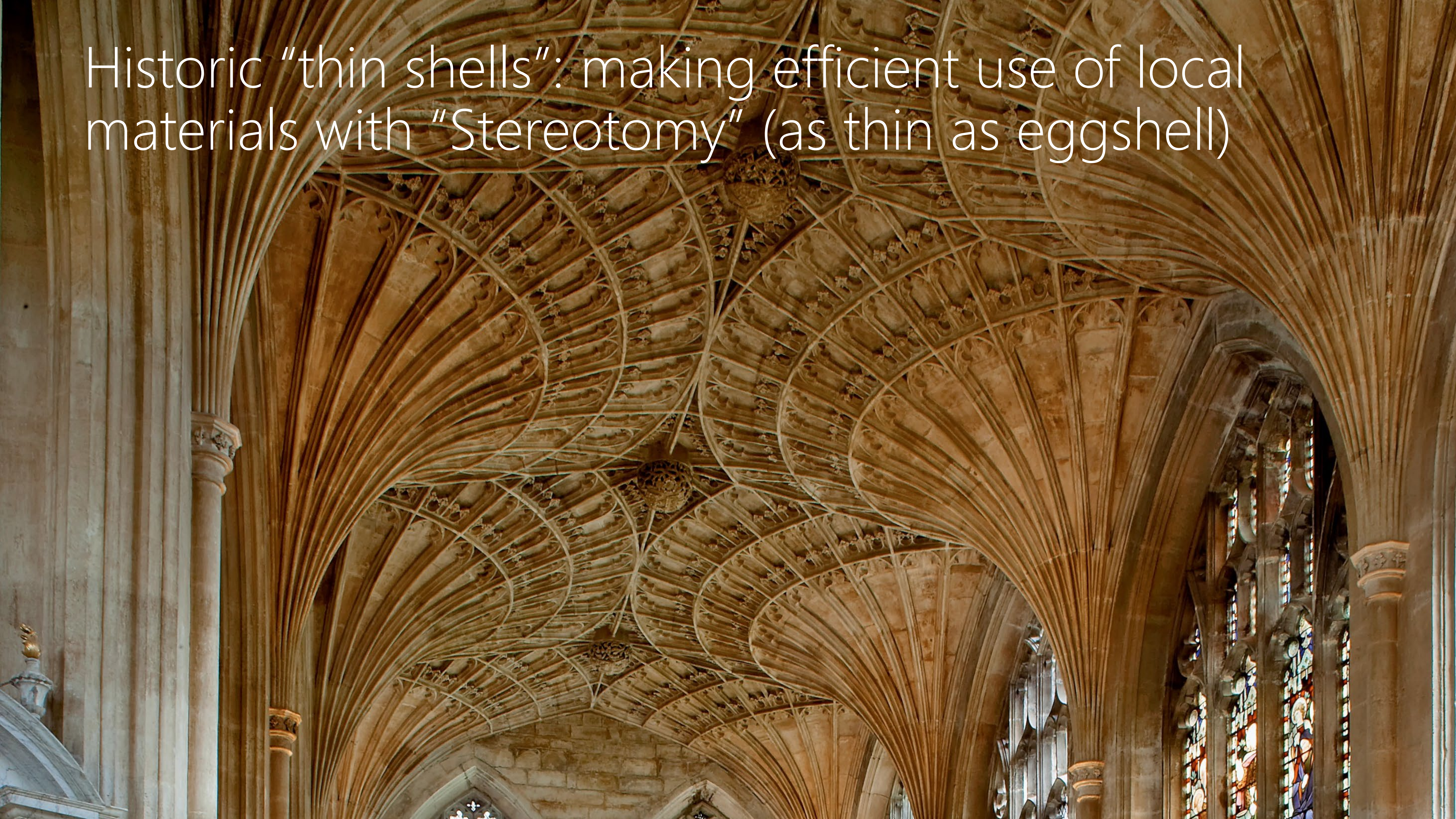
	LEVEL 1: Fragmented			LEVEL 2: Connected			LEVEL 3: Integrated		
UNDERLYING DIMENSIONS →	Context (Re)activation	Sensuous Experience	Aesthetics	Connection across Contexts	Collective Experience	Sense of Belonging	Empowerment to co-create New Context(s)	Transcending Boundaries	Long-lasting Movement

Inclusion

LEVEL 1: Embedded			LEVEL 2: Secured			LEVEL 3: Transformational		
Equality	Accessibility	Prioritizing disadvantaged people	Overcoming segregation	Representation and social stability	Sharing resources and opportunities	Fostering shared social values	Societal development and collective growth	New ways of living (together)

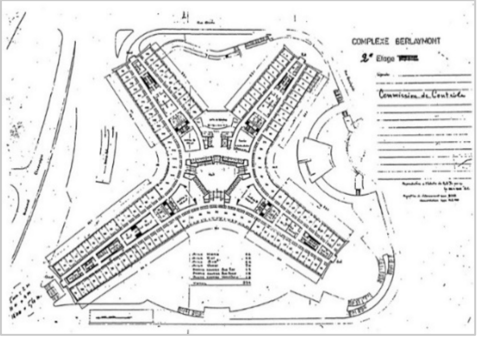
UNDERLYING DIMENSIONS →

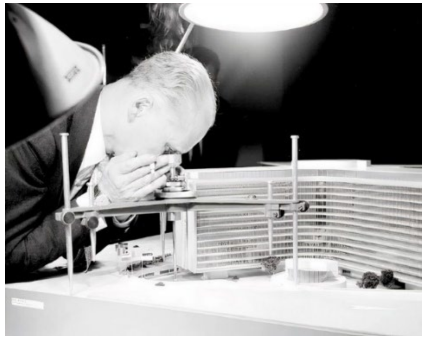
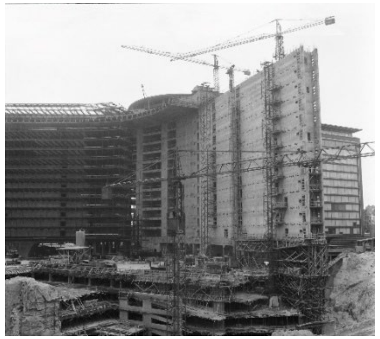
Historic "thin shells": making efficient use of local materials with "Stereotomy" (as thin as eggshell)



Barriers for AEC innovation

To the future and back: regulation and design decisions made today affect people generations from now.



--------------- 1959 ----------- 1963 ------------------- 1969 ------------- 2022 ------

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Regulations and policies maintain the old or enable the new. The context is critical for innovation success.

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