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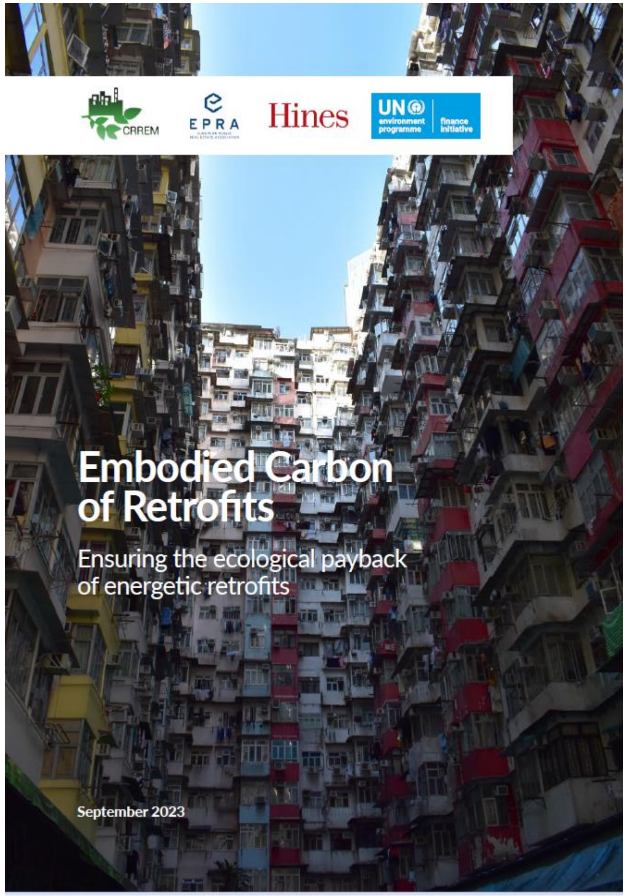
Publication:

On **25th September**: Whitepaper on ***"Embodied Carbon of Retrofits"***

- ✓ The paper is being jointly published through a collaborative effort involving CRREM, EPRA, UNEP FI and Hines
- ✓ More than 35 in-depth analyzed retrofit projects globally
- ✓ Clear guidance for data gathering and KPIs
- ✓ Reducing the carbon footprint by low-carbon retrofits
- ✓ First benchmarks for embodied carbon of retrofits and carbon-payback-periods



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HASSAN SABIR, FINANCE & ESG DIRECTOR, EPRA

MAHEEN ARSHAD, CLIMATE RISK SPECIALIST, UNEP-FI

PROF. DR. SVEN BIENERT, CRREM AND UNIVERSITY OF REGENSBURG

- INTRODUCTION REMARKS
- EPRA'S CONTRIBUTION TO THE WHITE PAPER

HASSAN SABIR, FINANCE & ESG DIRECTOR, EPRA

- OPENING REMARKS

MAHEEN ARSHAD, UNEP-FI

- WHITE PAPER CONTENT PRESENTATION PROF. DR. SVEN BIENERT, CRREM AND UNIVERSITY OF REGENSBURG

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EPRA EUROPEAN PUBLIC REAL ESTATE ASSOCIATION

Embodied carbon of retrofits

- Ensuring the Ecological Payback of Energetic Retrofits

External Report Launch Webinar

Prof. Dr. Sven Bienert 09/25/2023

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AGENDA

1. **THE CHALLENGE**
2. PROJECT OVERVIEW
3. REPORT HIGHLIGHTS
    - MANAGEMENT SUMMARY AND KEY RESULTS
    - DATA COLLECTION
    - CASE STUDIES OF ENERGETIC RETROFITS
    - BENCHMARKS FOR EMBODIED CARBON OF RETROFITS
    - RECOMMENDATIONS FOR ACTION
4. Q&A / OPEN DISCUSSION

- Properties are a main contributor to global climate change due to their **operational and embodied GHG emissions**.

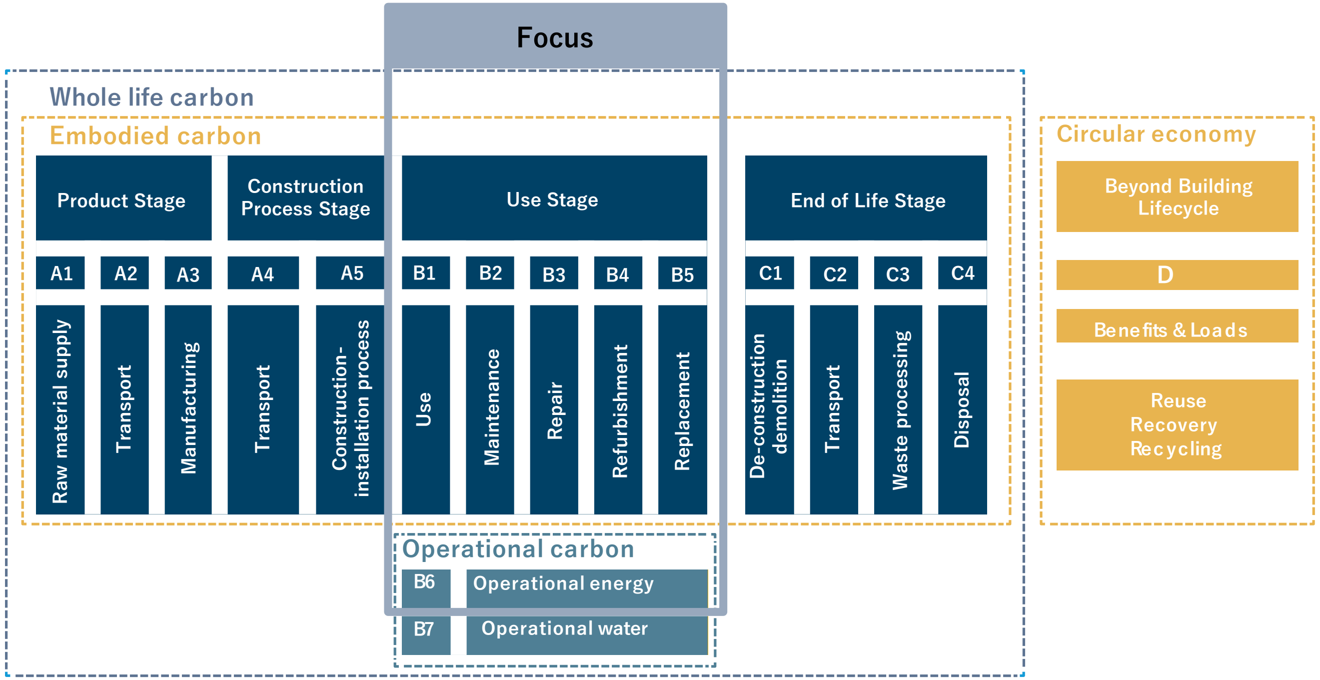
- A considerable portion of **existing buildings** lack the necessary energy efficiency to achieve climate-neutral building stock by 2050.

- The main objective is therefore to **reduce operational emissions by 80-90%** from the current global average of approximately 35 kg CO_2e/m^2 in 2020 to 0.4 kg CO_2e/m^2 in 2050 (CRREM).

- Since especially in OECD / developed countries most of the building stock that will be used in a decarbonized world in 2050 is already built today, focusing on existing properties and **carrying out energetic retrofits is having a high priority to tackle climate change** and avoid transition risks.

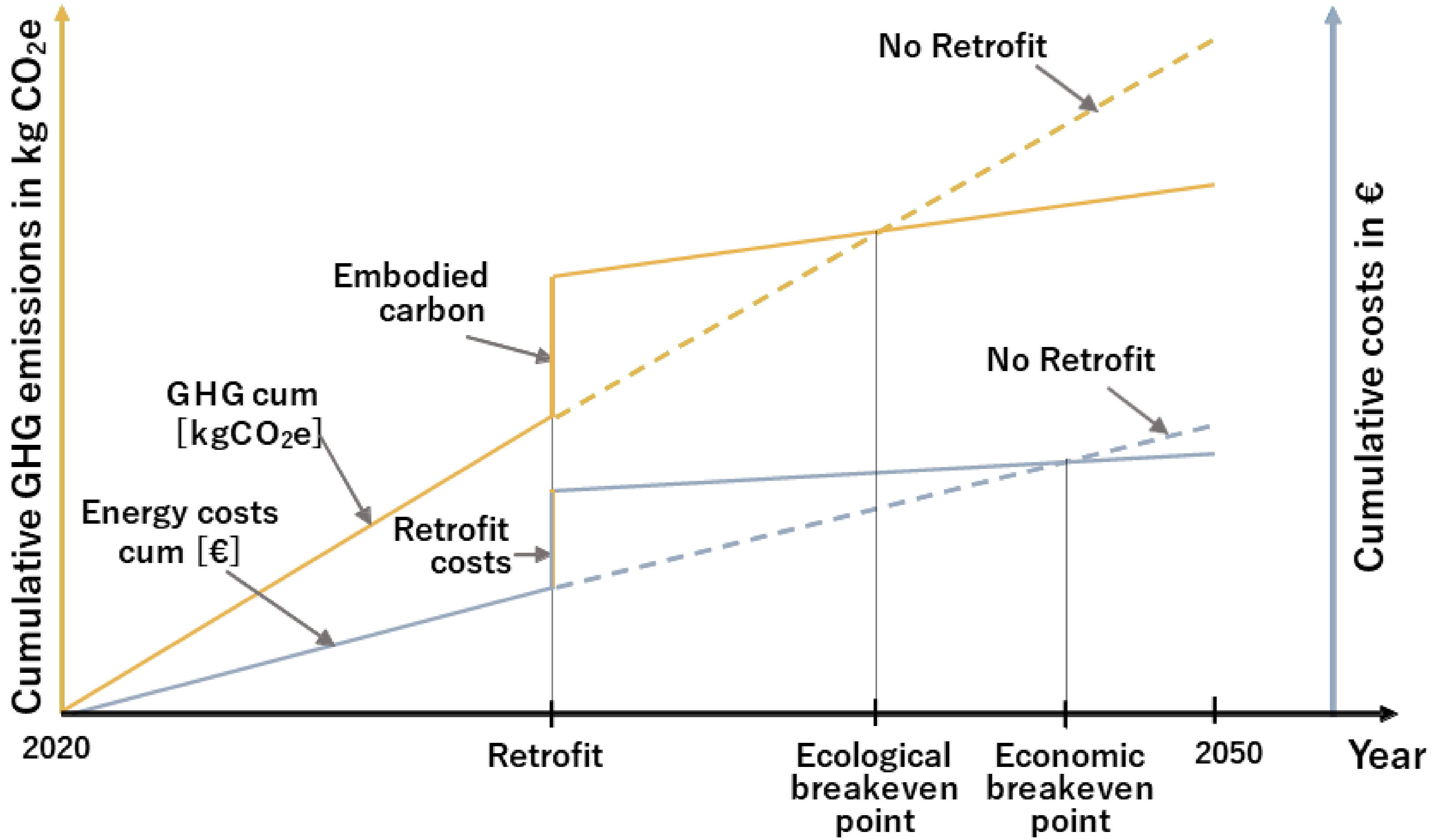
- At present **investors face four strategic challenges** that must be addressed as part of their **decarbonization strategy -** to achieve **net zero buildings:**
  I. **(Reduce)** embodied carbon of new construction
  II. **(Reduce)** operational carbon emissions of existing building stock
  III. **(Extend)** the economic life of buildings
  IV. **(Optimize)** energetic retrofits of buildings

IV. (Optimize) energetic retrofits of buildings



In contrast many research question with massive implication for practitioners are still a “blank spot”:

- How much **embodied carbon** does a **typical energetic retrofit** emit? And how can **KPIs** be derived?
- Can **benchmarks in kg/CO2e** for energetic retrofits be derived?
- What is a typical “**carbon payback**” period (embodied of retrofit vs. operational savings)?
- What are good approaches for **low carbon retrofits** / material? How should a smart retrofit process be structured?
- Which **low-hanging fruits** exist? (low embodied carbon + high operational savings)


Cumulative GHG emissions in kg CO_2e
No Retrofit
Embodied carbon
GHG cum [$kgCO_2e$]
No Retrofit
Energy costs cum [€]
Retrofit costs
Cumulative costs in €
2020
Retrofit
Ecological breakeven point
Economic breakeven point
2050
Year

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Prof. Dr. Sven Bienert
Founder & Managing Director
sven.bienert@iioe.at

Julia Wein, MScRE
Consultant
julia.wein@iioe.at

Hunter Kuhlwein, MScRE
Consultant
hunter.kuhlwein@iioe.at

Sebastian Leutner, MScREI, MScRE
Consultant
sebastian.leutner@iioe.at

Yannick Schmidt, MA
Consultant
yannick.schmidt@iioe.at

Maximilian Spanner, MScRE
Consultant
maximilian.spanner@iioe.at

Vanessa Huber, MA
Consultant
vanessa.huber@iioe.at

Kathrin Scheidhammer, MScRE
Consultant
kathrin.scheidhammer@iioe.at

Authors of this report:

- Sven Bienert
- Hunter Kuhlwein
- Yannick Schmidt
- Berivan Agbayir
- Benedikt Gloria

Project Timeline & Completed Tasks

- October 2022: **Kick – off** (intern)
- November 2022: **Literature research**
- November – December 2022: Development **Date template**
- December 2022 – May 2023: Approaching **50+ companies** // **data collection and analysis**
- March 2023: Create an additional **survey** to capture market sentiment
- March 2023: Start draft of report
- March 2023 – July 2023 : **Completion of benchmarks** and case studies // **Final report** (draft)
- September 2023: **Publication of the report**

Special thanks to all the companies that have provided us with data

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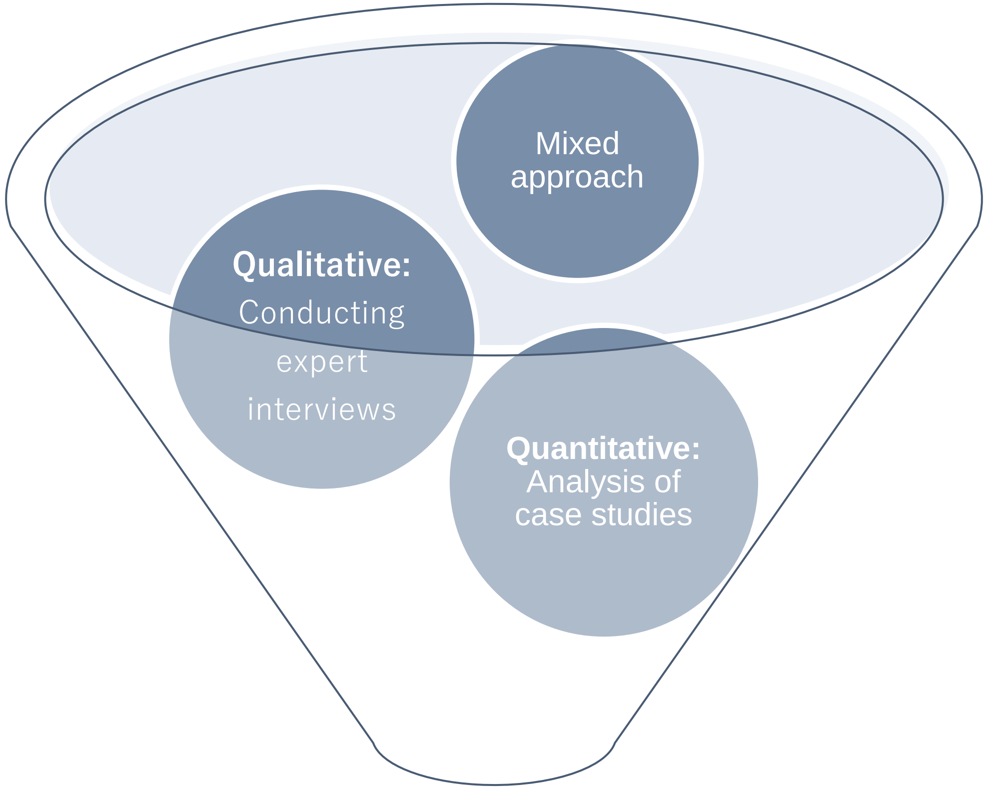
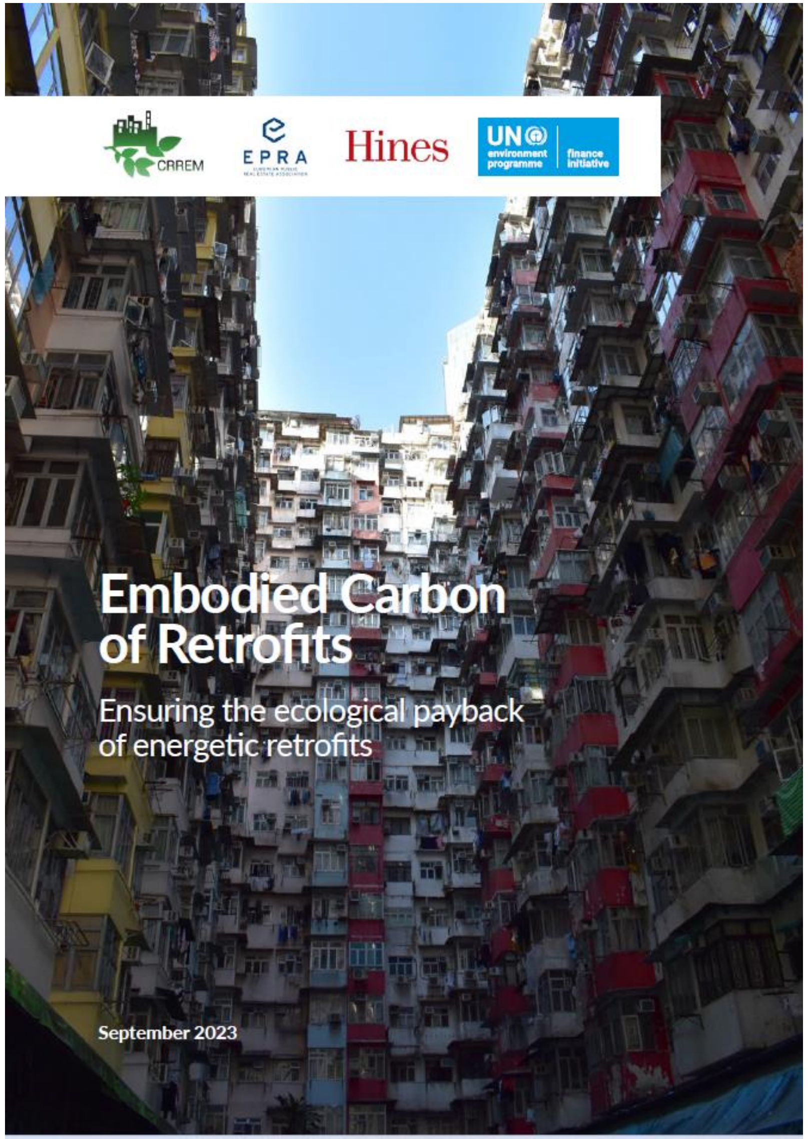


- **Qualitative**: Expert interviews were conducted with 50+ stakeholders. Alongside that, a survey was also carried out.

- **Quantitative**: Out of 47 property data sets delivered, 36 case studies were analyzed and integrated in Best-practise case-studies and used to derive benchmarks.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Embodied Carbon of Retrofits
Ensuring the ecological payback of energetic retrofits
September 2023

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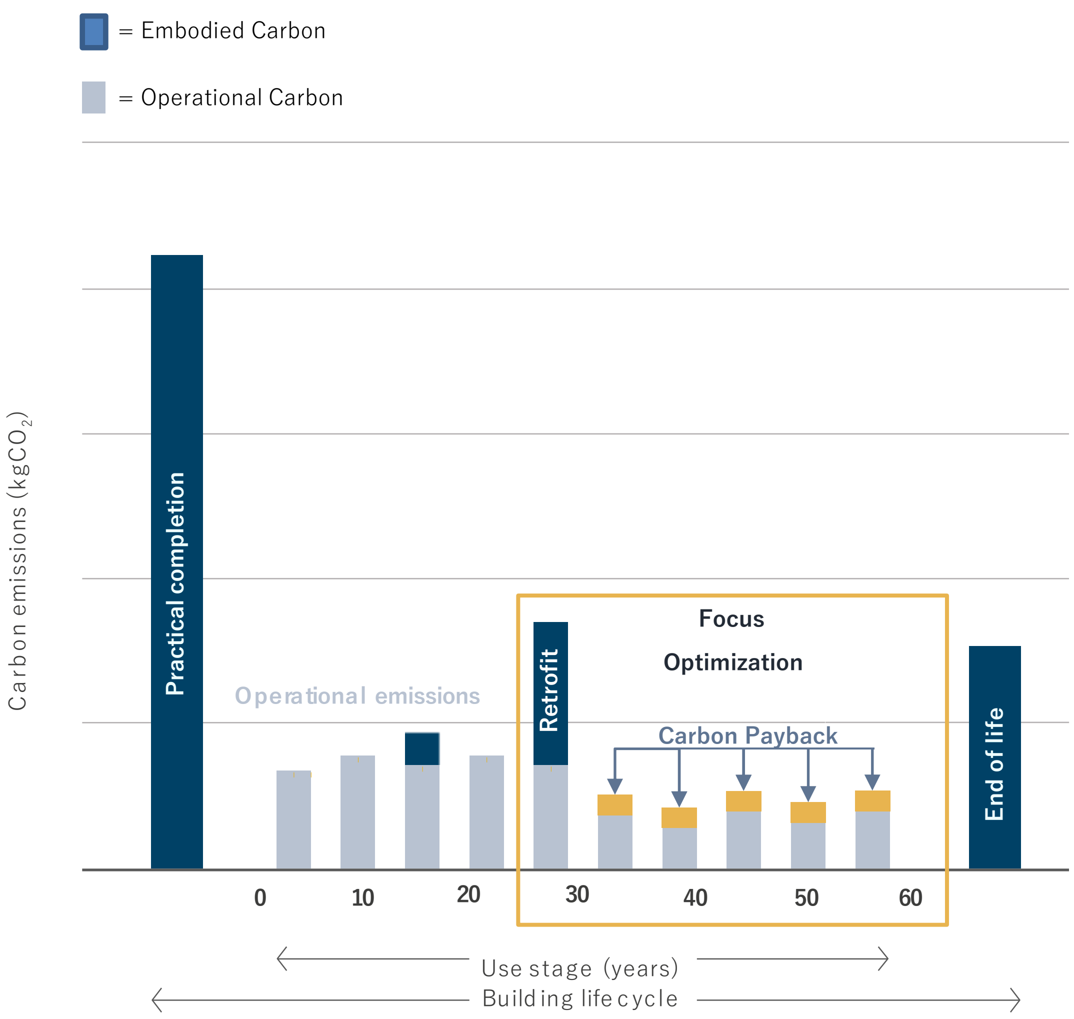
(Optimize) energetic retrofits of buildings



- Energetic retrofit measures in existing buildings are crucial for decarbonization strategies
- **Adopting a holistic approach is essential** to identify the optimal retrofit strategy for the portfolio
- The assessment process for energy-related retrofit measures is influenced by various factors, including the **number, timing, and scope of retrofits**
- It is not just essential to identify the "bad performing/high consuming" assets and ensure financial viability of the measures to reduce operational emissions. Since embodied carbon of retrofits add to the Scope 3 emissions of investors they also need to be reduced and optimized.

- Significant Carbon Emission Challenge related to retrofits - Until 2050: Global release of 30-40 Gigatons CO_2e through transforming existing buildings into Net-Zero-Ready (assuming current market practise). This represents approximately **7-9 percent** of the **remaining anthropogenic greenhouse gas budget** (1.5-degree).
- Defining Ecological Performance Assessment and relevant KPIs - Optimization must focus on two aspects:
  I. Ratio between Embodied Carbon (in kg/m²) vs. resulting operational savings (in kg/m²/a) – we introduce the new KPI "**Carbon-Payback** Period" (in years).
  II. Ensuring a **low-carbon-retrofit** which could reduce embodied emission by 50 % and more compared to current market practise.
- Empirical Results and first Benchmarks:
  - (Deep and medium) Energetic retrofits analyzed cause embodied carbon emissions of **20-140 kg /m²** (current market practise).
  - **Carbon payback** ranges between 1 (low hanging fruits) to **up to 8 years** (medium and deep retrofits).
- Stakeholder Perception vs. Current Market Practice: Reducing/optimizing the carbon payback and embodied emission of the retrofit is so far not on the agenda of most market participants. In contrast all investors/asset managers stated this should be a focus area.
- **Databases on EPDs of materials** need to be expanded and **data gathering as well as process of investors** carrying out retrofits must be revised.

What data is needed to **calculate the embodied carbon of a retrofit?**

Material quantity [unit] × Carbon factor [kg CO_2e per unit material used]
=
Embodied Carbon [kg CO_2e] of the energetic retrofit

+

What data is needed to **calculate the impact of a retrofit?**

Operational consumption **before** the measure
-
Operational consumption **after** the measure
=
Impact of the retrofit (savings of CO_2)

→

Carbon payback period in years

PITFALLS & CHALLENGES RELATED TO DATA COLLECTION

Often self-declared / (No) guarantee that all emissions are covered (potentially Greenwashing)

Investor & asset manager / **Real Estate Company**

Material production

Calculation of embodied carbon (A1-A3)

Planning of the energetic retrofit

Investment carried out

Calculation of embodied carbon

Manufacturer

Focus on financial payback and (max.) operational saving / No analytics or structured process in place for ecological pay back / Lack of data

Challenge I.: Databases on Materials

Provider of database	Name of database	Number included datasets	Geographical coverage	Life cycle stages covered	Cost	Data origin	Type of tool	Latest Update
University of Bath	ICE Database	> 200	UK	A1 – A3	Free	LCI Data, Reports, Journals, Literature	Excel-based	2019
Federal Ministry for Housing, Urban Development and Building	Ökobaudat	>1,400	Germany	A1 - D	Free	EPD, generic data	Online Application	2023
HQE-GBC Alliance	INES	> 7,000	France	A1 – A5	Free	EPD, generic data	Online Application	-
Carbon Leadership Forum / Building Transparency	EC3	> 90,000	US	A1 – A5	Free	EPD	Cloud-based	2023
Sphera	GaBi	> 15,000	EU	A1 – C4	Fee required	-	Desktop software application	-
Athena Sustainable Materials Institute	Athena Impact Estimator	> 200,000	US & Canada	A1 – C4	Free	TRACI v2.1 Database, Athena LCI Database	Desktop software application	2020
Melbourne School of Desing	Epic Database	> 850	Australia	A1 – A3	Free	EPD	Online Application	2019

- To facilitate the assessment of **embodied carbon emissions**, relevant information is collected and compiled into aggregated form within **commercial** or **governmental databases**.

- Having analyzed the most relevant databases we identified some **shortcomings**:
  I. Variance of scope and comparability of assessment between the databases.
  II. Regional coverage (e.g., no valid data for many Asian markets)
  III. Missing data and limited inclusion of materials related to retrofits (batteries, heat pumps, PV etc.),
  IV. Often lack of external validation, and they are not exhaustive in terms of specific producers, regions etc. covered.

- Note that basically all available software tools are also relying in their backends on these data sources.

- Selection of materials has a significant impact. **Low-carbon-materials make the difference** for the energetic retrofit.
- To date most **projects analyzed were carried out and calculated using "normal/typical"** materials and did not put a special emphasis on low-carbon-solutions while carrying out the energetic retrofit.
- Insulation material e.g., can even work as a carbon sink – with respective **impacts on Scope 3 emission** profile:

Conventional materials:

Material EPD label	Approx. kg CO2e (GWP) | A1- A3	Unit
Basement Ceiling insulation 4 - 16 cm	2 – 9	m^2
Facade insulation (EPS) 14 cm - 30 cm	7 – 14	m^2
Rockwool 14 cm - 30 cm	7 – 15	m^2
LED Suspended Luminaire	21 – 36	Piece
Photovoltaic system (1000 kWh/m²*a)	297	m^2
Air water heat pump	643	Piece
Central fan 30000 m³/h	847	Piece
Gas heat / power plant (500 kW)	4,150	Piece

Low carbon materials:

Embodied Carbon (in kg / unit)

Material EPD label	Approx. kg CO2e (GWP) | A1- A3	Unit
Straw insulation	-127	m^3
Hemp fibre insulation 10 cm	-2	m^2
Cork panel 6 cm	-0,34	m^2
Cork panel 1 cm	0,03	m^2
Aerogel 1 cm	12	m^2
Wood fibre insulation boards	-82	m^3
Flexible wood fibre panels	-28	m^3
Glass wool insulation 3,4 cm	3	m^2

Conventional materials vs Low carbon

Insulation of the façade: Residential with a living area of 1.466 m² and a facade area of 1.514 m²

01

Status quo analysis of the Asset:

02

Elaborating of Retrofit Strategy

03

Benchmarking:

04

Optimize Embodied Carbon Measures:

Wood fibre insulation (40 cm)

-16,94 Kg Co_2e/m^2 NLA

EPS insulation (20 cm)

9,83 Kg Co_2e/m^2 NLA

Note: The U-values of the insulation materials must be considered.

Challenge II.: Data Availability at Asset Level

Best Case Scenario:

- ❖ Information on the masses of the materials used according to the RICS catalogue

Minimum Data requirements:

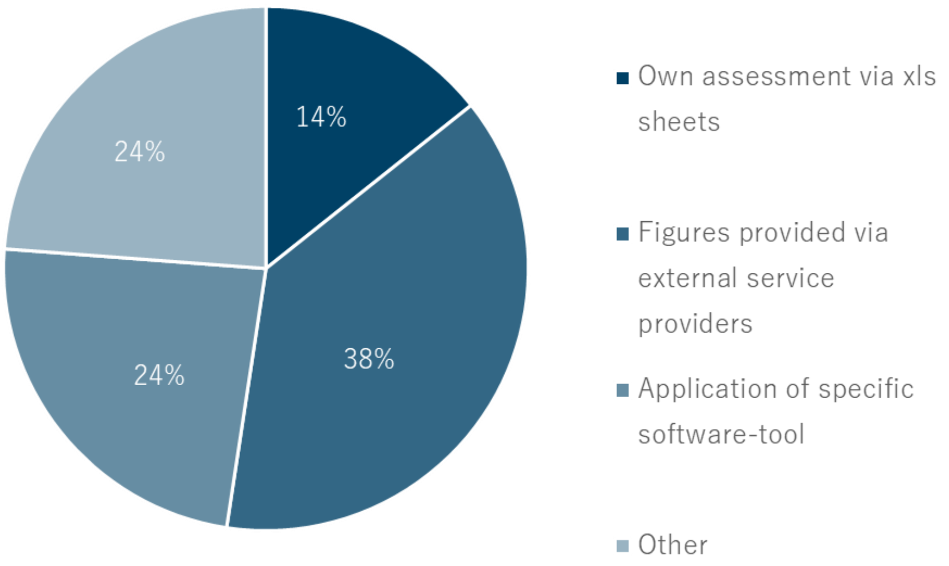
- ❖ Which measures were carried out?
- ❖ Base information about building
- ❖ kWh consumption of operation before and after retrofit

→ Almost no complete datasets available within the industry

Building	
Facade area (only required if a measure was carried out on the facade):	782,00 m²
Window quantity (only required if a measure was carried out on the window):	60
Number of heating systems (only required if a measure was carried out on the heating system):	1
Ground area (only required if a measure was carried out on the attic):	652,00 m²
…tal c…s of a…easu…	289.21…0 €

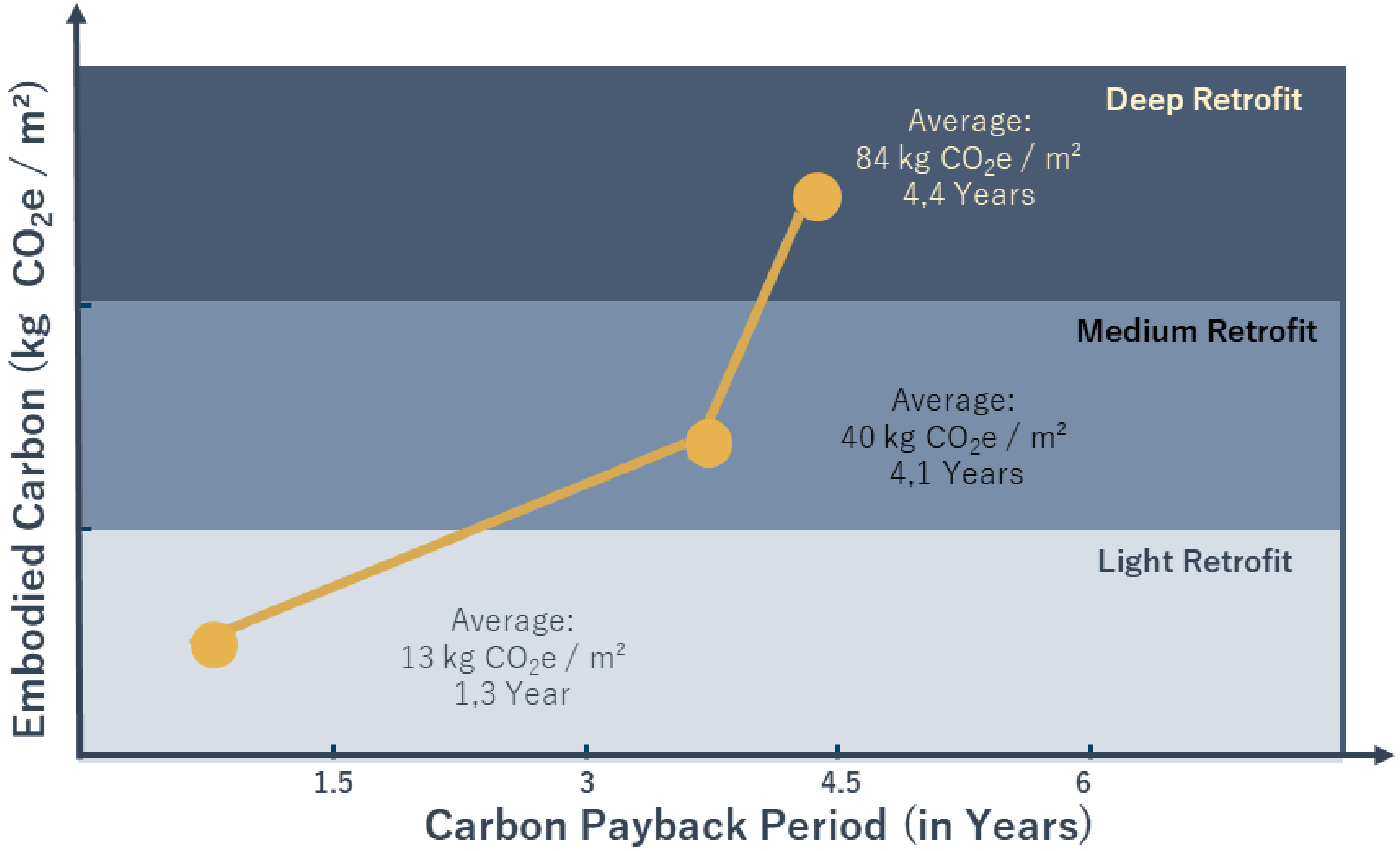
Measure 1	Insulation facade
Used materials	Thermal insulation composite systems
Realization of the measure	2017
Description of the measure	Installed TICS of the brand doitBAU ESP WLG031 XXm².
Tota… osts	35.0…00 €

- For the **investors** carrying out the energetic retrofit we find **many challenges**.
- Survey provides insights into how market participants are dealing with the data-gathering related to embodied carbon in retrofit projects**.**
- Most market participants are **tracking so far only embodied carbon for new construction**. The very few that track grey emissions for retrofits have different approaches (see chart on the right).
- Essentially **no one so far was analyzing in detail the trade off** between embodied and operational savings – however all stated this was essential!



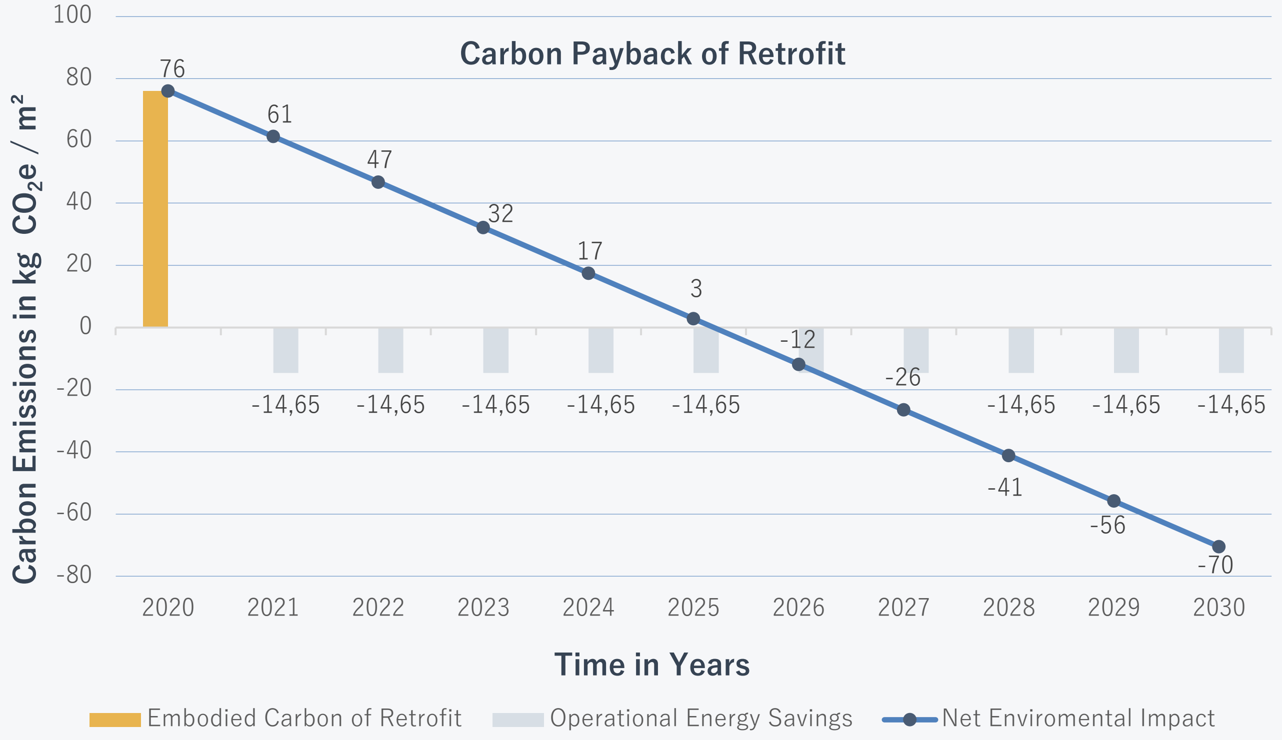
- Often the **savings were just based on modeled data** and potential (future) EPC ratings. So, gathering more ex post real consumption data is needed.
- Separating investments in a portion of **“ordinary” capex spending vs. what is really the energetic retrofit** is unclear.

Detailed Results



- Average starting consumption Data:
  - 188 kWh/m²/a
  - 40 kg CO_2/m²/a
- Average consumption data after retrofit:
  - 109 kWh/m²/a
  - 26 kg CO_2/m²/a
- Achieved savings:
  - Deep :
    25 kg CO_2/m²/a
  - Light and Medium :
    10 kg CO_2/m²/a

Asset Type	Residential / Germany
Gross Internal Area (within range)	500 – 1.000 m²
Retrofit Embodied Carbon	76 kg CO_2e / m²
Costs per sqm	705 € / m²
Scope of Retrofit	Medium
Carbon Payback Time	5.2 years



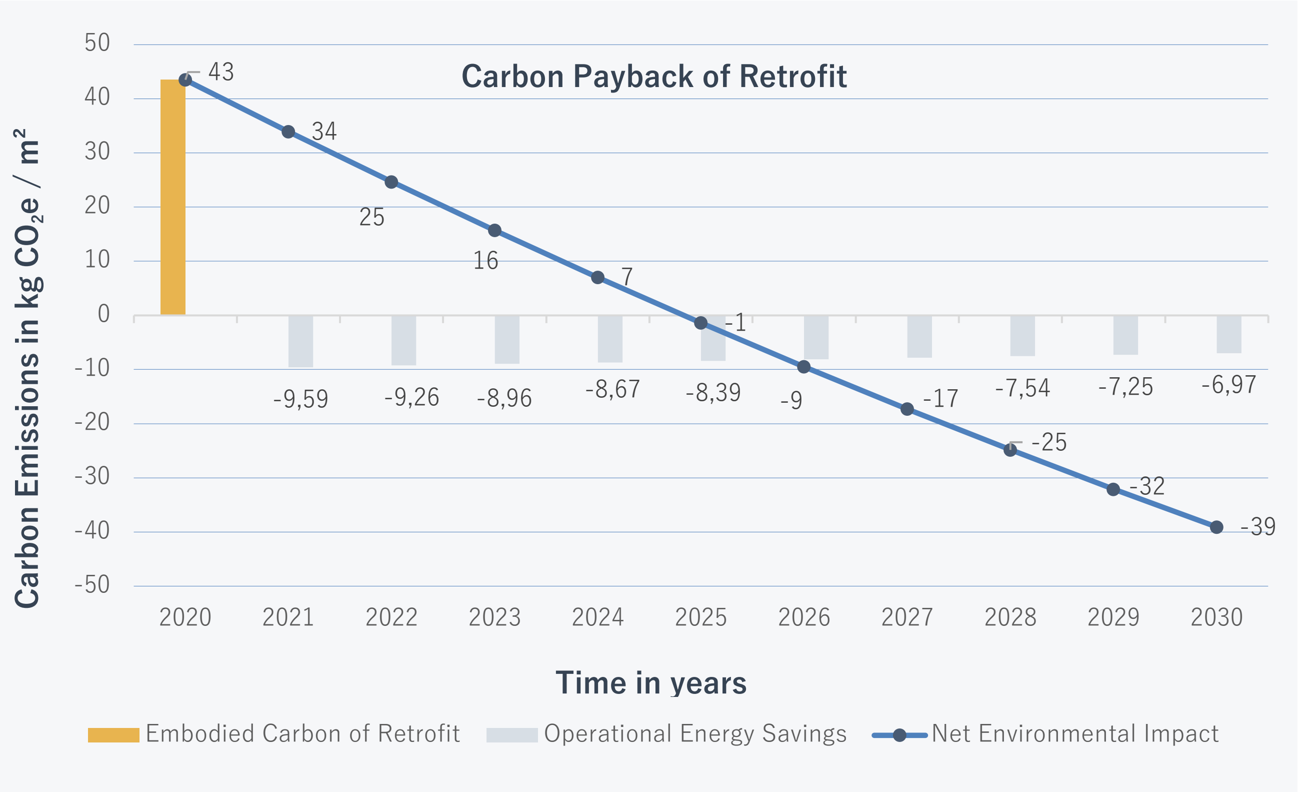
Measures taken:

- Enhanced energy efficiency through facade insulation with polystyrene insulation and mortar, reducing heat loss and improving thermal performance.
- Upgraded windows to PVC frames, enhancing insulation and reducing energy consumption.
- Improved attic insulation using rockwool insulation, minimizing heat transfer and improving energy efficiency.
- Enhanced basement ceiling insulation with polystyrene insulation, preventing heat loss and improving overall energy efficiency in the building.

Case Study on Logistics - UK

Sample image

Asset Type	Logistics / UK
Gross Internal Area (within range)	2.500 – 5.000 m²
Retrofit Embodied Carbon	43 kg CO_2e / m²
Costs per sqm	425 € / m²
Scope of Retrofit	Medium
Carbon Payback Time	4.8 years

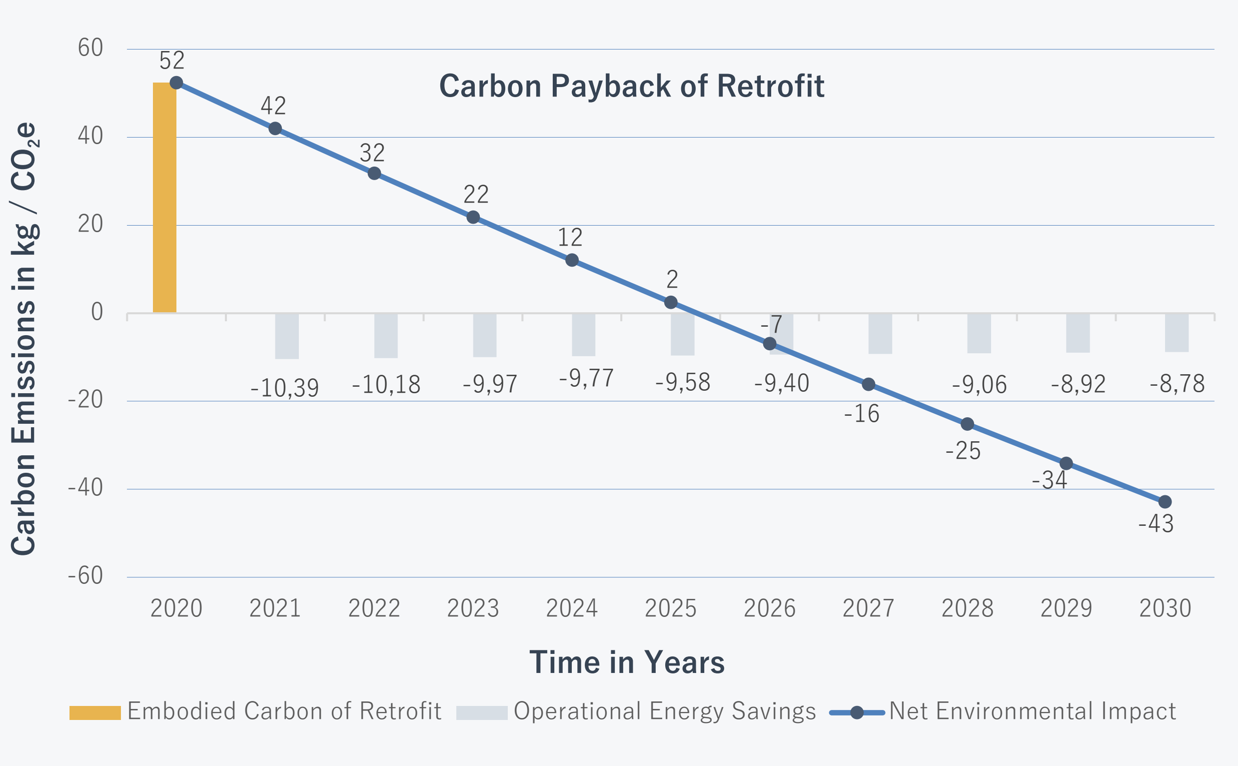


Measures taken:

- Electrification of heating: Installation of air to water heat pump
- Underfloor heating
- LED exchange
- Insulation of facade with stone wool insulation
- Insulation roof with glass wool insulation

Case Study on Office - USA

Asset Type	Office / USA
Gross Internal Area	25.000 - 35.000 m²
Retrofit Embodied Carbon	52 kg CO_2e / m²
Costs per sqm	188 € / m²
Scope of Retrofit	Medium
Carbon Payback Time	5.3 years

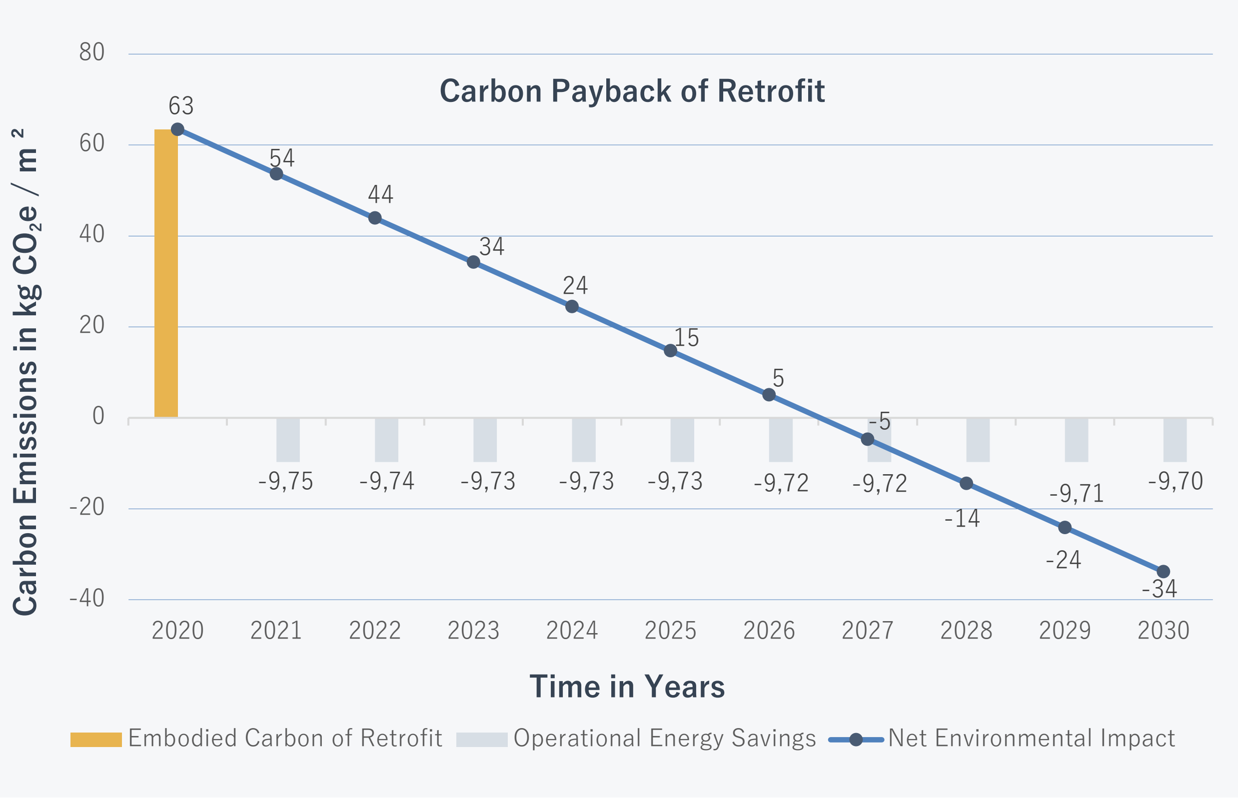


Measures taken:

- Photovoltaic system installation (approx. 1,000 m²)
- Installation of external shading systems
- Dx Unit upgrade - high efficiency, variable speed: Upgrading the direct expansion (Dx) unit to a high-efficiency model with variable speed capabilities
- Chiller Water Cooling Conversion: Conversion from air-cooled chiller systems to water-cooled chiller systems
- Building integrated Photovoltaic system installation


Sample image

Asset Type	Mixed-Use / EU
Gross Internal Area (within range)	12.000 - 20.000 m^2
Retrofit Embodied Carbon	63 kg CO_2e / m^2
Costs per sqm	368 € / m^2
Scope of Retrofit	Deep
Carbon Payback Time	6.5 years



Measures taken:

- Upgraded the lighting to energy-efficient LED fixtures
- Replaced the windows with modern, high-performance windows, improving insulation and minimizing heat loss or gain
- Installed a photovoltaic (PV) system on the building (approx. 300 m^2)
- Implemented a comprehensive roof insulation measure, including a 16 cm insulation layer effectively minimizing heat transfer and optimizing energy efficiency

Benchmarks (current Market Standard)

	Light	Medium	Deep
Typical measures	• Replacement of convention light bulbs with LED light bulbs. • Insulation attic • HVAC replacement and retro-commissioning • Other electronical measures with low risk and short payback periods	Individual measures on the building envelope: • Façade and roof insulation • Basement insulation • Replacement of windows • Remediation of thermal bridges • Improved building air tightness	Measures on the entire building envelope: • Window replacement • Combined bundle of HVAC, thermal envelope, and renewable power and heat supply • Downsizing of HVAC system due to lower heating and cooling demands • Elimination of perimeter zone conditioning • Building envelope insulation • Improved airtightness

Residential real estate (Multifamily)

	Light	Medium	Deep	*New building*[1]
Savings	< 25 % of energy consumption	25 – 50 % of energy consumption	> 50 % of energy consumption	*n/a*
Embodied carbon/m²(current market practice)	n/a	**In our cases 20 to 80 Kg CO_2e/m²**		*600 - 700 kg CO_2e/m²*
Typical carbon payback period in years	n/a	**1 up to 5 years**		*n/a*

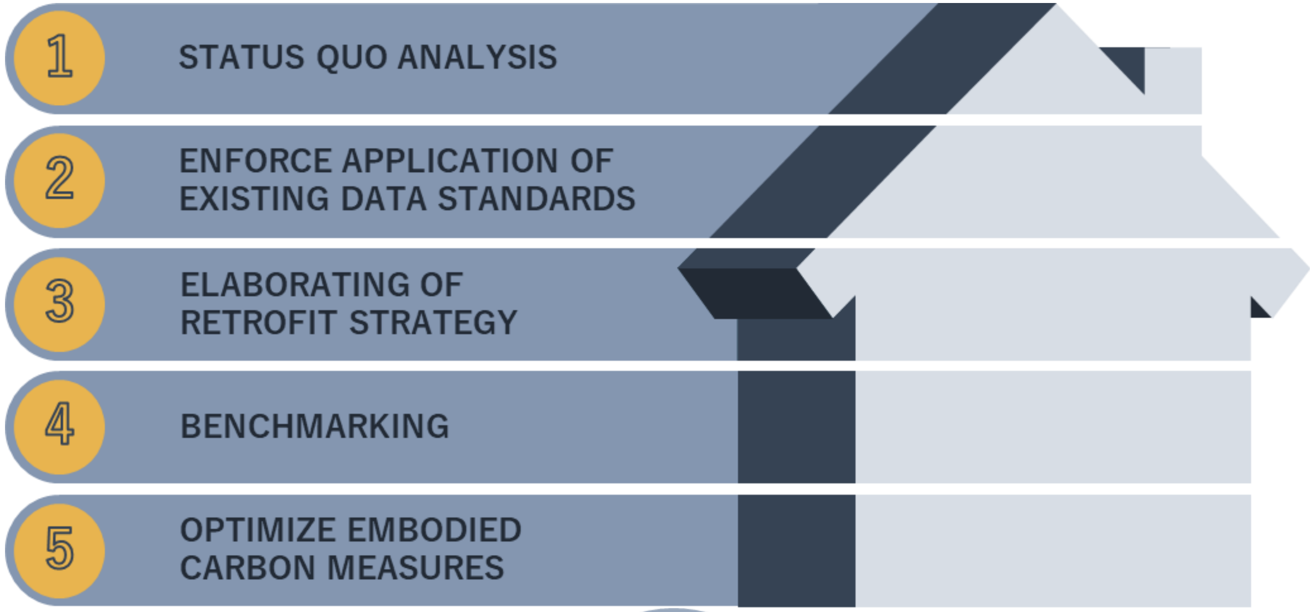
Commercial real estate

	Light	Medium	Deep	*New building*[1]
Savings	< 25 % of energy consumption	25 – 50 % of energy consumption	> 50 % of energy consumption	*n/a*
Embodied carbon/m² (current market practice)	Up to 30 kg CO_2e/m²	**In our cases up to 140 kg CO_2e/m²**		*600 - 750 kg CO_2e/m²*
Typical carbon payback period in years	Below 3 years	**Up to 8 years**		*n/a*

1: Le Den et al. (2022): Towards embodied carbon benchmarks for buildings in Europe

Call for Action: Clear Strategy and Processes

- **Track your Scope 3 emissions**: Embodied Carbon becomes increasingly important for market participants in both – new construction and retrofits.
- **Ensure data gathering and KPIs**: Handling this topic good requires the development of additional expertise and clear processes. Embodied Carbon measures will be considered as an essential KPI.
- **Financial implications on the rise**: The topic is gaining more and more financial significance, with increasing carbon prices. Also showcasing in sustainability reporting and to the broader financial markets that investors track this topic will be beneficial (taxonomy, banks, ESG-Investors etc.).
- **Be ahead of the regulation wave**: for new construction embodied limits are already becoming reality. Clearly retrofits are the next logical step.



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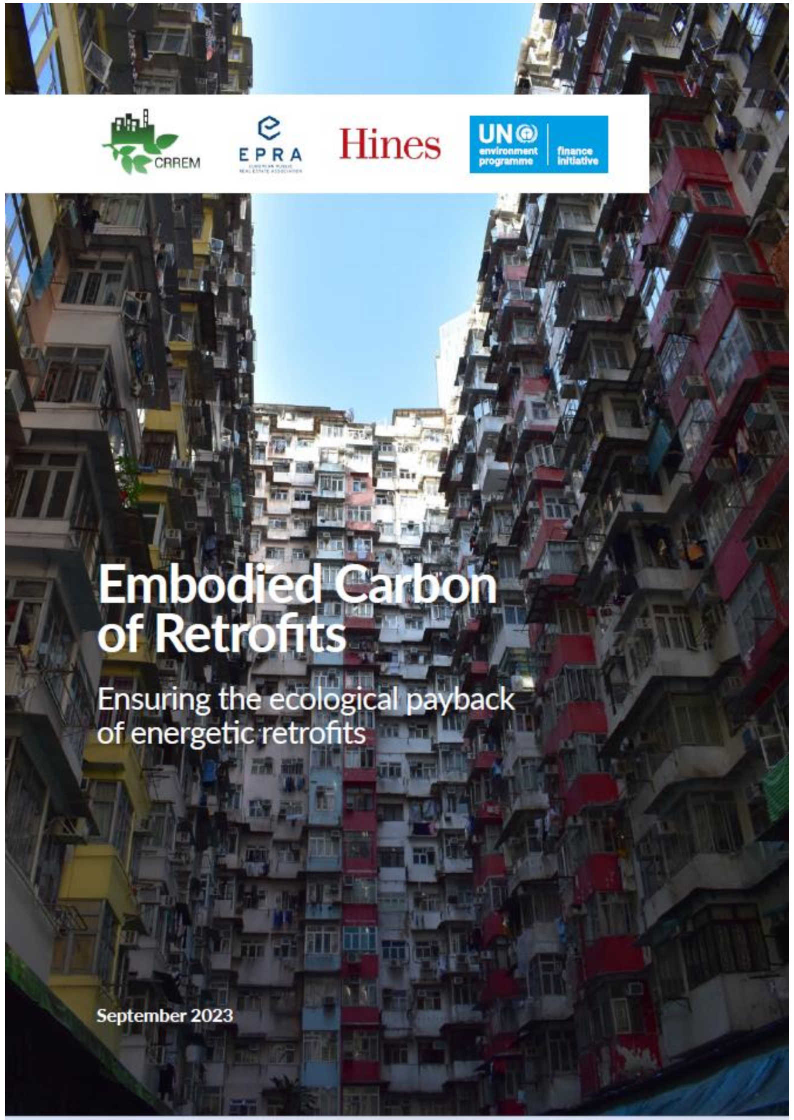

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Q&A

&

OPEN DISCUSSION

WE WOULD LIKE TO THANK OUR PARTNERS FOR THE FINANCIAL SUPPORT:

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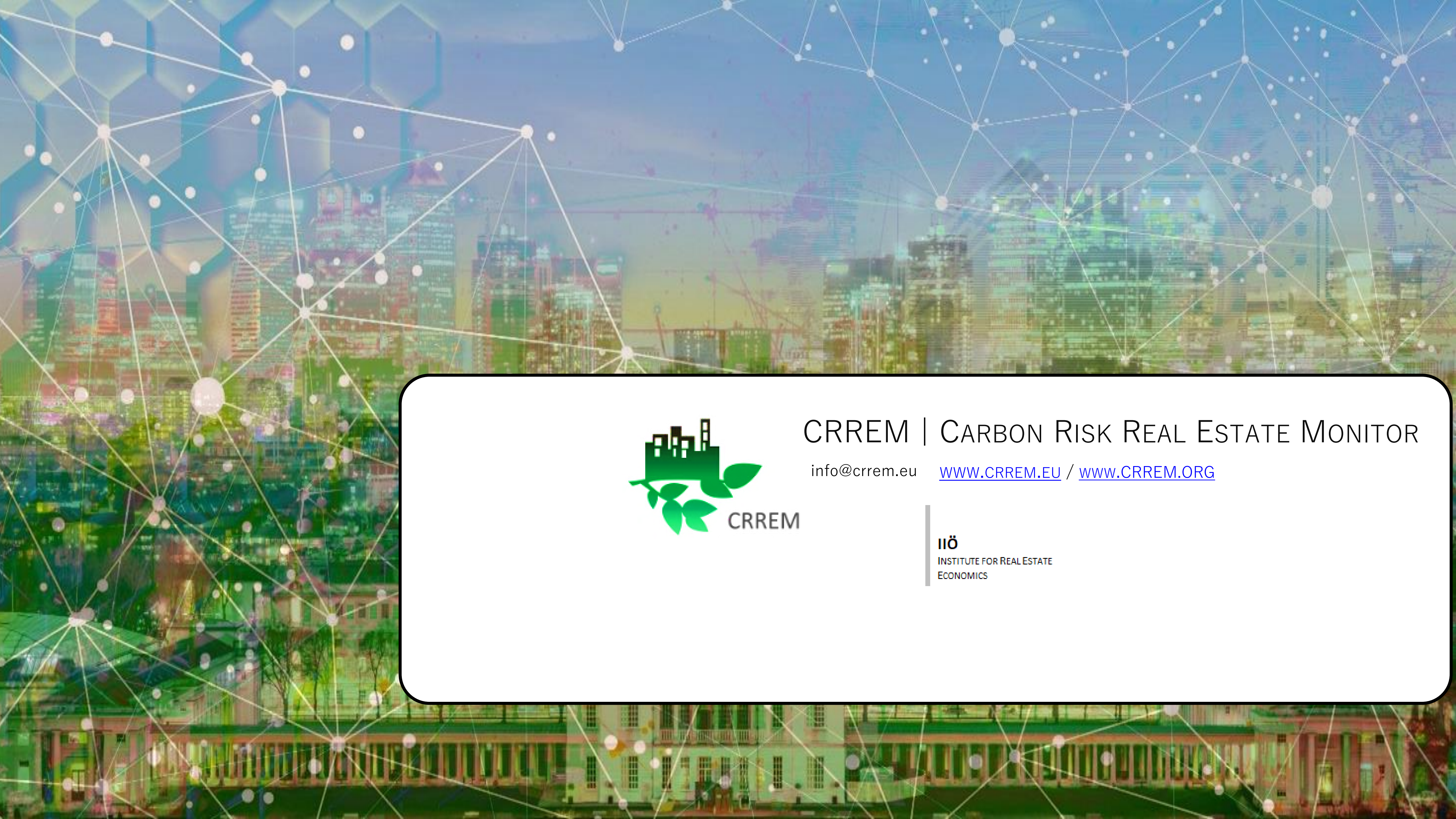
PARTNERS (WHO HAVE ESPECIALLY ALSO SUPPORTED THE DEVELOPMENT & RELEASE OF THE GLOBAL PATHWAYS) :



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info@crrem.eu WWW.CRREM.EU / WWW.CRREM.ORG

IIÖ
Institute for Real Estate Economics

Net-Zero building definition

All newly constructed buildings should be net-zero buildings latest from 2030 onwards and all existing buildings should be transformed into net-zero buildings latest by 2050.

A **new or renovated** net-zero building is **highly energy efficient** and **does not cause any on-site GHG emissions from fossil fuels**. It uses **renewable energy, preferably generated on-site**, if technically feasible, and/or **off-site** to fully cover its remaining, very low energy demand

Net-Zero *ready* building definition

A net-zero ready building will transform into a net-zero building latest by 2050, without any required, additional changes to the building or its equipment.

A **new or renovated** net-zero ready building is **highly energy efficient** and **does not cause any on-site GHG emissions from fossil fuels**. It uses **renewable energy, preferably generated on-site**, if technically feasible, and/or **an energy supply that will be fully decarbonized latest by 2050** to fully cover its remaining, very low energy demand.