BUILDINGS ROLE IN THE CLIMATE CRISIS – STATUS, POSSIBILITIES AND NEED

INAUGURAL LECTURE
PROFESSOR HARPA BIRGISDÓTTIR
29.09.2021

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SUSTAINABILITY
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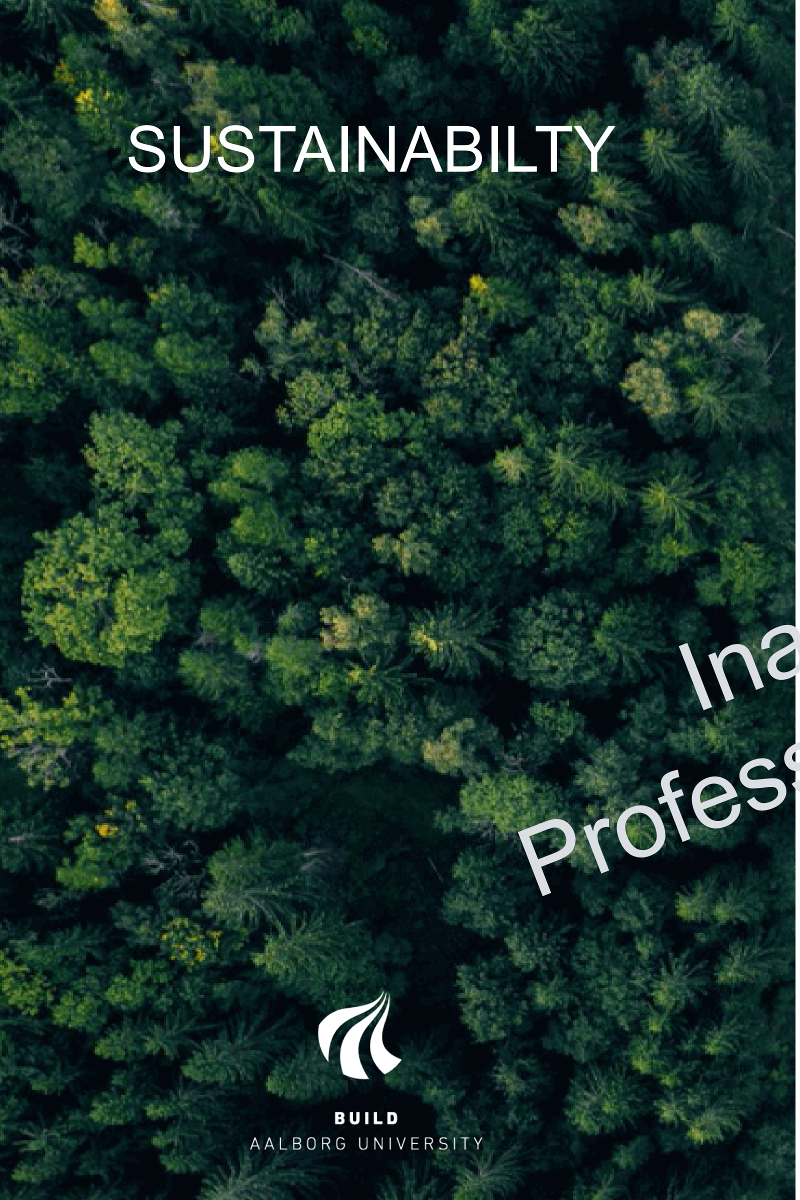
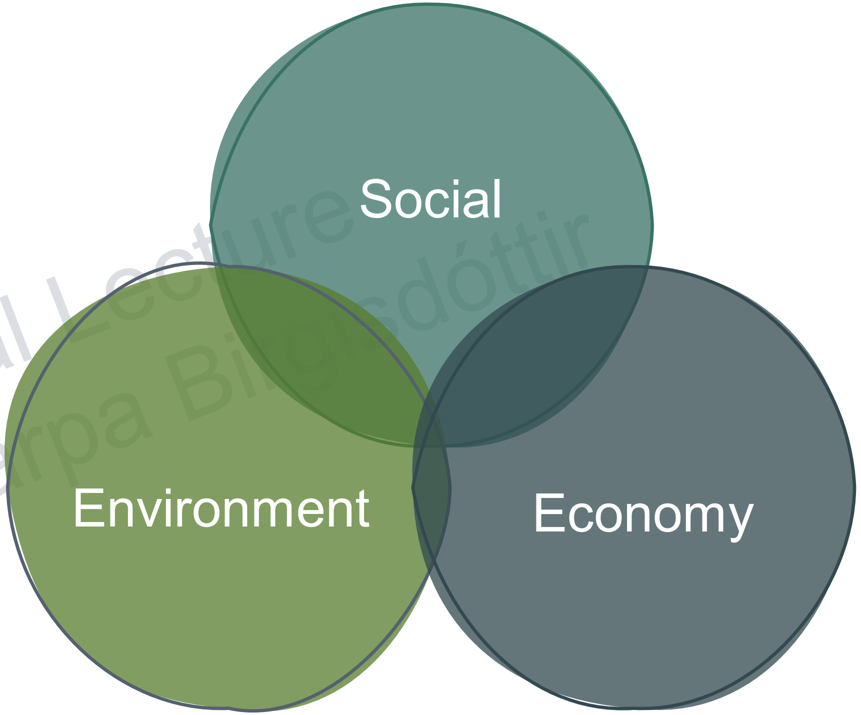
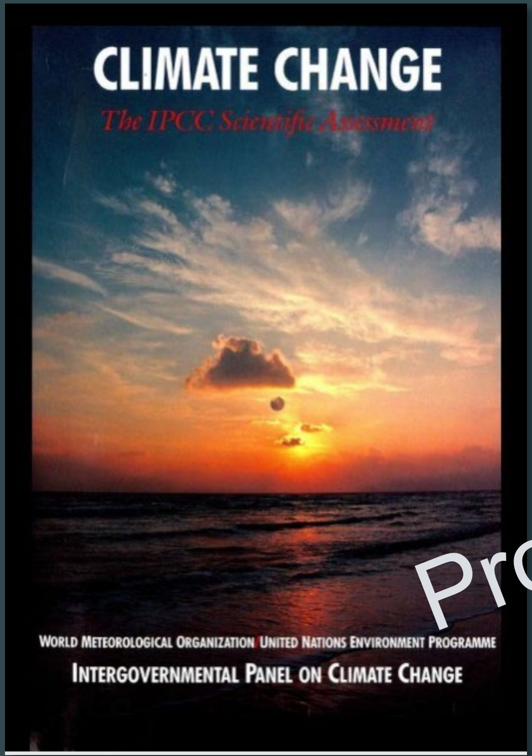
SUSTAINABILTY

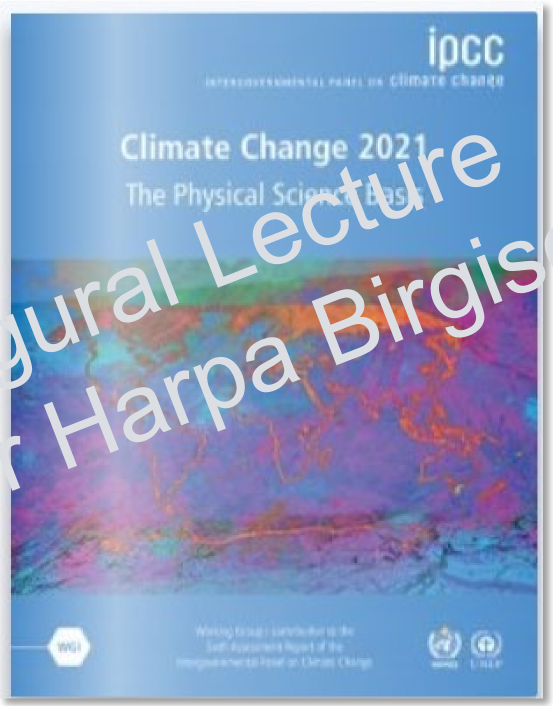




CLIMATE URGENCY



1990



August 6th 2021

September 16th 2021

BUILDINGS

9% of the global workforce is related to buildings

- 187.000 in Denmark

We spend 90% of our time inside buildings

- Living
- Work
- Education etc.

30-40% of our environmental challenges can be associated to buildings

- Global warming
- Resource consumption
- Waste generation

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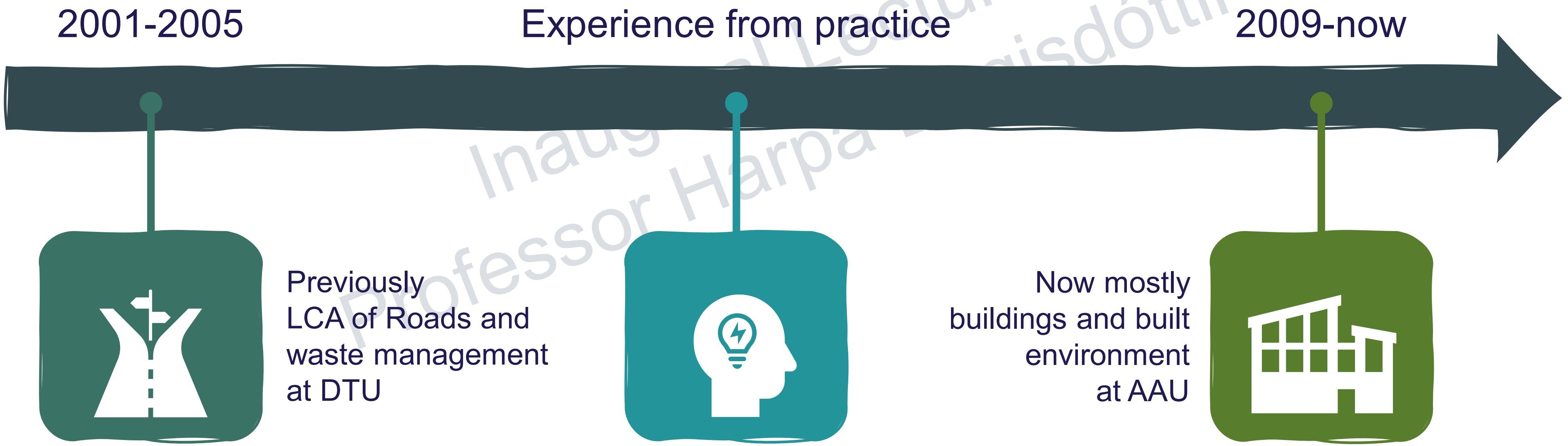
GREENHOUSE GAS EMISSIONS RELATED TO BUILT ENVIRONMENT ON GLOBAL SCALE

Embodied
Emissions related to Materials used in buildings

Operational
Emissions related to Operational energy consumption

MY RESEARCH AREA UNTIL NOW
LCA & SUSTAINABILITY



MY RESEARCH AT AAU (2009-now)

Sustainability Assessment of buildings

Development of LCA tools

Development of methods to evaluate environmental impacts in the built environment

Analysis of environmental impacts in the built environment

SUSTAINABILTY ASSESSMENT OF BUILDINGS

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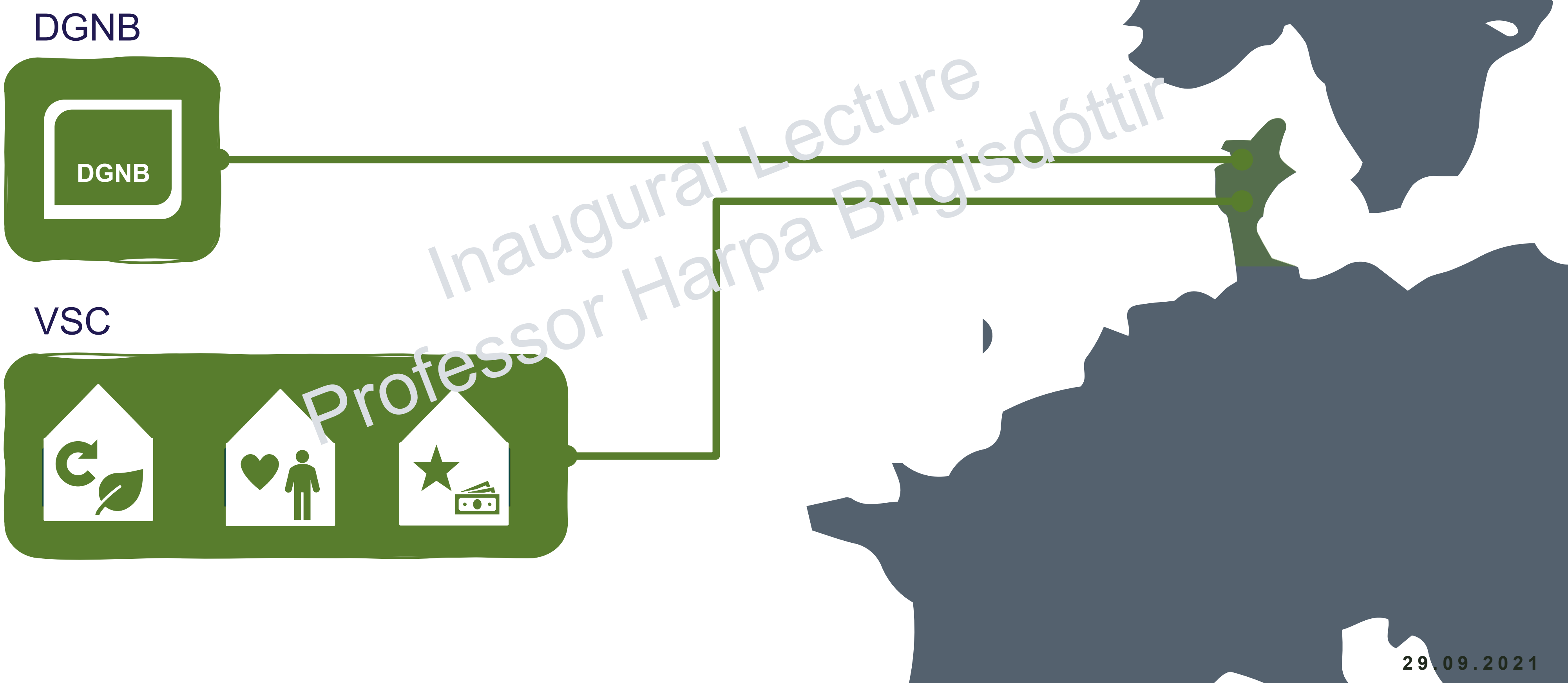
SUSTAINABILITY ASSESSMENT OF BUILDINGS
NATIONAL LEVEL



SUSTAINABILITY ASSESSMENT OF BUILDINGS

EUROPEAN LEVEL

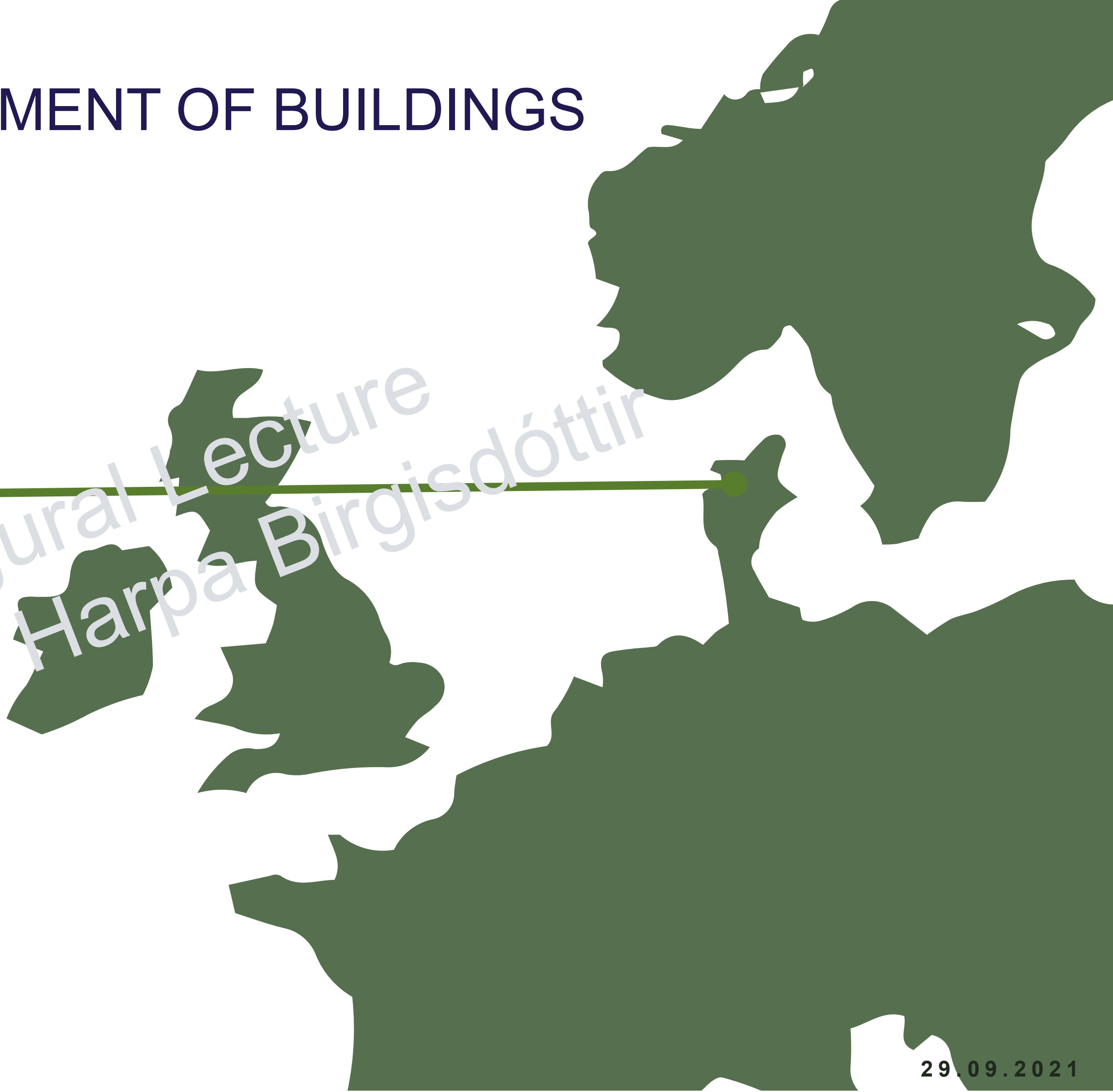
European Level(s)

Level(s)

Dansk test af Level(s)

– en fælles europæisk dokumentationsmetode for bæredygtigt byggeri

Analyse af erfaringer og anbefalinger til videreudvikling og implementering af Level(s) – resumé



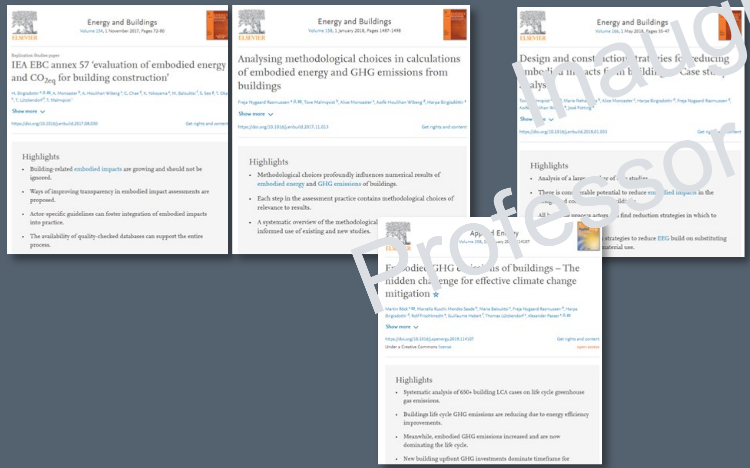
SUSTAINABILITY ASSESSMENT OF BUILDINGS

INTERNATIONAL LEVEL

OUR RESEARCH – TO INDUSTRY AND TO ACADEMIA

OUR RESEARCH – TO INDUSTRY AND TO ACADEMIA

Academic papers



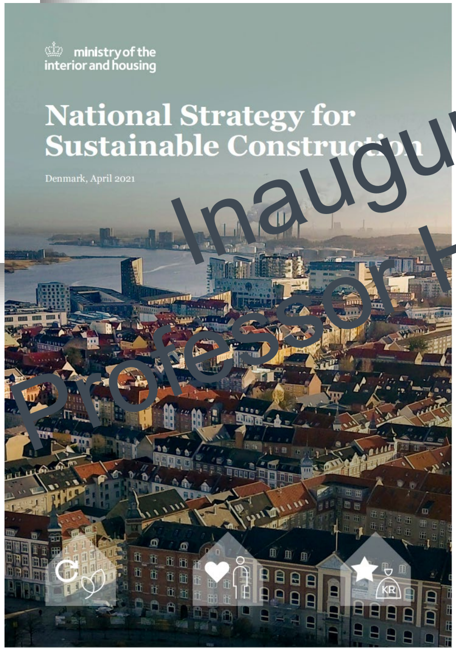
Tool and analysis

Aftale mellem regeringen (Socialdemokratiet) og Venstre, Dansk Folkeparti, Socialistisk Folkeparti, Radikale Venstre, Enhedslisten, Det Konservative Folkeparti og Alternativet om:

National strategi for bæredygtigt byggeri

5. marts 2021

1



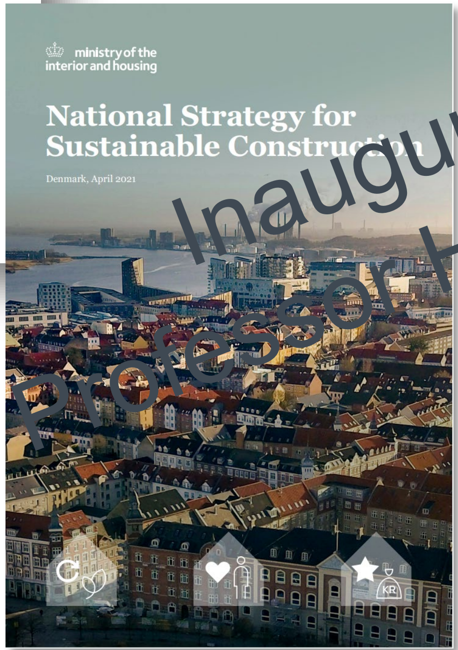
- March 5th 2021
- Danish National Strategy for Sustainable Construction
- Including limit values for GHG emissions (CO_2) from new construction from 2023

Aftale mellem regeringen (Socialdemokratiet) og Venstre, Dansk Folkeparti, Socialistisk Folkeparti, Radikale Venstre, Enhedslisten, Det Konservative Folkeparti og Alternativet om:

National strategi for bæredygtigt byggeri

5. marts 2021

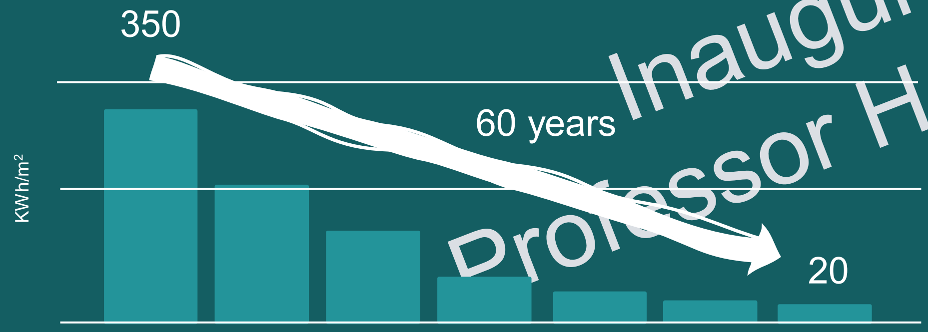
1



- How did we get there?
- How did our research at BUILD contribute?
- How can our on-going research at BUILD contribute to the future reductions?
- Are these requirements meeting the urgent needs for reduction?

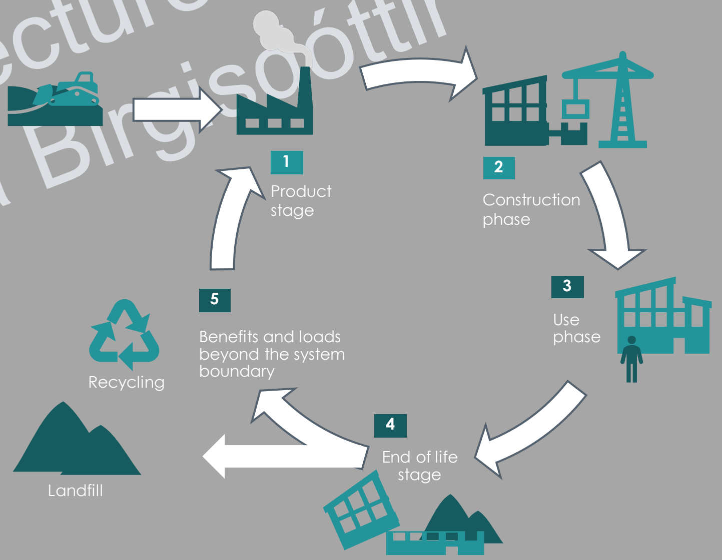
THE PAST VS NOW

Development of the operational energy requirements

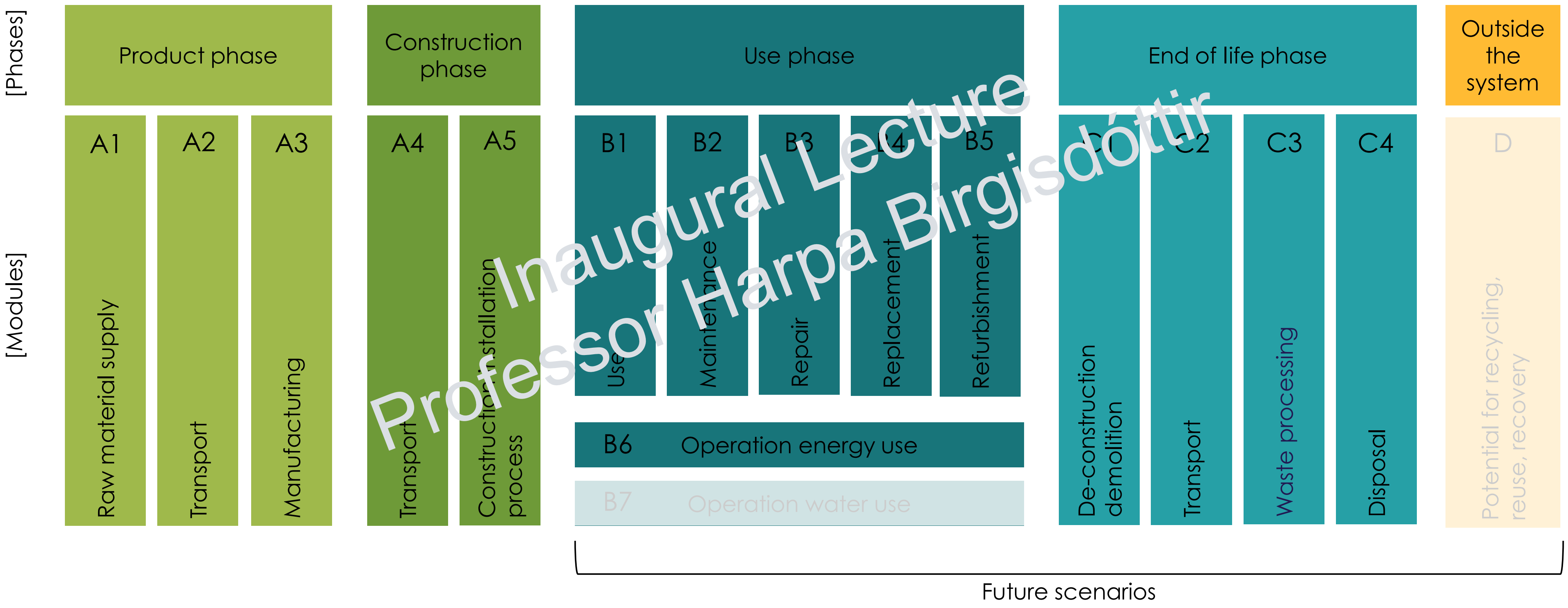


Kilde Energistyrelsen

Focus on building life cycle



BUILDING LIFE CYCLE



FOCUS IN RESEARCH

New construction
Whole life carbon
Embodied carbon

Method development, simplification and harmonisation

Biogenic materials

Urgency

LCAbyg

Existing buildings
Renovation

Circular strategies

LCAbyg DEVELOPMENT

Vision

Mainstreaming the LCA discipline in the built environment – by bringing it from “inside University walls” to “Building Design Practice”

LCAbyg

1. Development of thorough evaluation methods
2. Correctness in calculation and evaluation
3. Sound simplification and usability
4. Accessibility of sound data
5. Digitalization (BIM, EPD)

FOCUS IN RESEARCH

New construction
Whole life carbon
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METHOD DEVELOPMENT

1

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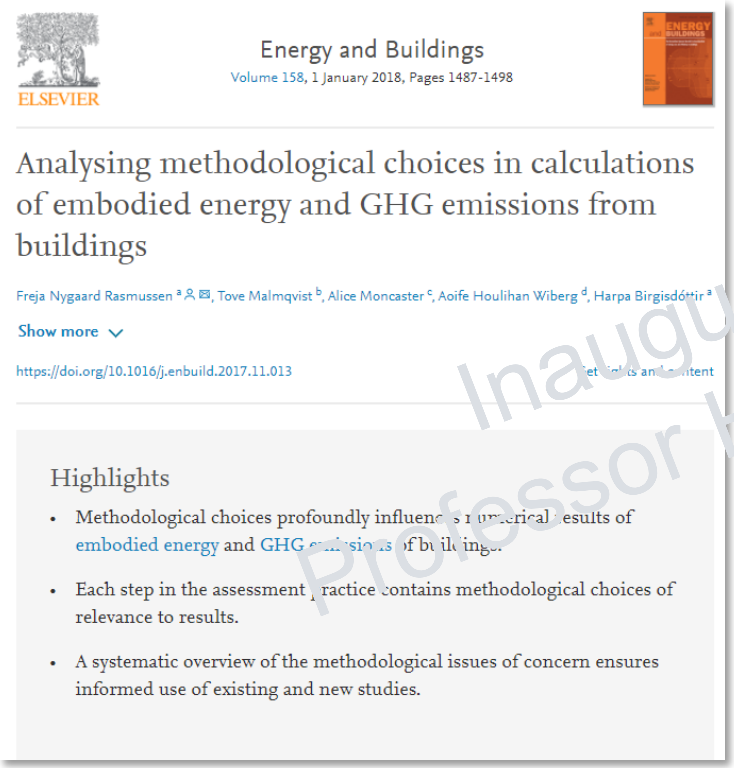
METHODOLOGICAL CHOICES IMPORTANCE FOR RESULTS


Energy and Buildings

Volume 158, 1 January 2018, Pages 1487-1498

ELSEVIER

Analysing methodological choices in calculations of embodied energy and GHG emissions from buildings

Freja Nygaard Rasmussen [a], Tove Malmqvist [b], Alice Moncaster [c], Aoife Houlihan Wiberg [d], Harpa Birgisdóttir [a]

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https://doi.org/10.1016/j.enbuild.2017.11.013

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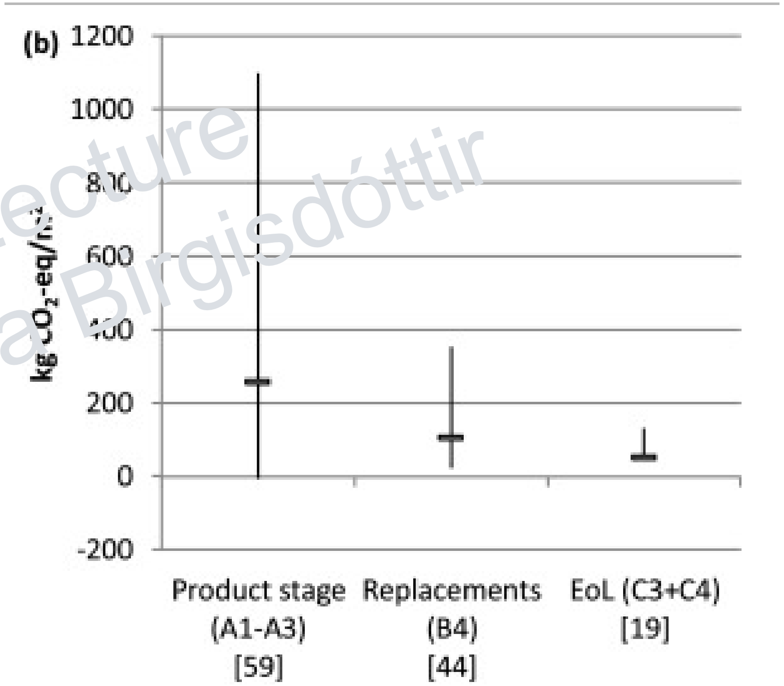
Highlights

- Methodological choices profoundly influence numerical results of embodied energy and GHG emissions of buildings.
- Each step in the assessment practice contains methodological choices of relevance to results.
- A systematic overview of the methodological issues of concern ensures informed use of existing and new studies.



METHOD DEVELOPMENT

2

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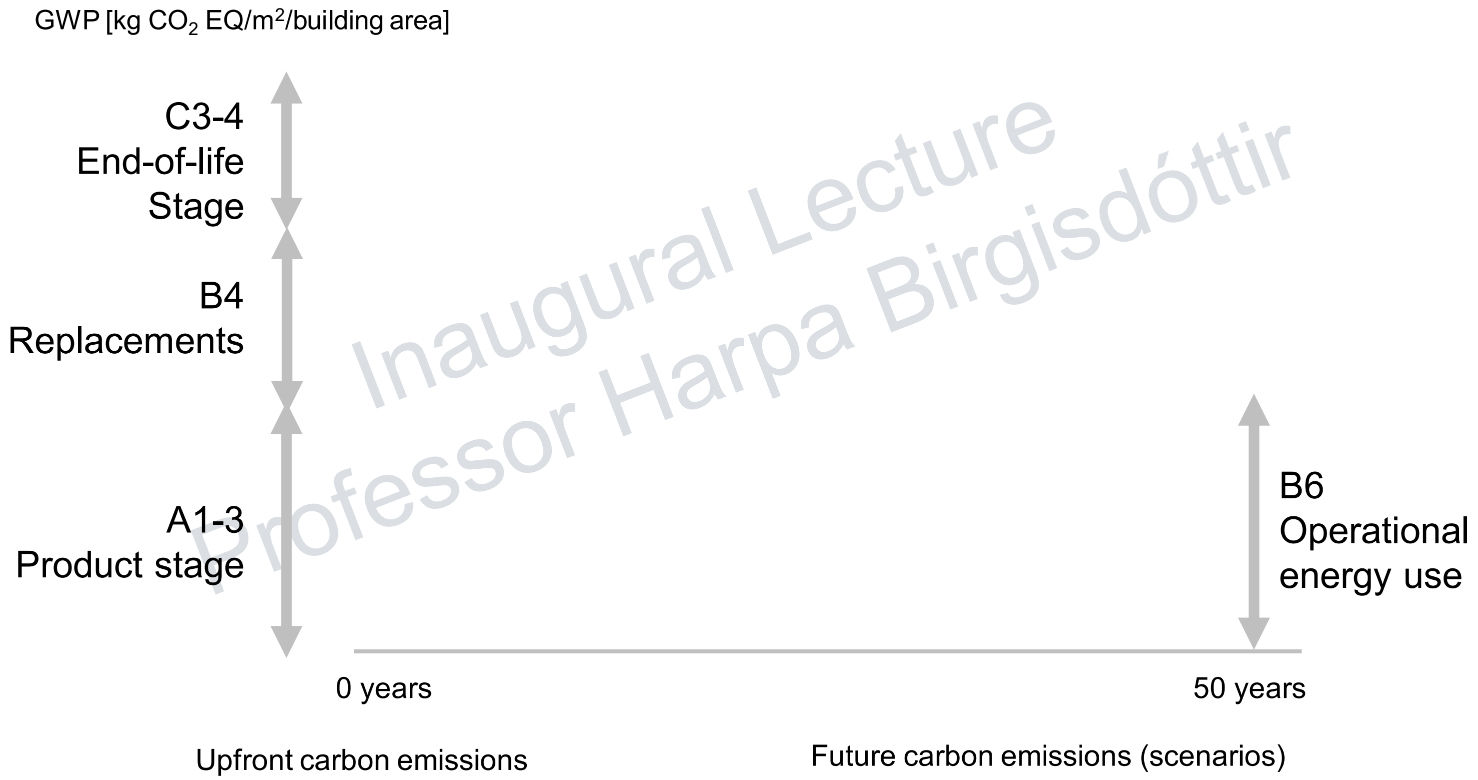
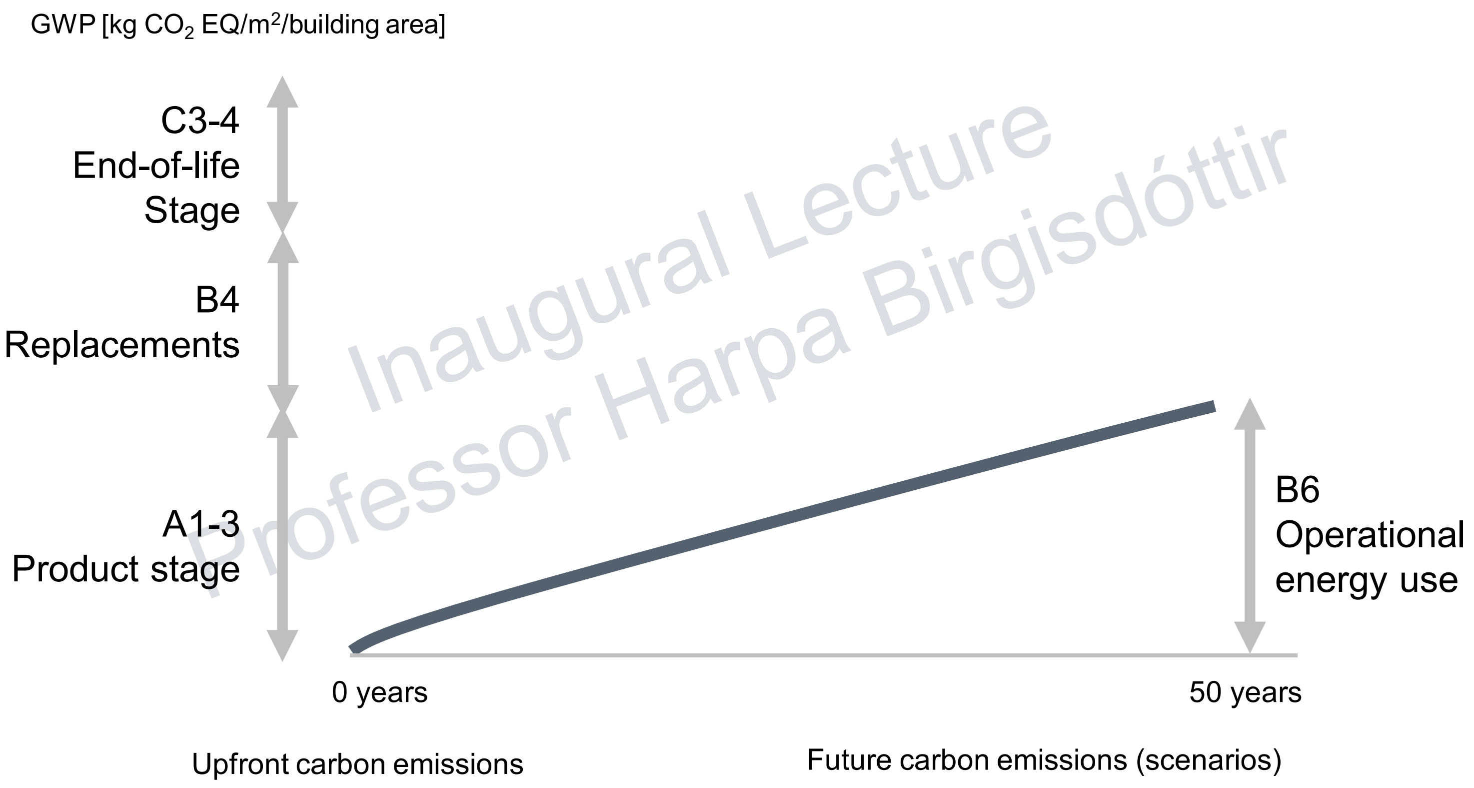
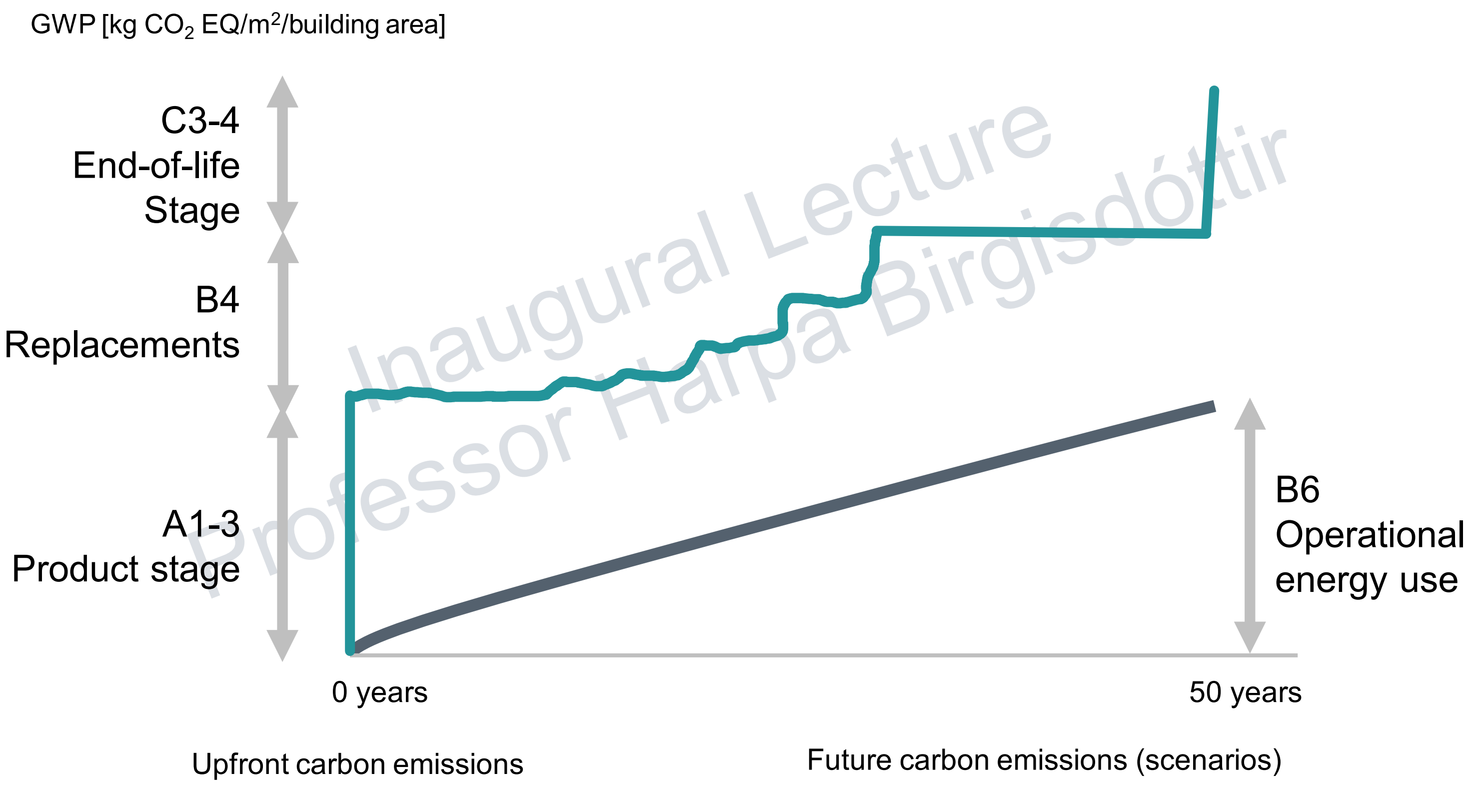
BUILDING LIFE CYCLE – AND TIMING



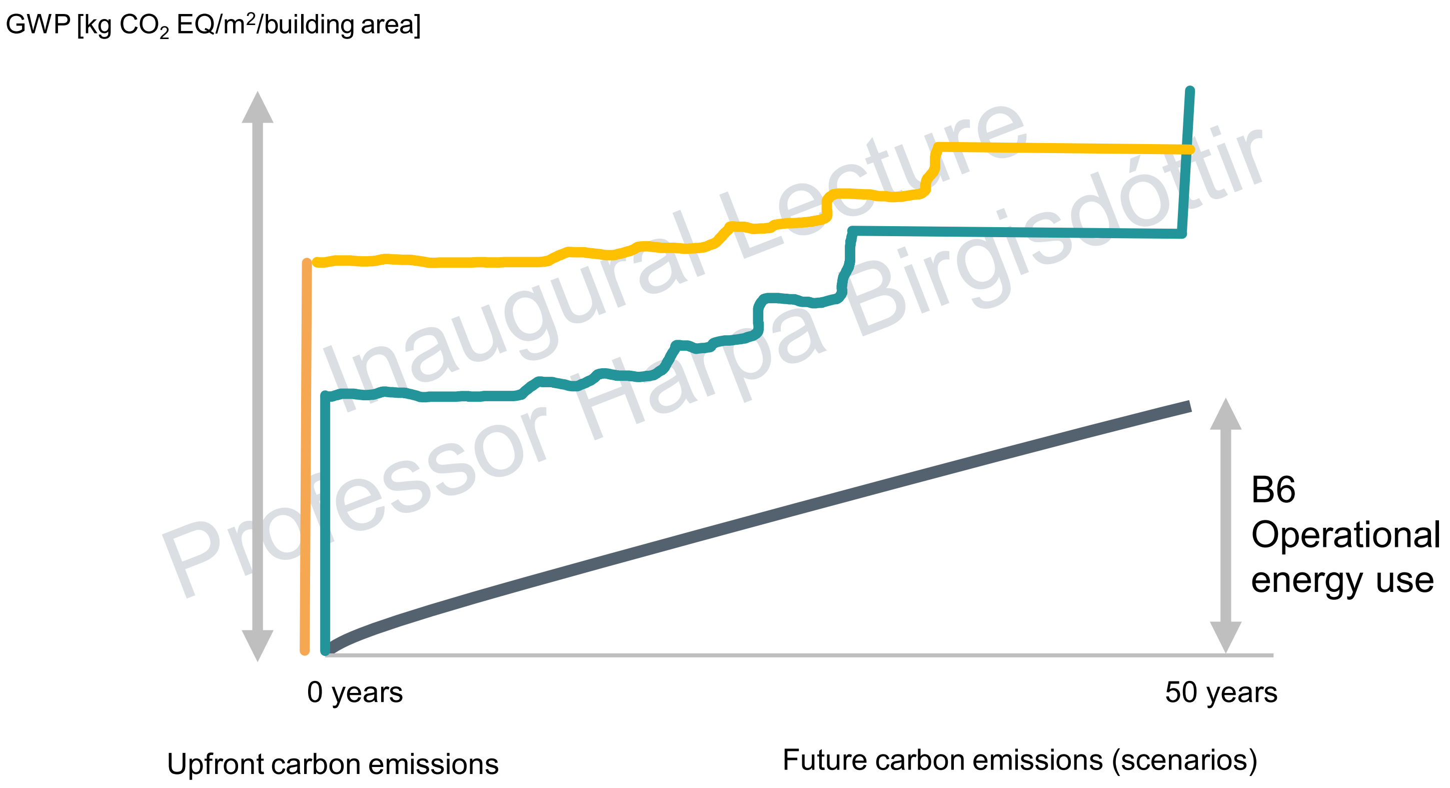
BUILDING LIFE CYCLE – AND TIMING



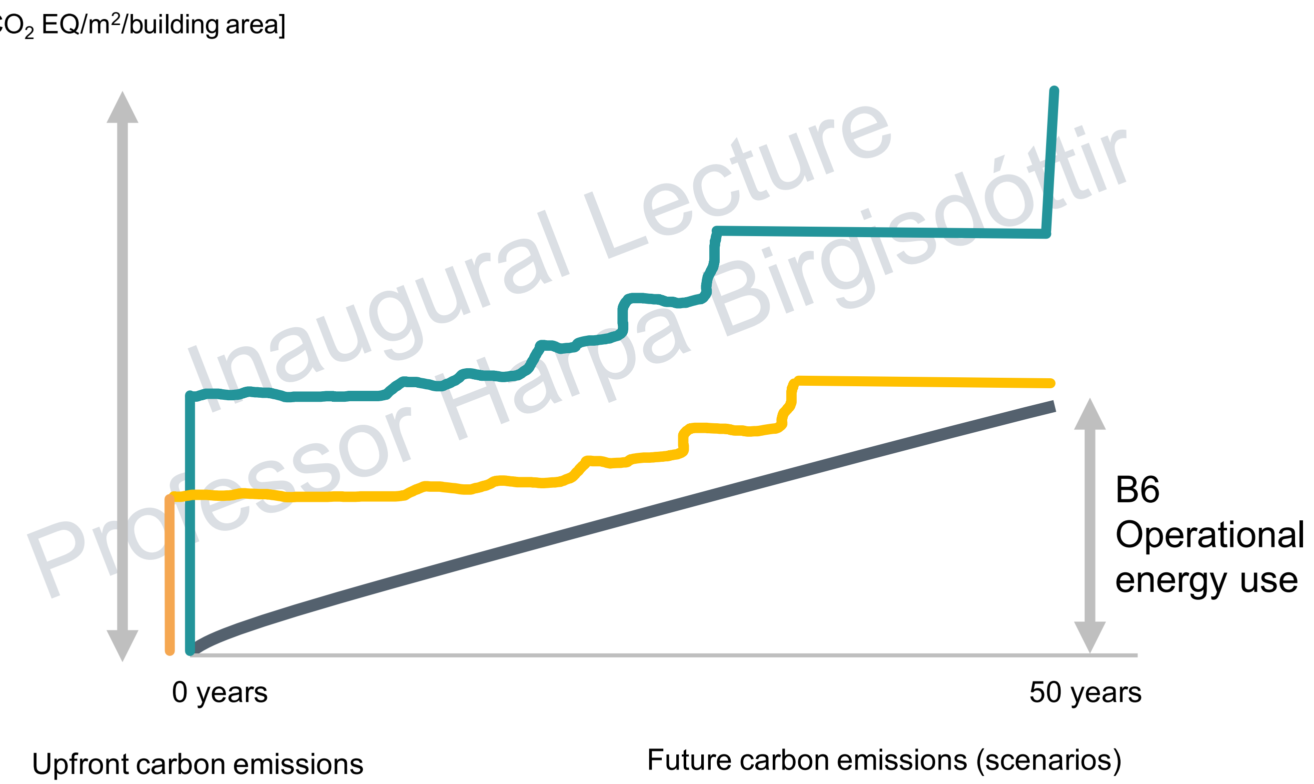
BUILDING LIFE CYCLE – AND TIMING



BUILDING LIFE CYCLE – AND TIMING



BUILDING LIFE CYCLE – AND TIMING



WHY ALL THIS FOCUS ON TIME?

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TIMING OF EMISSIONS

We need to reduce emissions as fast as possible to be able to meet the Paris agreement

Reduction of emission of GHG gasses with 70% compared to 1990

2030

Climate neutral society

2050

FOCUS IN RESEARCH

New construction
Whole life carbon
Embodied carbon

Method development, simplification and harmonisation

Urgency

LCAbyg

Biogenic materials

Existing buildings
Renovation

Circular strategies

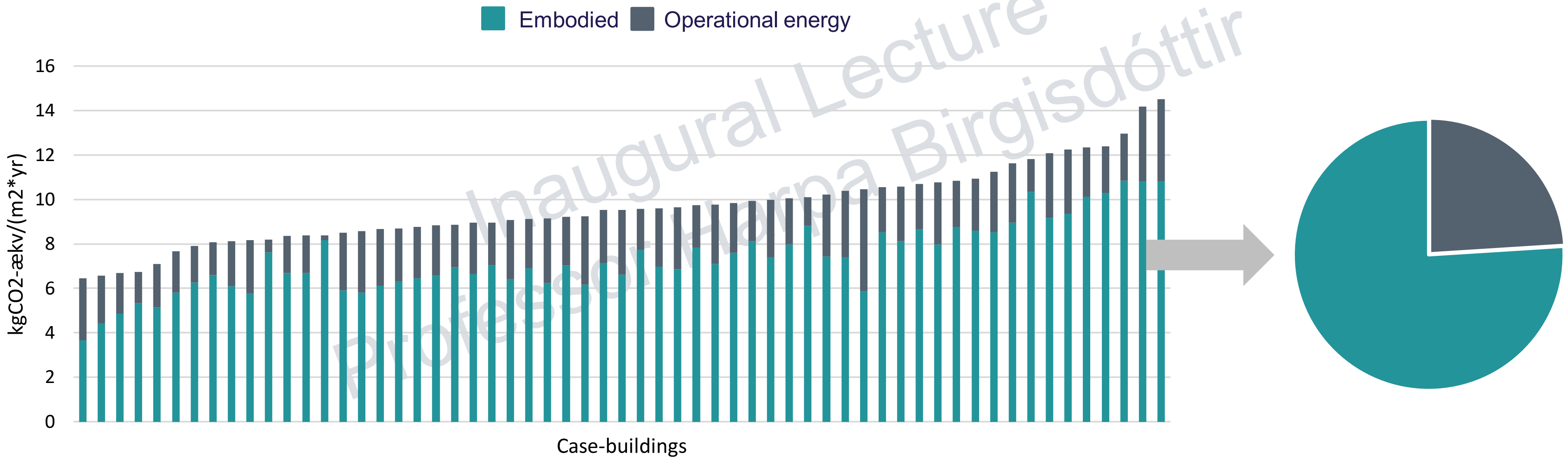
NEW CONSTRUCTION
WHOLE LIFE CARBON & EMBODIED CARBON
1 NATIONAL LEVEL

REPORT:
WHOLE LIFE CARBON ASSESSMENT OF 60 DANISH BUILDING CASES

Purpose

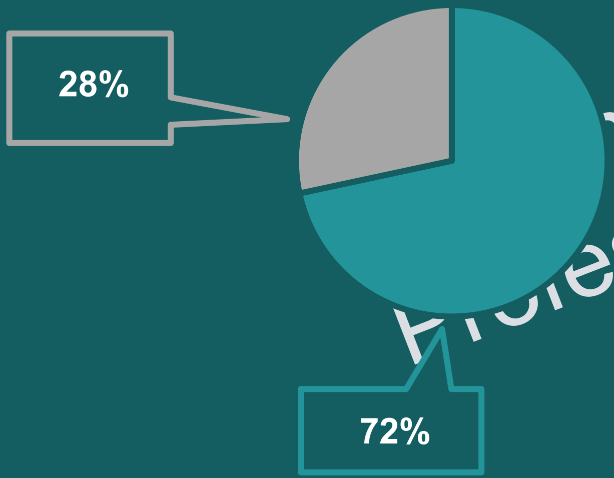
- To establish sufficient data background on the climate impact of buildings in Denmark over their life cycle.
- On the basis of this, possible reference values are calculated and suggested

WHOLE LIFE CARBON
(50 YEARS REFERENCE STUDY PERIOD)

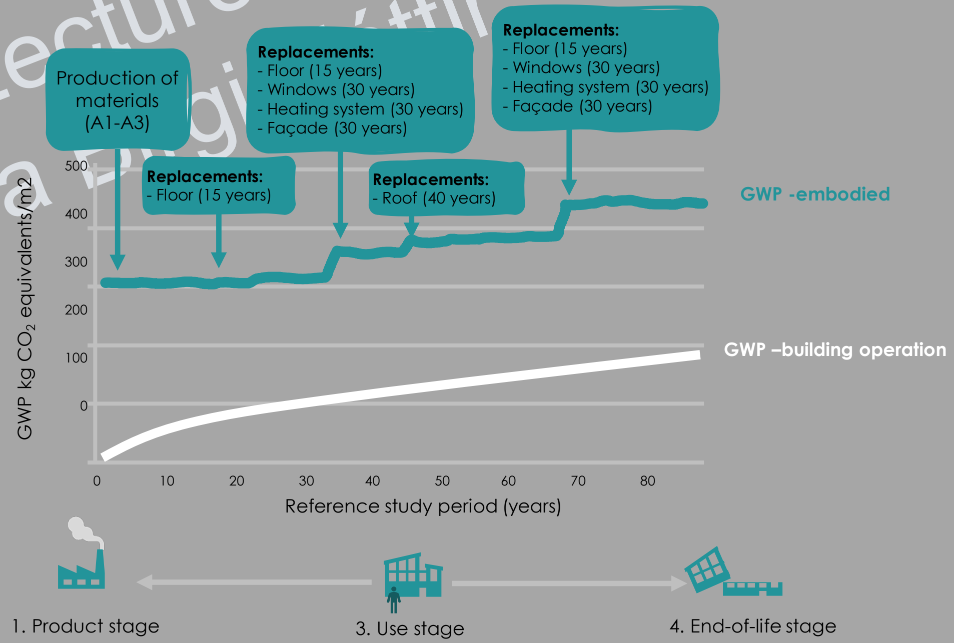


IMPORTANT LESSONS FOR WHOLE LIFE CARBON OF NEW BUILDINGS

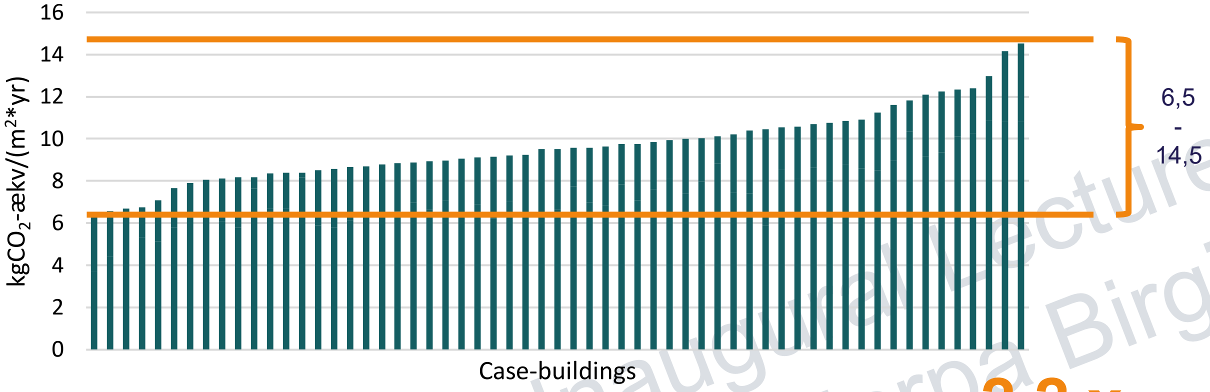
1. The importance of embodied



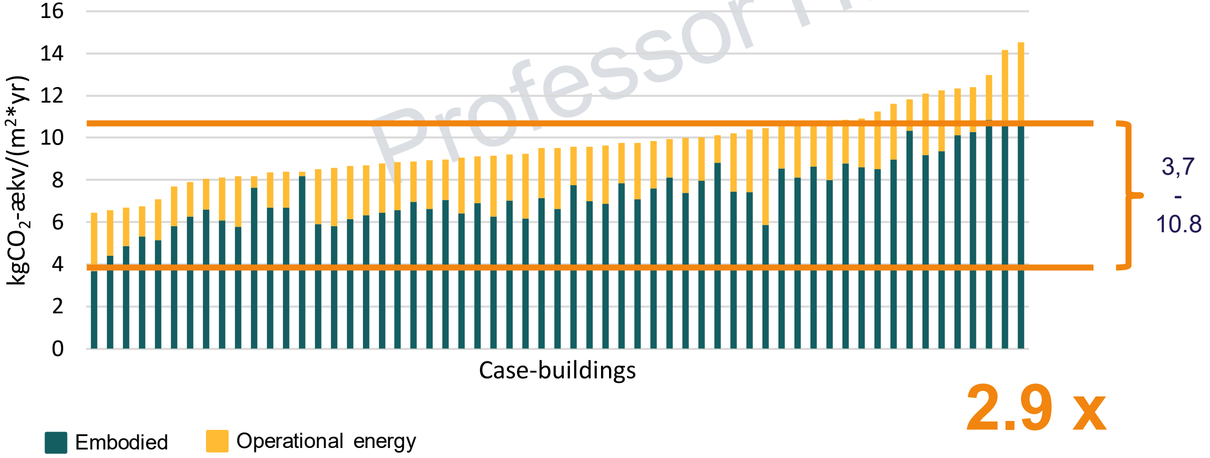
2. The timing of emissions



IMPORTANT LESSONS FOR WHOLE LIFE CARBON OF NEW BUILDINGS

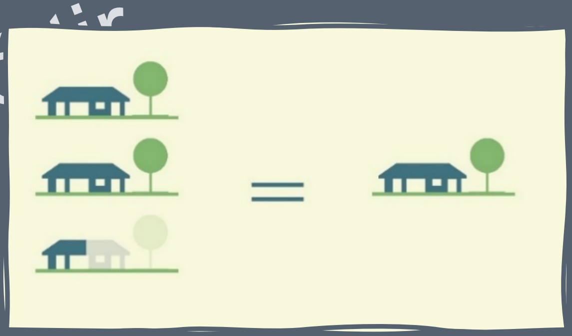


2.2 x



2.9 x

3. Large potential to reduce!



HOW WERE THE RESULTS USED ?

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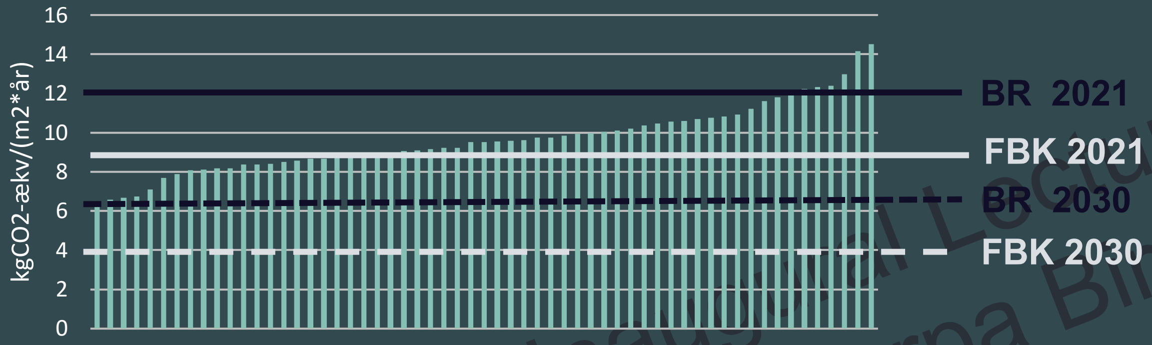
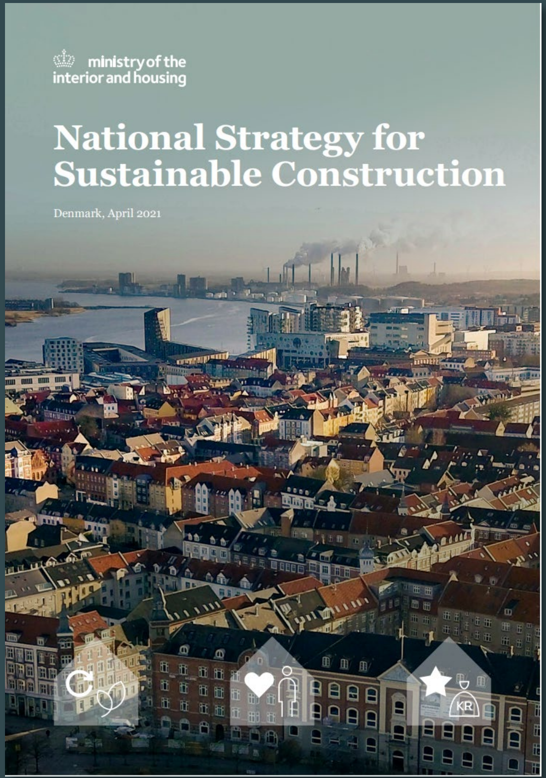
CLIMATE PARTNERSHIPS SUGGES-TIONS OF LIMIT VALUES (IN 2020)



	Building regulation kg CO_2/m²/year	Voluntary sustainability class kg CO_2/m²/year
2021	**12**	**8,5**
-- --		
2030	**6**	**3,5 - 4**



NEW NATIONAL STRATEGY (2021)

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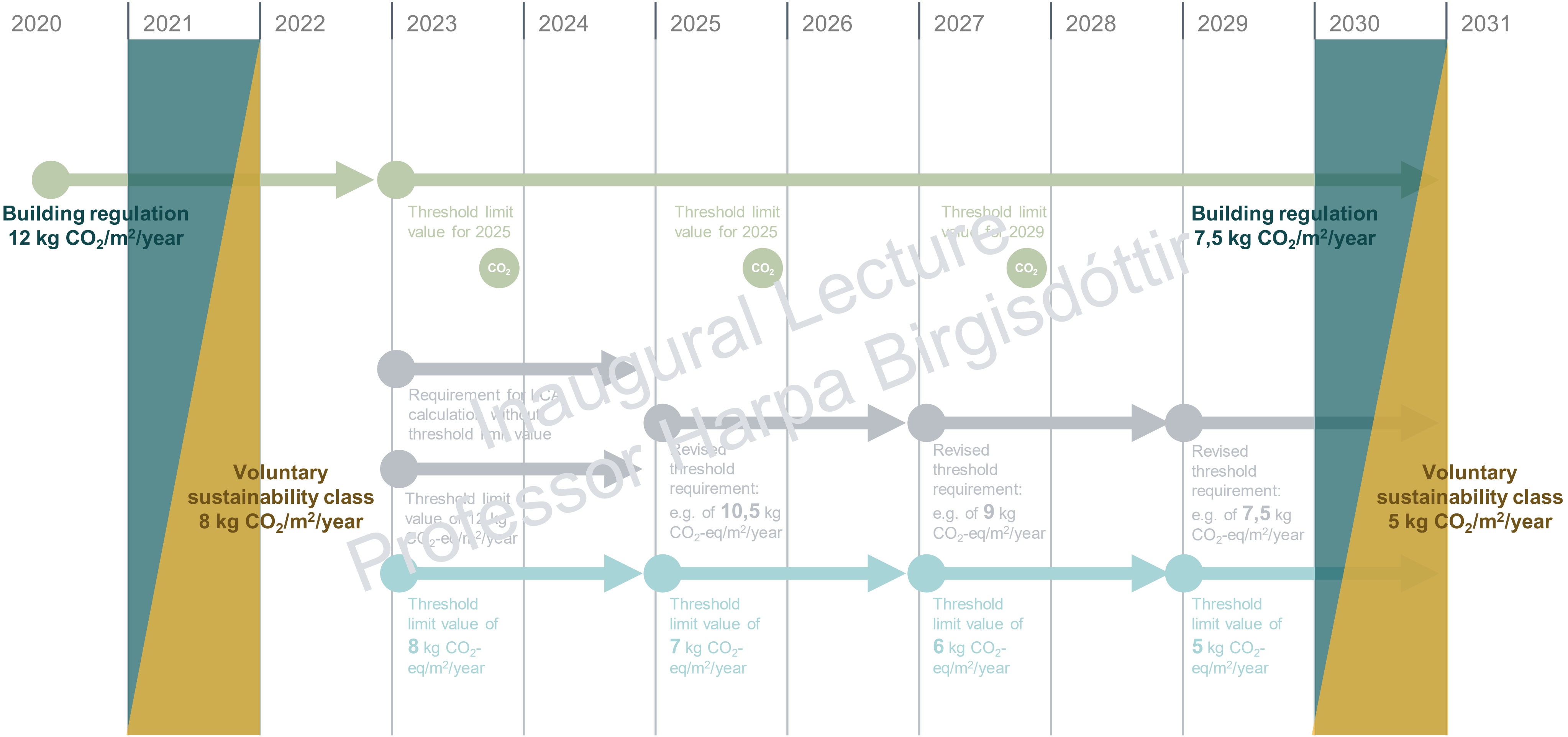
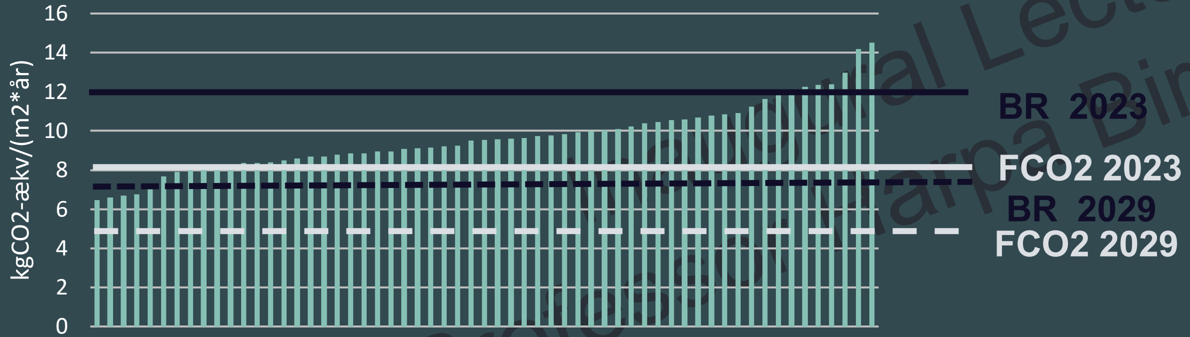
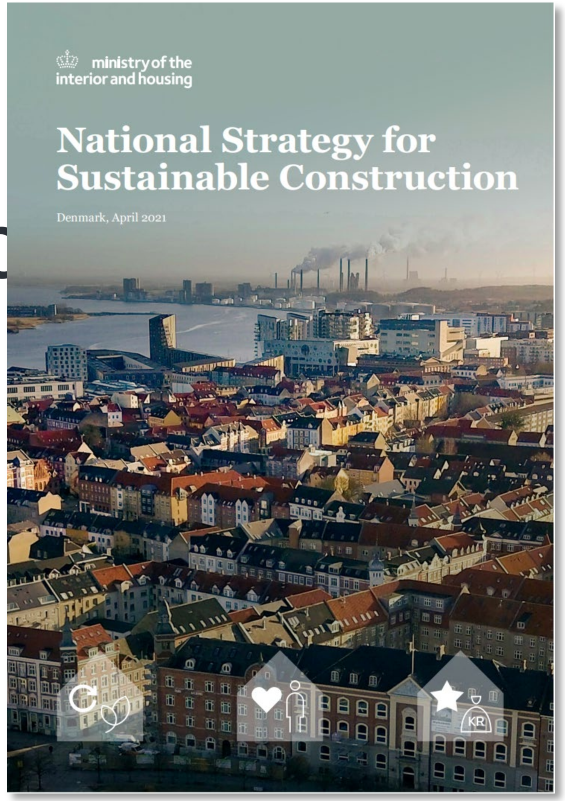

2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
Building regulation
12 kg CO_2/m^2/year
Threshold limit value for 2025
Threshold limit value for 2025
Threshold limit value for 2029
CO_2
Building regulation
7,5 kg CO_2/m^2/year
Requirement for LCA calculation without threshold limit value
Threshold limit value of 12 kg CO_2-eq/m^2/year
Revised threshold requirement: e.g. of 10,5 kg CO_2-eq/m^2/year
Revised threshold requirement: e.g. of 9 kg CO_2-eq/m^2/year
Revised threshold requirement: e.g. of 7,5 kg CO_2-eq/m^2/year
Voluntary sustainability class
8 kg CO_2/m^2/year
Voluntary sustainability class
5 kg CO_2/m^2/year
Threshold limit value of 8 kg CO_2-eq/m^2/year
Threshold limit value of 7 kg CO_2-eq/m^2/year
Threshold limit value of 6 kg CO_2-eq/m^2/year
Threshold limit value of 5 kg CO_2-eq/m^2/year

NATIONAL STRATEGY LIMIT VALUES (IN 2021)





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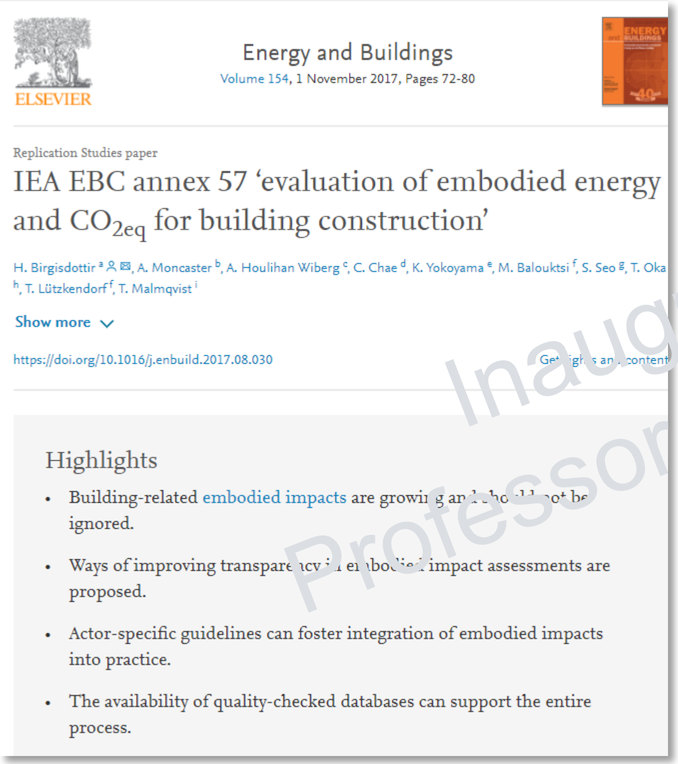
NEW CONSTRUCTION
WHOLE LIFE CARBON & EMBODIED CARBON
2 INTERNATIONAL PERSPECTIVE

29.09.2021

EMBODIED IMPACTS ARE IMPORTANT



Energy and Buildings
Volume 154, 1 November 2017, Pages 72-80

ELSEVIER

Replication Studies paper

IEA EBC annex 57 ‘evaluation of embodied energy and CO_{2eq} for building construction’

H. Birgisdottir [a], A. Moncaster [b], A. Houlihan Wiberg [c], C. Chae [d], K. Yokoyama [e], M. Balouktsi [f], S. Seo [g], T. Oka [h], T. Lützkendorf [f], T. Malmqvist [i]

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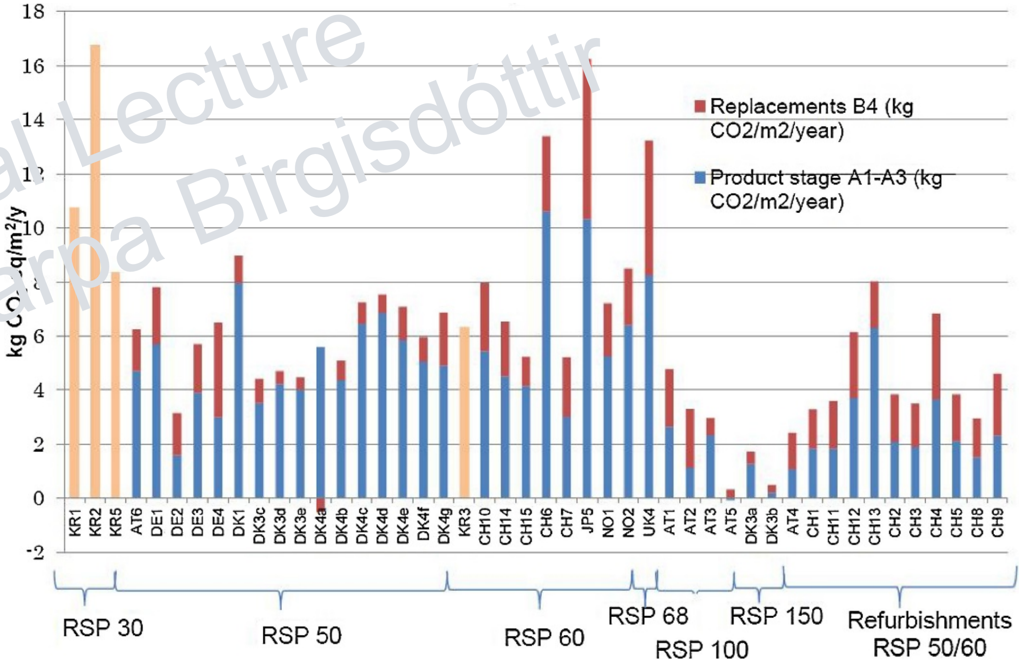
https://doi.org/10.1016/j.enbuild.2017.08.030

Highlights

- Building-related embodied impacts are growing and should not be ignored.
- Ways of improving transparency in embodied impact assessments are proposed.
- Actor-specific guidelines can foster integration of embodied impacts into practice.
- The availability of quality-checked databases can support the entire process.

But methods different and comparison is difficult



EMBODIED IMPACTS ARE IMPORTANT

Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation ☆

Martin Röck [a], Marcella Ruschi Mendes Saade [b], Maria Balouktsi [c], Freja Nygaard Rasmussen [d], Harpa Birgisdottir [d], Rolf Frischknecht [e], Guillaume Habert [f], Thomas Lützkendorf [c], Alexander Passer [a]

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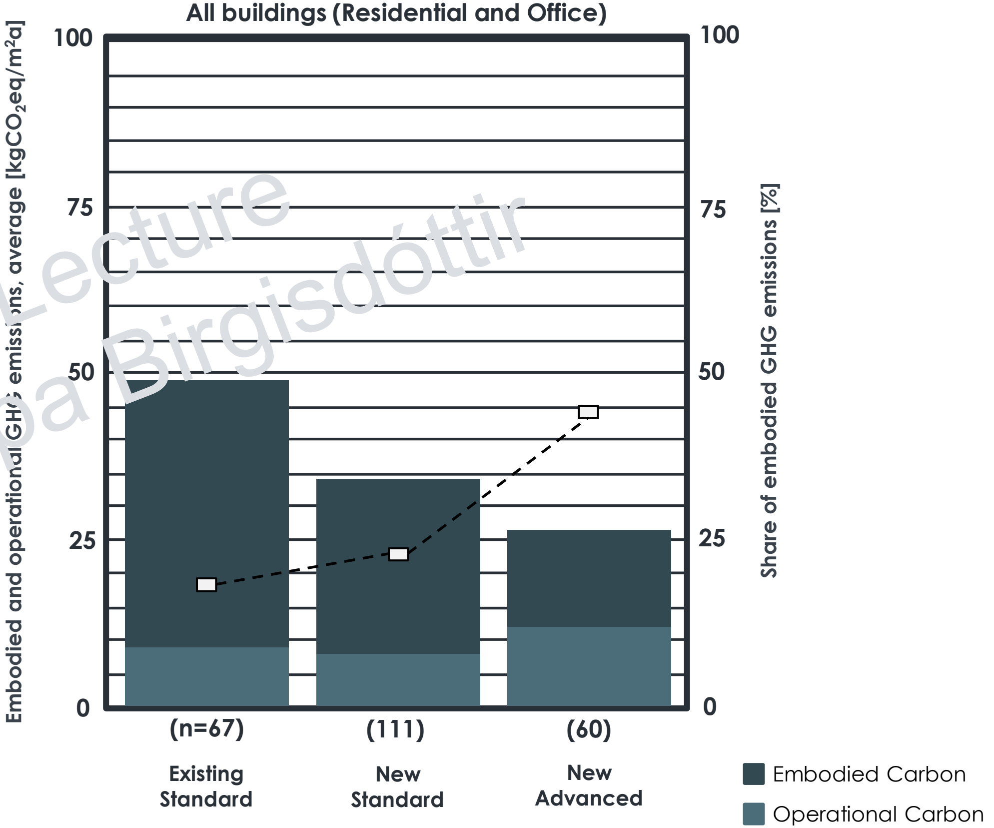
Highlights

- 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.



EMBODIED IMPACTS ARE IMPORTANT – AND TIMING MATTERS

Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation ☆

Martin Röck[a], Marcella Ruschi Mendes Saade[b], Maria Balouktsi[c], Freja Nygaard Rasmussen[d], Harpa Birgisdottir[d], Rolf Frischknecht[e], Guillaume Habert[f], Thomas Lützkendorf[c], Alexander Passer[a]

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https://doi.org/10.1016/j.apenergy.2019.114107

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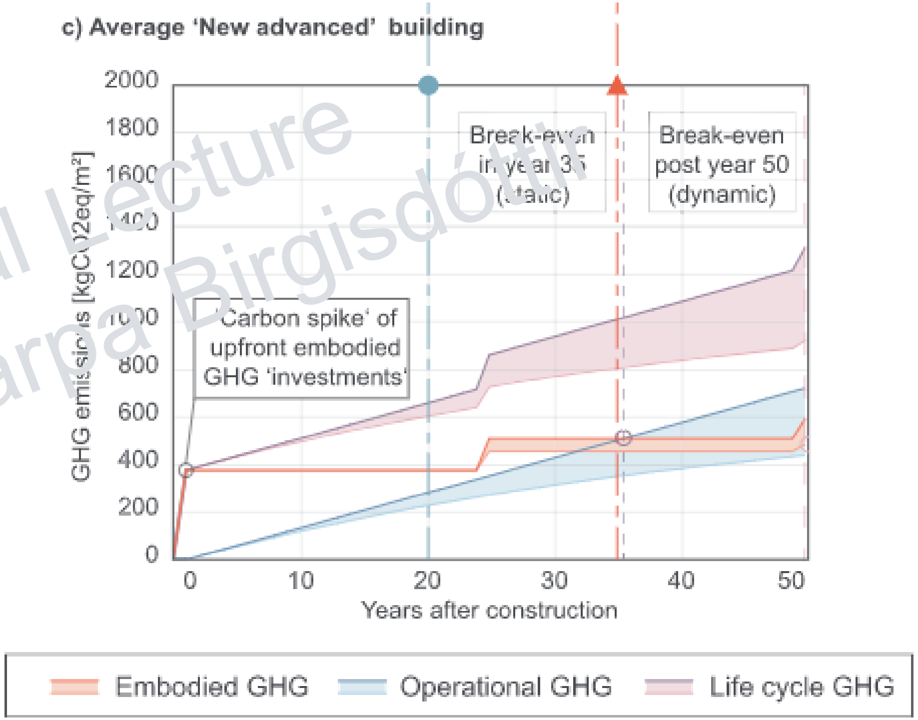
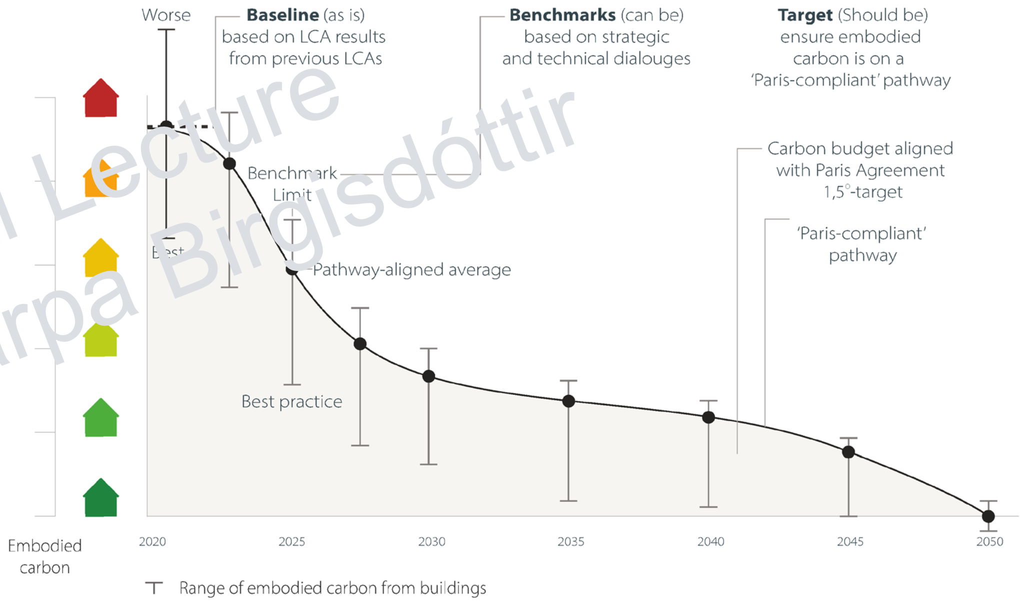


NEW CONSTRUCTION
WHOLE LIFE CARBON & EMBODIED CARBON
3 EUROPEAN PERSPECTIVE

29.09.2021

NEED FOR EU HARMONISED BENCHMARKS (ONGOING RESEARCH)

- Call for benchmarks due to different European policies and initiatives, e.g.
  - Revision of Energy Performance of Building Directive
  - Level(s)
  - EU Taxonomy
- Embodied Carbon Baseline in Belgium, Denmark, Finland, France and Netherlands.
- Science based targets based on carbon budgets and absolute sustainability



NO DOUBT THAT WE NEED TO REDUCE CLIMATE IMPACTS RELATED TO BUILDINGS, BUT WHAT DO WE HAVE IN THE TOOLBOX?

IDENTIFICATION OF DIFFERENT DESIGN STRATEGIES THAT REDUCE EMBODIED CARBON

ELSEVIER
Energy and Buildings
Volume 166, 1 May 2018, Pages 35-47

Design and construction strategies for reducing embodied impacts from buildings – Case study analysis

Tove Malmqvist [a], Marie Nehasilova [b], Alice Moncaster [c], Harpa Birgisdottir [d], Freja Nygaard Rasmussen [d], Aoife Houlihan Wiberg [e], José Potting [a]
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https://doi.org/10.1016/j.enbuild.2018.01.033
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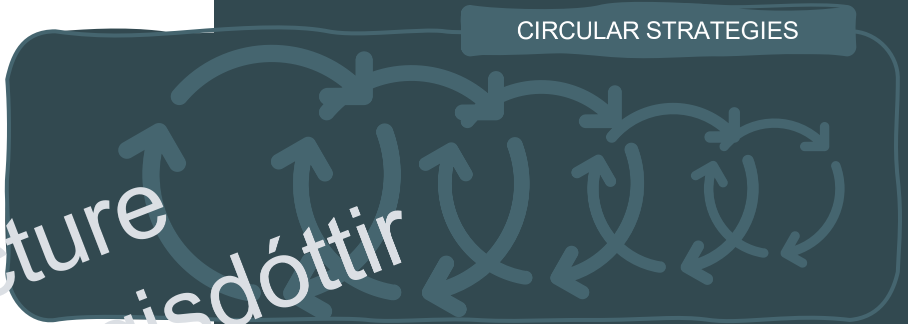
Highlights

- Analysis of a large number of case studies.
- There is considerable potential to reduce embodied impacts in the design and construction of buildings.
- All building process actors can find reduction strategies in which to engage.
- Design and construction strategies to reduce EEG build on substituting materials and reducing material use.



Project:
IEA Annex 57

BIOGENIC MATERIALS
INCREASED USE OF WOOD IN BUILDIGS

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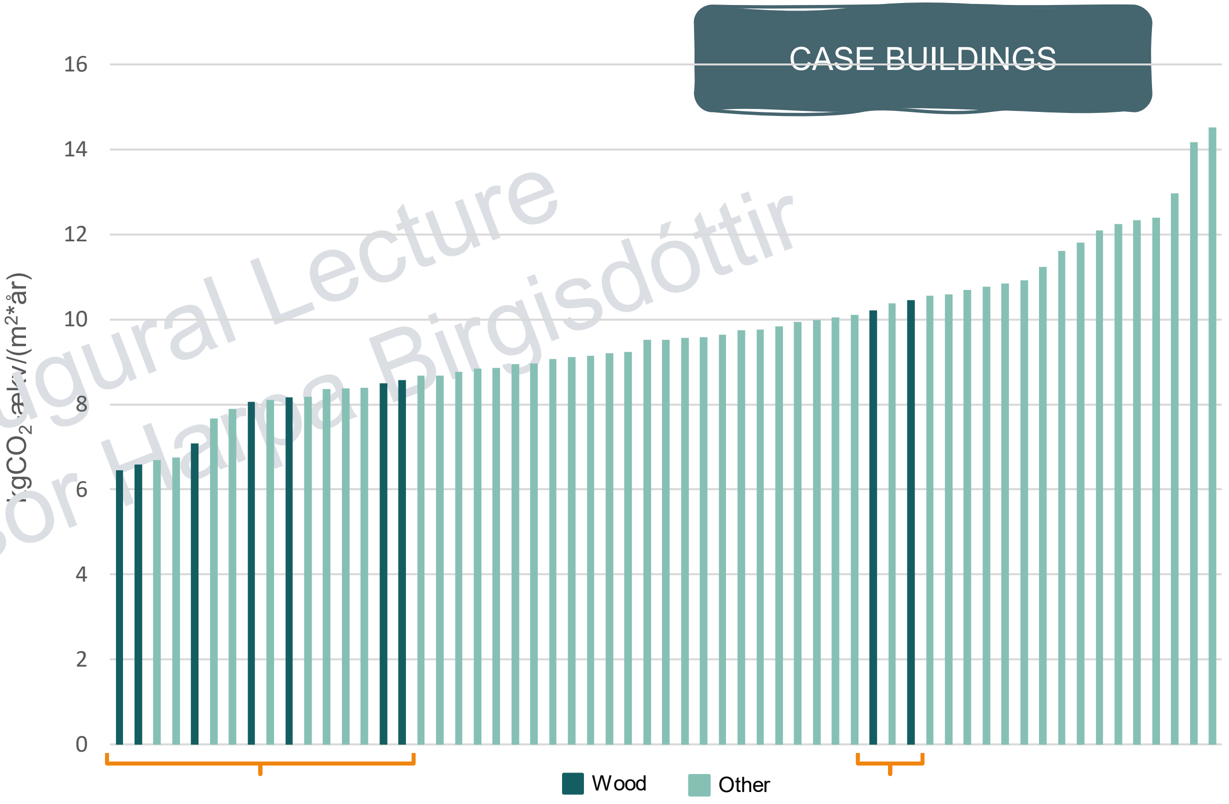
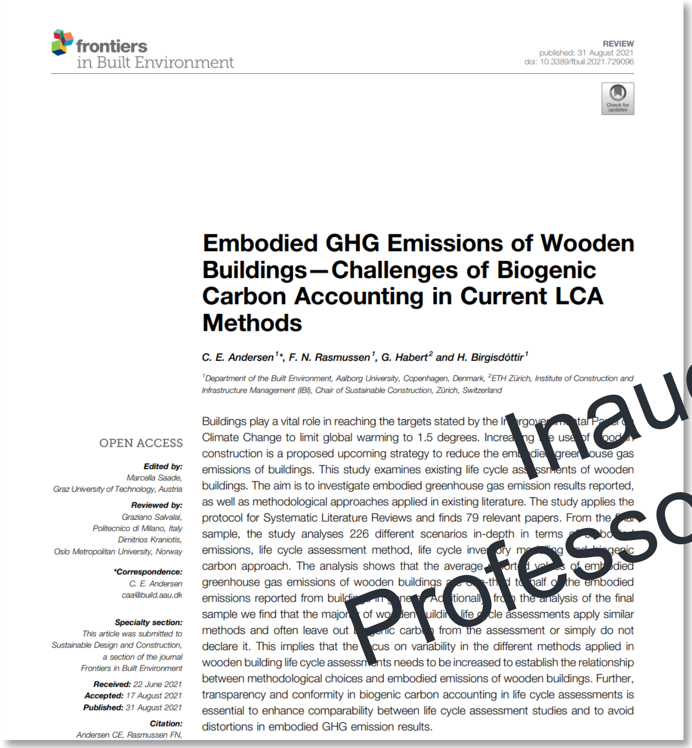
CLIMATE IMPACTS FROM BUILDINGS WITH STRUCTURAL MATERIALS OF WOOD



WOODEN BUILDINGS HAVE LOWER CLIMATE IMPACTS



frontiers in Built Environment
REVIEW
published: 31 August 2021
doi: 10.3389/fbuil.2021.729096

Check for updates

Embodied GHG Emissions of Wooden Buildings—Challenges of Biogenic Carbon Accounting in Current LCA Methods

C. E. Andersen[1]*, F. N. Rasmussen[1], G. Habert[2] and H. Birgisdóttir[1]

[1]Department of the Built Environment, Aalborg University, Copenhagen, Denmark, [2]ETH Zürich, Institute of Construction and Infrastructure Management (IBI), Chair of Sustainable Construction, Zürich, Switzerland

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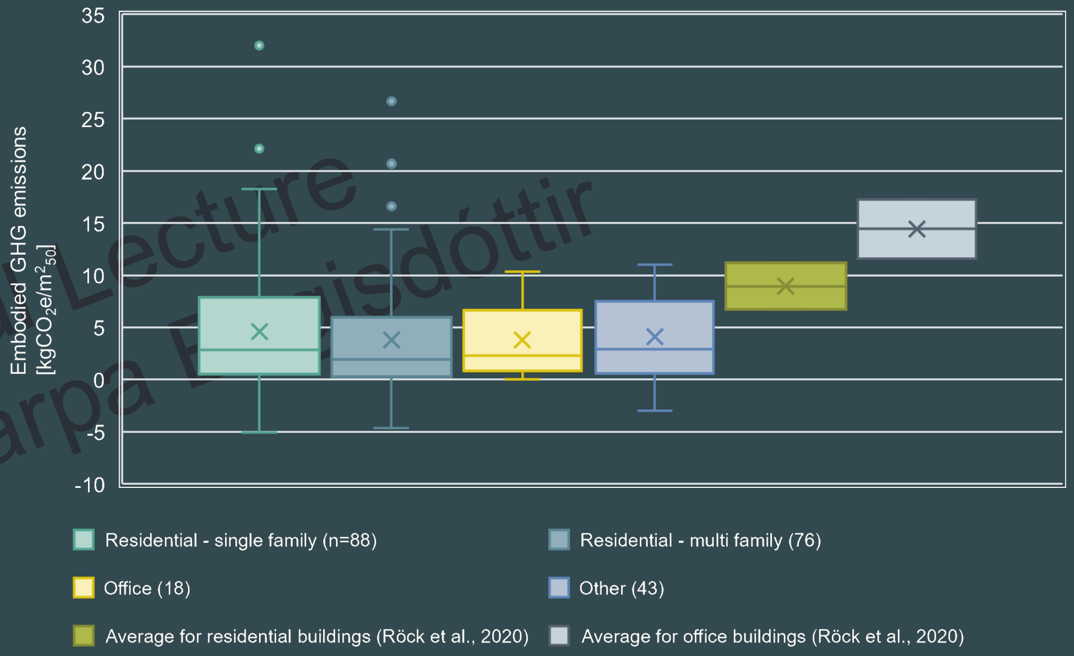
Citation:
Andersen CE, Rasmussen FN,

Buildings play a vital role in reaching the targets stated by the Intergovernmental Panel on Climate Change to limit global warming to 1.5 degrees. Increasing the use of wood in construction is a proposed upcoming strategy to reduce the embodied greenhouse gas emissions of buildings. This study examines existing life cycle assessments of wooden buildings. The aim is to investigate embodied greenhouse gas emission results reported, as well as methodological approaches applied in existing literature. The study applies the protocol for Systematic Literature Reviews and finds 79 relevant papers. From the final sample, the study analyses 226 different scenarios in-depth in terms of embodied emissions, life cycle assessment method, life cycle inventory modelling and biogenic carbon approach. The analysis shows that the average reported values of embodied greenhouse gas emissions of wooden buildings are one-third to half of the embodied emissions reported from buildings in general. Additionally, from the analysis of the final sample we find that the majority of wooden building life cycle assessments apply similar methods and often leave out biogenic carbon from the assessment or simply do not declare it. This implies that the focus on variability in the different methods applied in wooden building life cycle assessments needs to be increased to establish the relationship between methodological choices and embodied emissions of wooden buildings. Further, transparency and conformity in biogenic carbon accounting in life cycle assessments is essential to enhance comparability between life cycle assessment studies and to avoid distortions in embodied GHG emission results.



226 scenarios from literature shows that wooden buildings have a **factor 0,3 to 0,6** lower climate impacts compared to other materials

Project:
Camilla E. Andersen PhD

Increased use of wood
Villum foundation and
Realdania

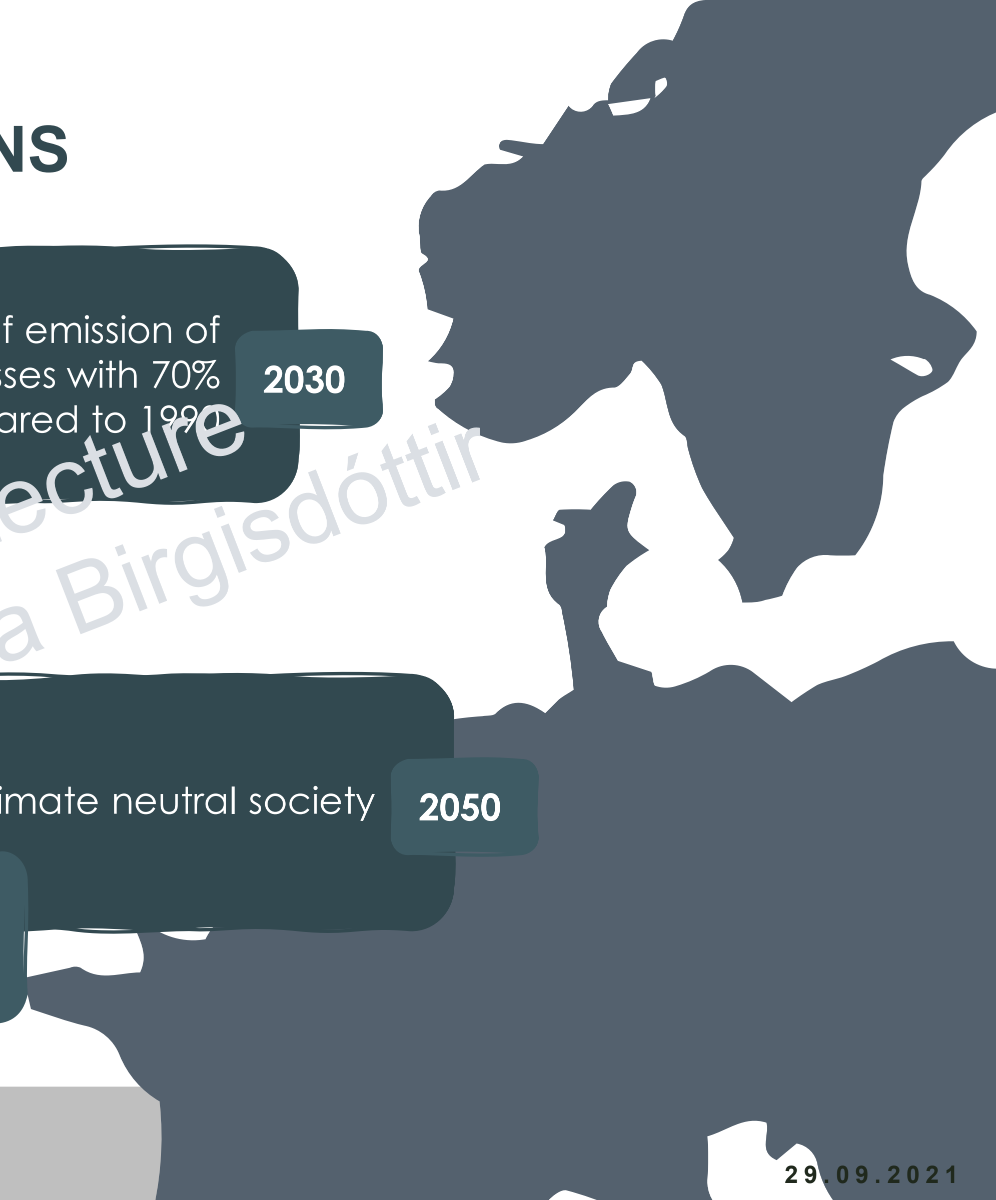
WOOD AND TIMING OF EMISSIONS

Reduction of emission of GHG gasses with 70% compared to 1990

2030

Climate neutral society

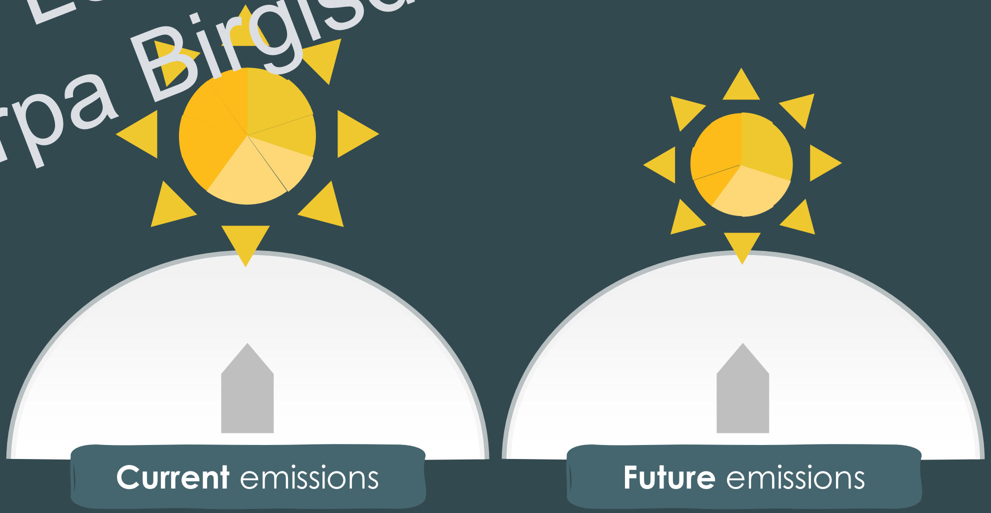
2050



DYNAMIC LCA MODELLING

TIMING IS IMPORTANT

- GHG accumulate in the atmosphere
- The sooner the emission occur, the longer time the GHG have to accumulate in the atmosphere
- → larger potential Global warming



Project:
Camilla E. Andersen PhD

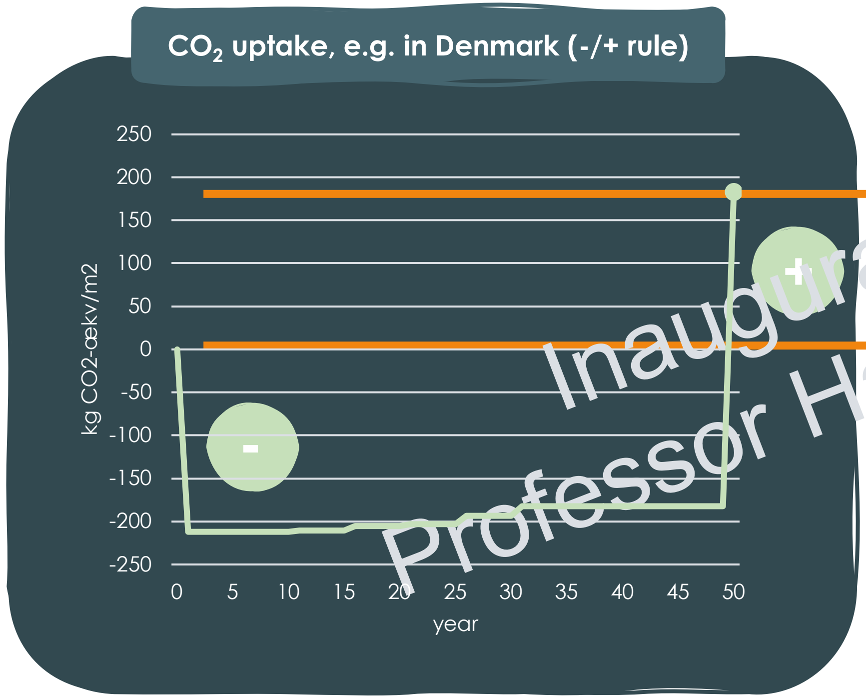
Increased use of wood
Villum foundation and
Realdania

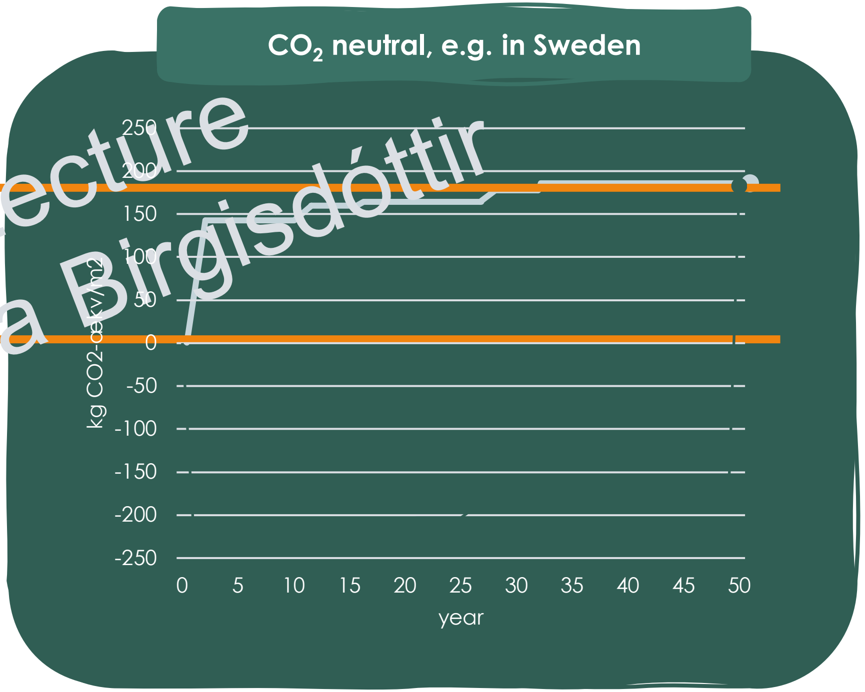
DYNAMIC LCA MODELLING

Timing is especially important for the use of wood in buildings

DYNAMIC LCA MODELLING

Timing is only partly included in current methods





DYNAMIC LCA MODELLING

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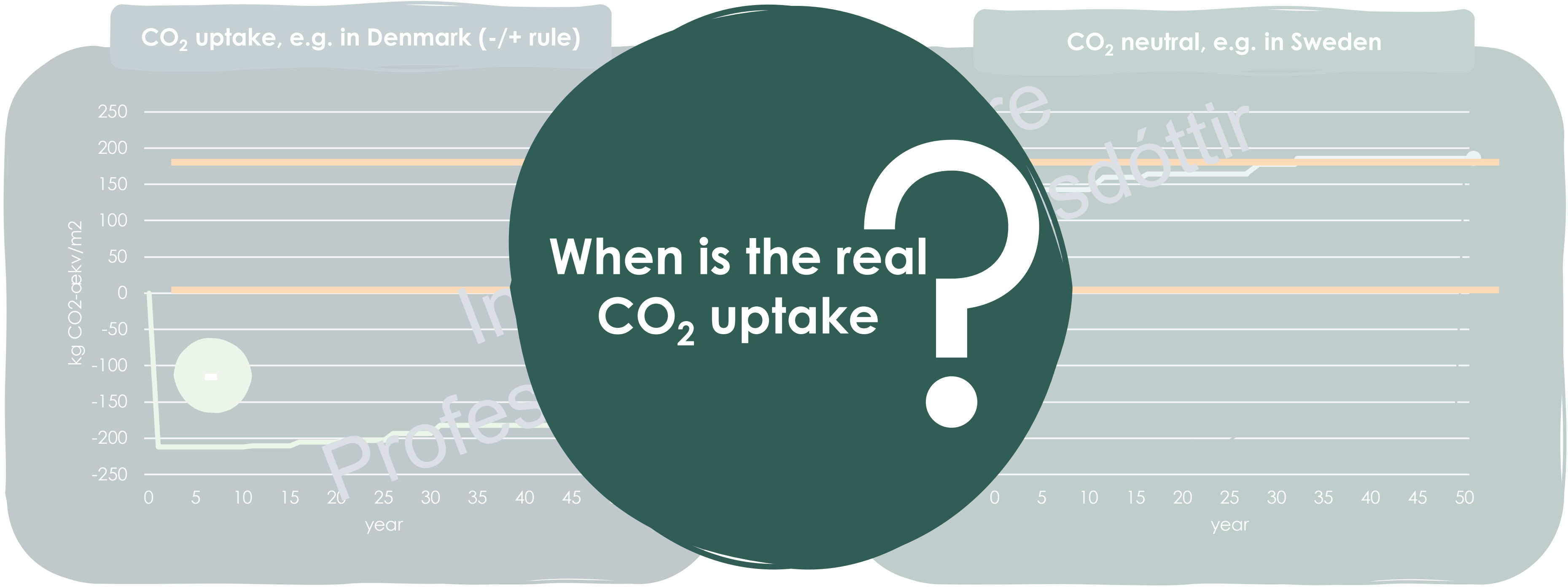
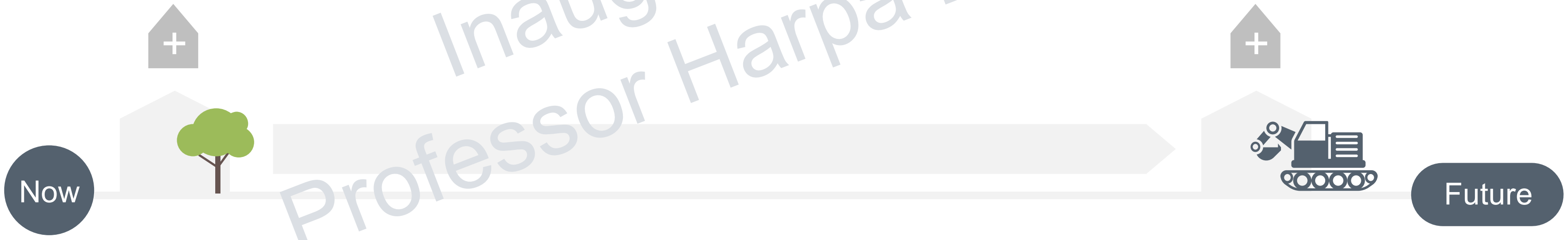


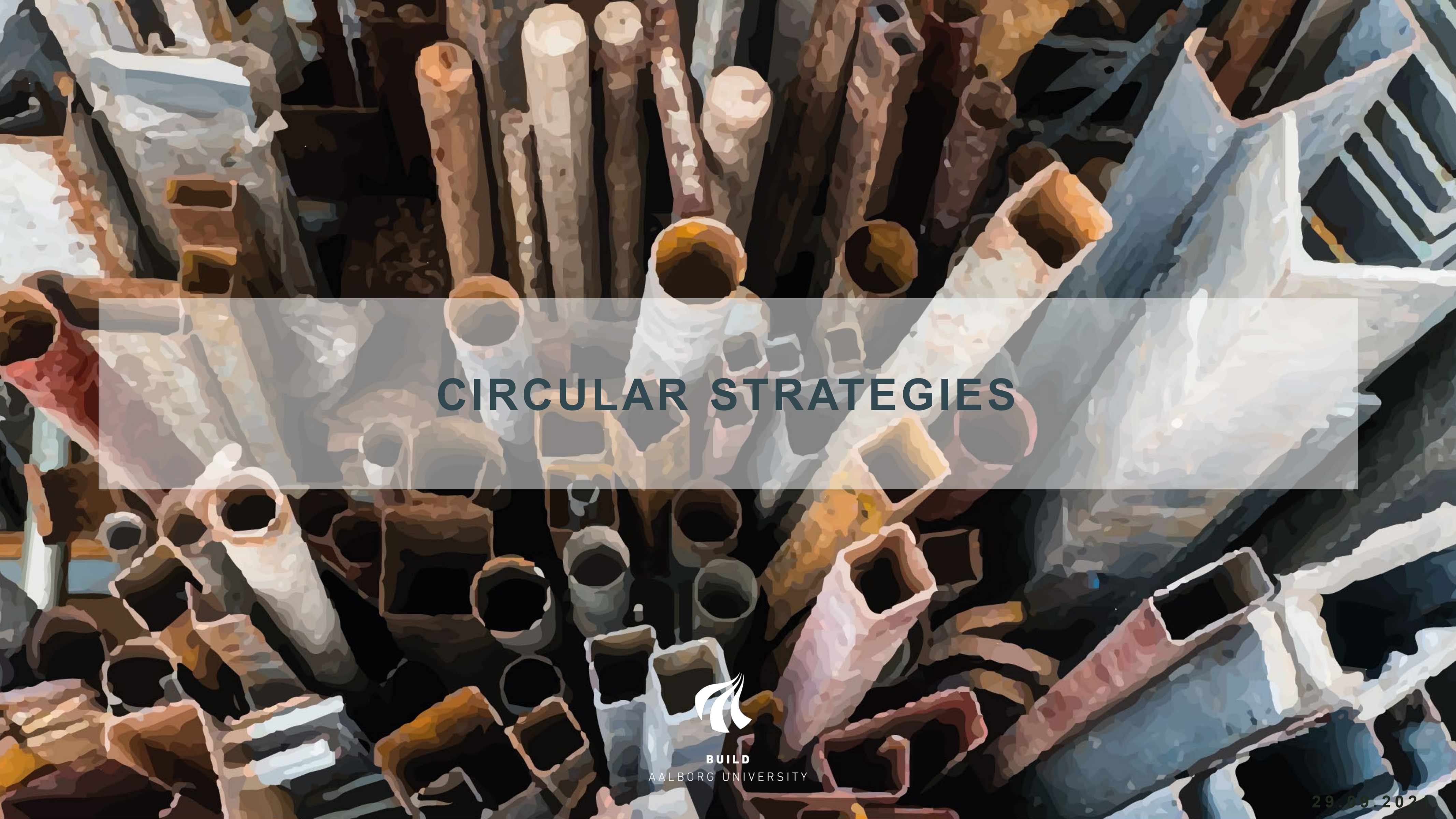
DYNAMIC LCA MODELLING

The ongoing research in our research project

Development of a model that includes the timing of emissions –

- Show the effect of emissions now and in future
- Show the effect of temporary sequestration of carbon from wood in buildings





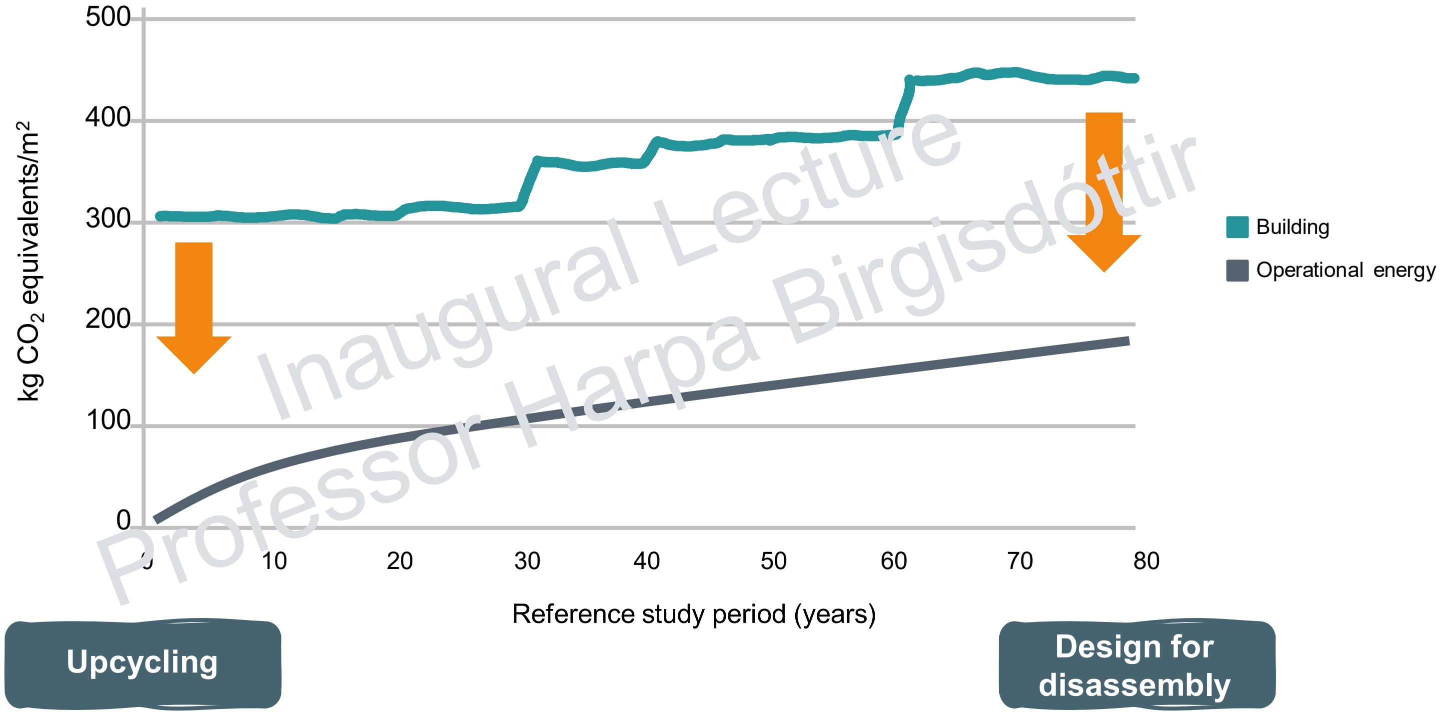
CIRCULAR STRATEGIES

BUILD
AALBORG UNIVERSITY

MANY CIRCULAR STRATEGIES EXISTS
WHAT ARE THE BENEFITS?

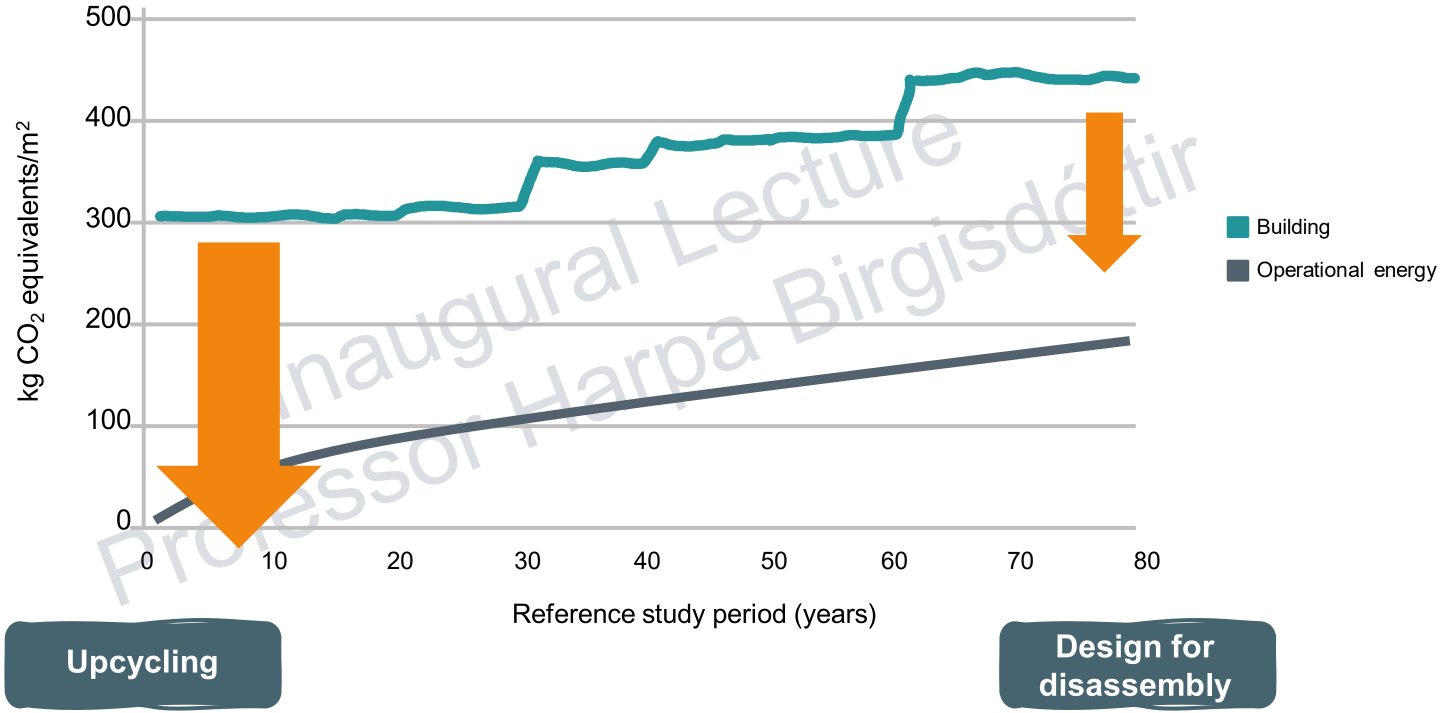
- Disassembly
- Prefabrication
- Component and material optimisations
- Layer independence
- Material selection
- Secondary materials
- Reuse buildings, components and materials
- Material storage
- Adaptability
- Durability
- Optimized shapes and dimensions
- Short use
- Modularity
- Standardization
- Accessibility
- Symbiosis

MANY CIRCULAR STRATEGIES TARGETING DIFFERENT SOLUTIONS AND TIMESCALES



Project:
Leonora PhD, Freja PhD and others

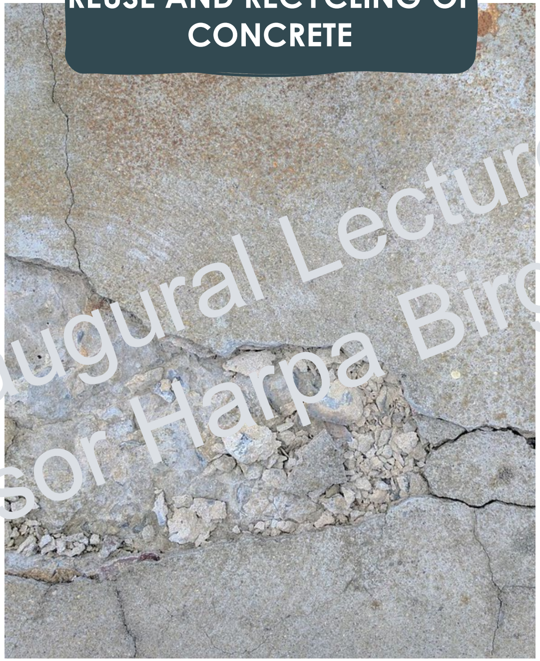
MANY CIRCULAR STRATEGIES TARGETING DIFFERENT SOLUTIONS AND TIMESCALES

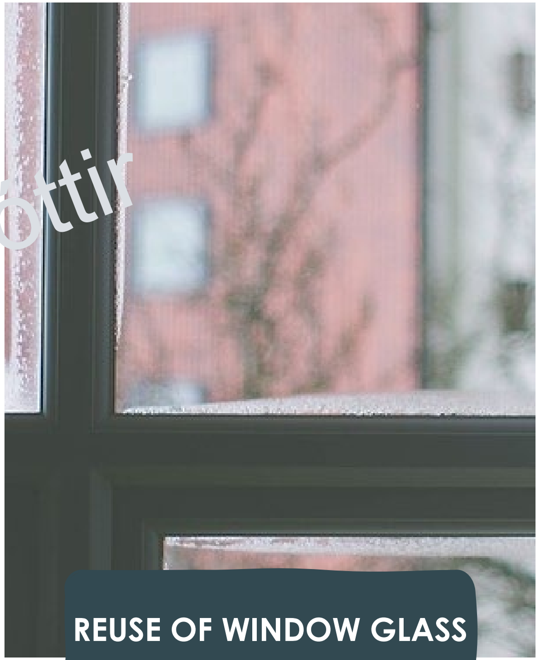


Project:
Leonora PhD, Freja PhD and others

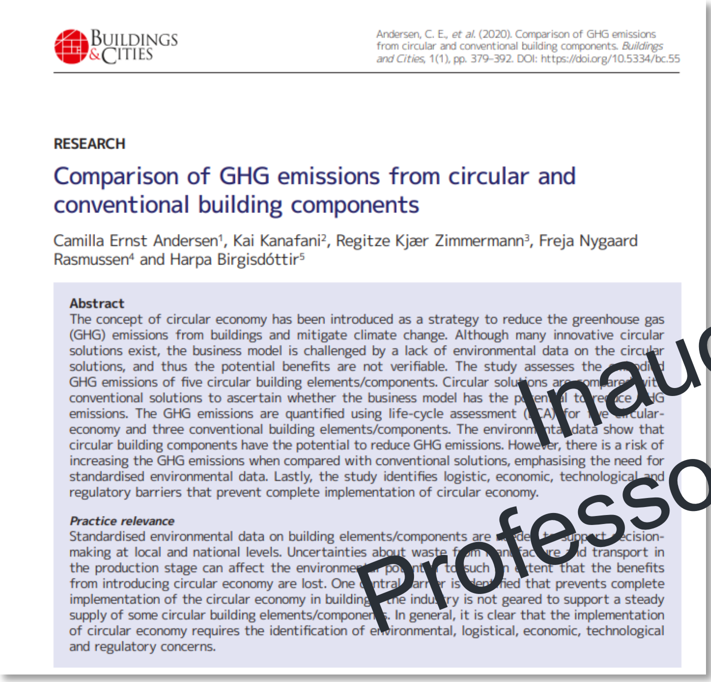
CICULAR STRATEGIES


REUSE OF BRICKS

REUSE AND RECYCLING OF CONCRETE



REUSE OF WINDOW GLASS

ENVIRONMENTAL BENEFITS OF REUSE AND RECYCLING



BUILDINGS & CITIES

Andersen, C. E., *et al.* (2020). Comparison of GHG emissions from circular and conventional building components. *Buildings and Cities*, 1(1), pp. 379–392. DOI: https://doi.org/10.5334/bc.55

RESEARCH

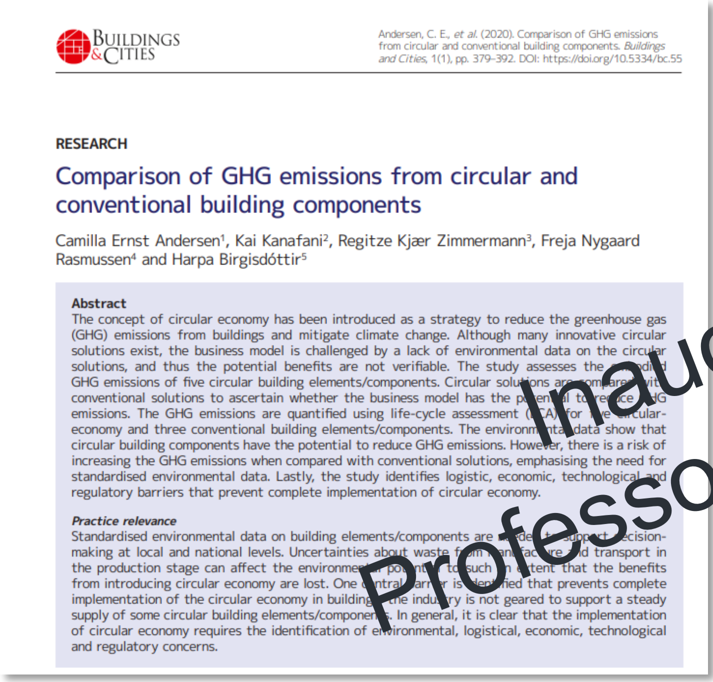
Comparison of GHG emissions from circular and conventional building components

Camilla Ernst Andersen[1], Kai Kanafani[2], Regitze Kjær Zimmermann[3], Freja Nygaard Rasmussen[4] and Harpa Birgisdóttir[5]

Abstract
The concept of circular economy has been introduced as a strategy to reduce the greenhouse gas (GHG) emissions from buildings and mitigate climate change. Although many innovative circular solutions exist, the business model is challenged by a lack of environmental data on the circular solutions, and thus the potential benefits are not verifiable. The study assesses the embodied GHG emissions of five circular building elements/components. Circular solutions are compared with conventional solutions to ascertain whether the business model has the potential to reduce GHG emissions. The GHG emissions are quantified using life-cycle assessment (LCA) for five circular-economy and three conventional building elements/components. The environmental data show that circular building components have the potential to reduce GHG emissions. However, there is a risk of increasing the GHG emissions when compared with conventional solutions, emphasising the need for standardised environmental data. Lastly, the study identifies logistic, economic, technological and regulatory barriers that prevent complete implementation of circular economy.

Practice relevance
Standardised environmental data on building elements/components are needed to support decision-making at local and national levels. Uncertainties about waste from manufacture and transport in the production stage can affect the environmental potential to such an extent that the benefits from introducing circular economy are lost. One central barrier is identified that prevents complete implementation of the circular economy in buildings: the industry is not geared to support a steady supply of some circular building elements/components. In general, it is clear that the implementation of circular economy requires the identification of environmental, logistical, economic, technological and regulatory concerns.

ENVIRONMENTAL BENEFITS OF REUSE AND RECYCLING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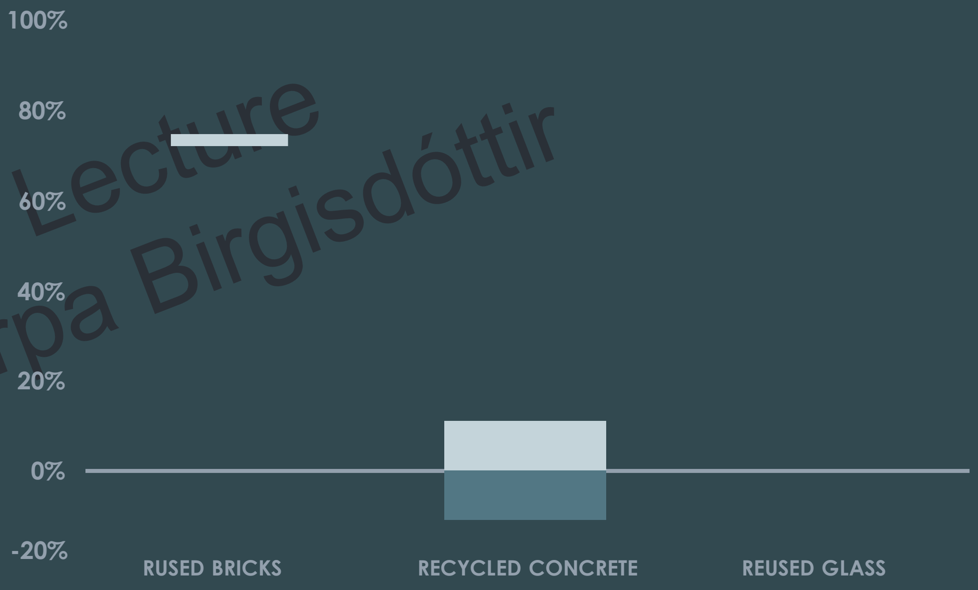

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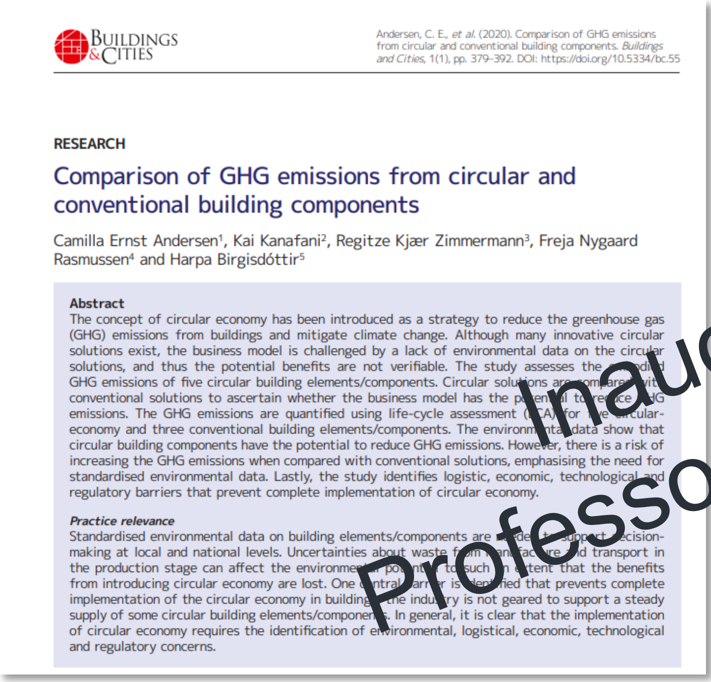
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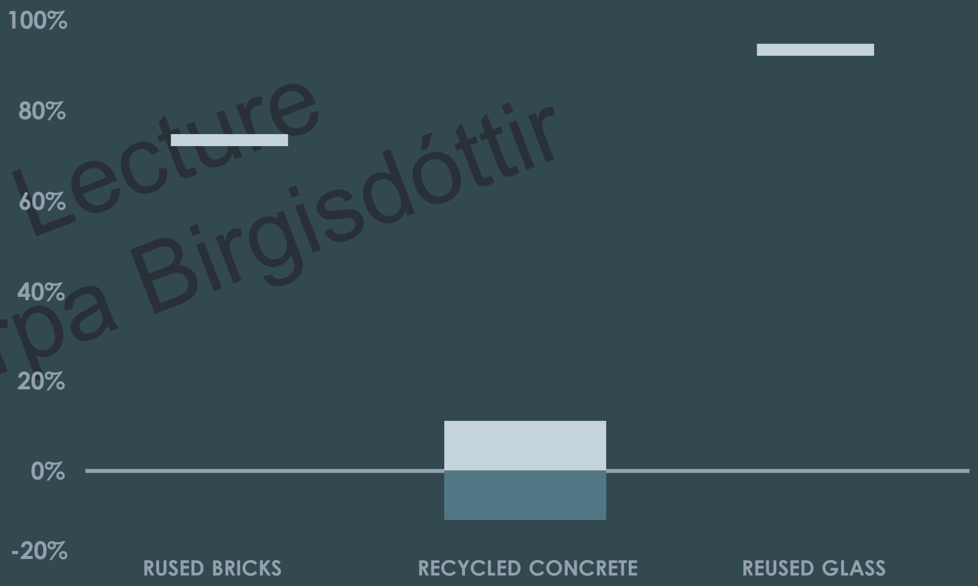
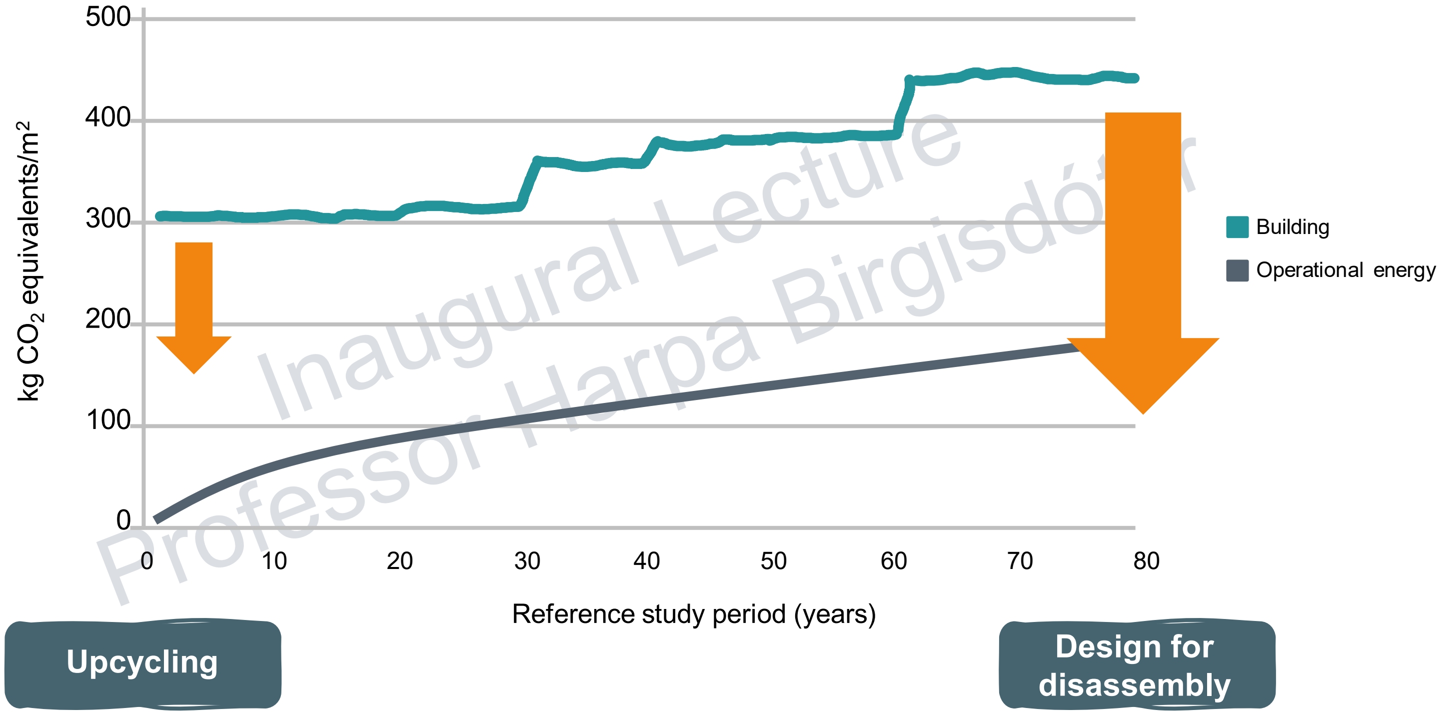
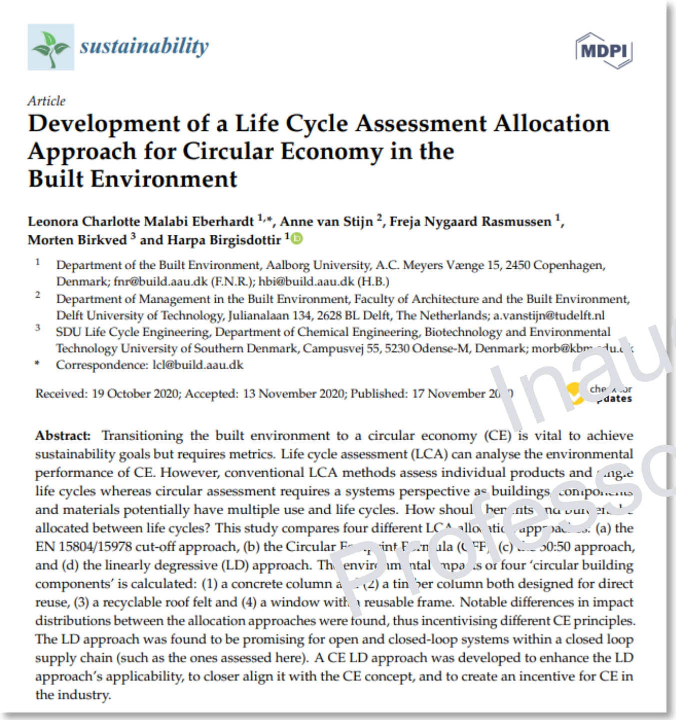


MANY CIRCULAR STRATEGIES TARGETING DIFFERENT SOLUTIONS AND TIMESCALES



Project:
Leonora PhD, Freja PhD and others

POTENTIAL ENVIRONMENTAL BENEFITS OF DESIGN FOR DISASSEMBLY



sustainability

MDPI

Article

Development of a Life Cycle Assessment Allocation Approach for Circular Economy in the Built Environment

Leonora Charlotte Malabi Eberhardt [1,*], Anne van Stijn [2], Freja Nygaard Rasmussen [1], Morten Birkved [3] and Harpa Birgisdottir [1]

1 Department of the Built Environment, Aalborg University, A.C. Meyers Vænge 15, 2450 Copenhagen, Denmark; fnr@build.aau.dk (F.N.R.); hbi@build.aau.dk (H.B.)
2 Department of Management in the Built Environment, Faculty of Architecture and the Built Environment, Delft University of Technology, Julianalaan 134, 2628 BL Delft, The Netherlands; a.vanstijn@tudelft.nl
3 SDU Life Cycle Engineering, Department of Chemical Engineering, Biotechnology and Environmental Technology University of Southern Denmark, Campusvej 55, 5230 Odense-M, Denmark; morb@kbm.sdu.dk
* Correspondence: lcl@build.aau.dk

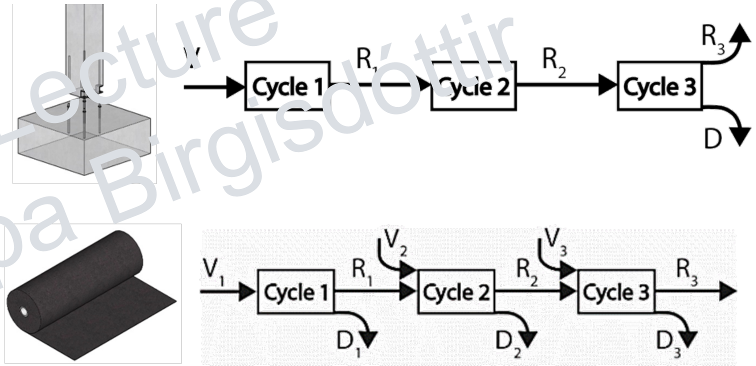
Received: 19 October 2020; Accepted: 13 November 2020; Published: 17 November 2020

check for updates

Abstract: Transitioning the built environment to a circular economy (CE) is vital to achieve sustainability goals but requires metrics. Life cycle assessment (LCA) can analyse the environmental performance of CE. However, conventional LCA methods assess individual products and single life cycles whereas circular assessment requires a systems perspective as buildings, components and materials potentially have multiple use and life cycles. How should benefits and burdens be allocated between life cycles? This study compares four different LCA allocation approaches: (a) the EN 15804/15978 cut-off approach, (b) the Circular Footprint Formula (CFF), (c) the 50:50 approach, and (d) the linearly degressive (LD) approach. The environmental impacts of four 'circular building components' is calculated: (1) a concrete column and (2) a timber column both designed for direct reuse, (3) a recyclable roof felt and (4) a window with a reusable frame. Notable differences in impact distributions between the allocation approaches were found, thus incentivising different CE principles. The LD approach was found to be promising for open and closed-loop systems within a closed loop supply chain (such as the ones assessed here). A CE LD approach was developed to enhance the LD approach's applicability, to closer align it with the CE concept, and to create an incentive for CE in the industry.

Reuse

Recycling



3x80 years

3x20 years

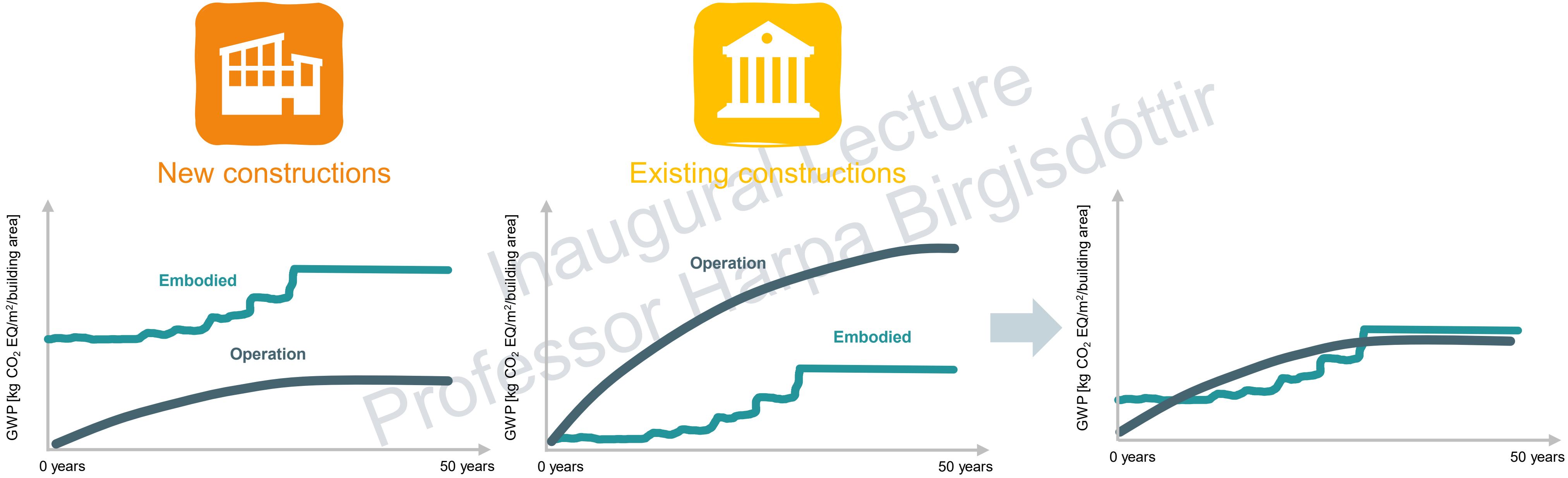
V = Production
R = Reuse/recycling
D = Disposal

Project:
Leonora PhD

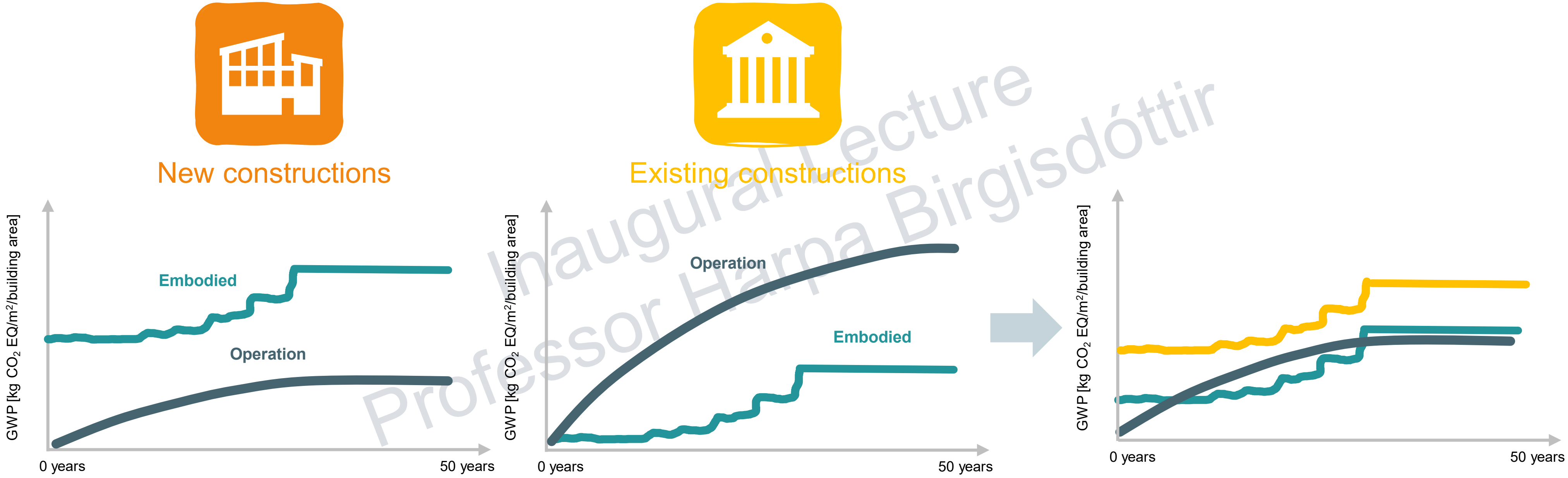
EXISTING BUILDINGS

BUILD
AALBORG UNIVERSITY

EXISTING BUILDINGS



EXISTING BUILDINGS



URGENCY

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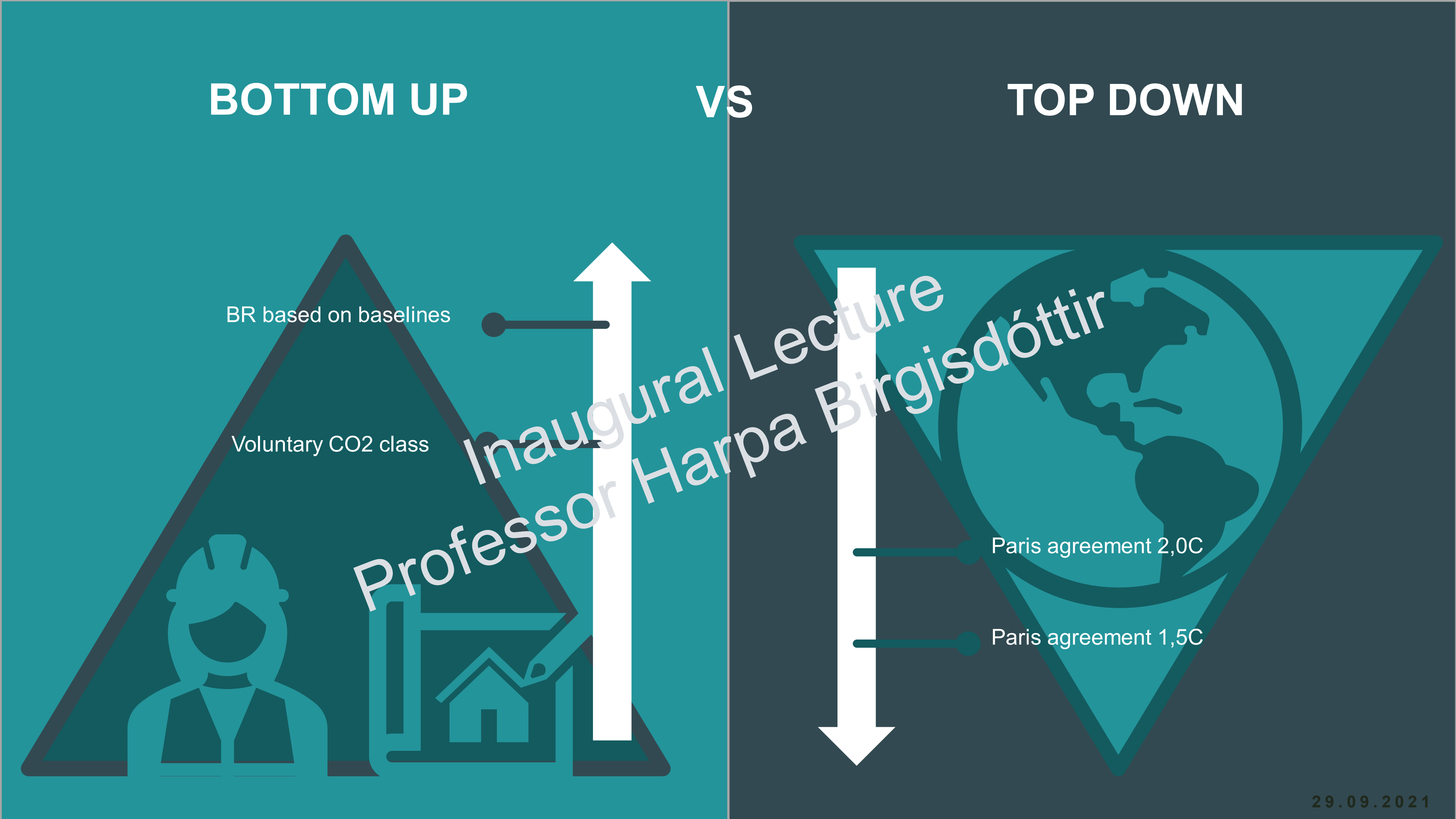
URGENCY

Are the requirements entering the Danish building regulation meeting the urgent needs for reduction?


BOTTOM UP
VS
TOP DOWN
BR based on baselines
Voluntary CO2 class
Paris agreement 2,0C
Paris agreement 1,5C
29.09.2021

CARBON BUDGET

BUILDINGS & CITIES

Habert, G., et al. (2020). Carbon budgets for buildings: harmonising temporal, spatial and sectoral dimensions. *Buildings and Cities*, 1(1), pp. 429–452. DOI: https://doi.org/10.5334/bc.47

SYNTHESIS

Carbon budgets for buildings: harmonising temporal, spatial and sectoral dimensions

Guillaume Habert[1], Martin Röck[2], Karl Steininger[3], Antonin Lupísek[4], Harpa Birgisdottir[5], Harald Desing[6], Chanjief Chandrakumar[7], Francesco Pittau,[8] Alexander Passer[9], Ronald Rovers[10], Katarina Slavkovic[11], Alexander Hollberg[12], Endrit Hoxha[13], Thomas Jusselme[14], Emilie Nault[15], Karen Allacker[16] and Thomas Lützkendorf[17]

Abstract

Target values for creating carbon budgets for buildings are important for developing climate-neutral building stocks. A lack of clarity currently exists for defining carbon budgets for buildings and what constitutes a unit of assessment—particularly the distinction between production- and consumption-based accounting. These different perspectives on the system and the function that is assessed hinder a clear and commonly agreed definition of 'carbon budgets' for building construction and operation. This paper explores the processes for establishing a carbon budget for residential and non-residential buildings. A detailed review of current approaches to budget allocation is presented. The temporal and spatial scales of evaluation are considered as well as the distribution rules for sharing the budget between parties or activities. This analysis highlights the crucial need to define the temporal scale, the roles of buildings as physical artefacts and their economic activities. A framework is proposed to accommodate these different perspectives and spatio-temporal scales towards harmonised and comparable cross-sectoral budget definitions.

Policy relevance

The potential to develop, implement and monitor greenhouse gas-related policies and strategies for buildings will depend on the provision of clear targets. Based on global limits, a carbon budget can establish system boundaries and scalable targets. An operational framework is presented that clarifies greenhouse gas targets for buildings in the different parts of the world that is adaptable to the context and circumstances of a particular place. A carbon budget can enable national regulators to set feasible and legally binding requirements. This will assist the many different stakeholders responsible for decisions on buildings to coordinate and incorporate their specific responsibility at one specific level or scale of activity to ensure overall compliance. Therefore, determining a task specific carbon budget requires an appropriate management of the global carbon budget to ensure that specific budgets overlap, but that the sum of them is equal to the available global budget without double-counting.

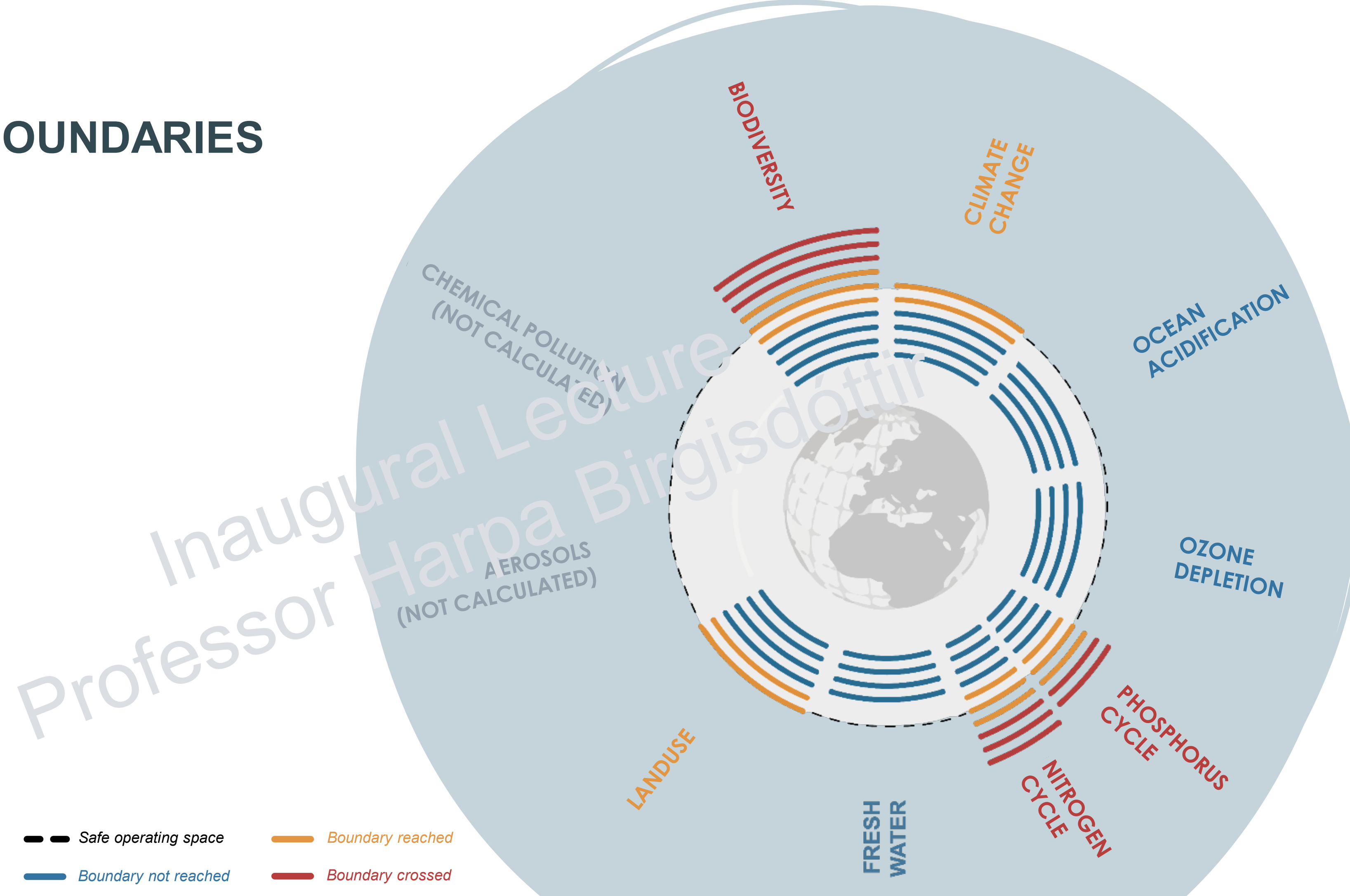
Keywords: building stock; buildings; built environment; carbon budget; climate policy; greenhouse gases

Paper as an output of a workshop at Sustainable Building conference in Graz

Focus on the:

- Importance of use of carbon budget
- Lack of clarity for defining the budgets
- Review of current approaches
- Crucial need for defining the temporal scale

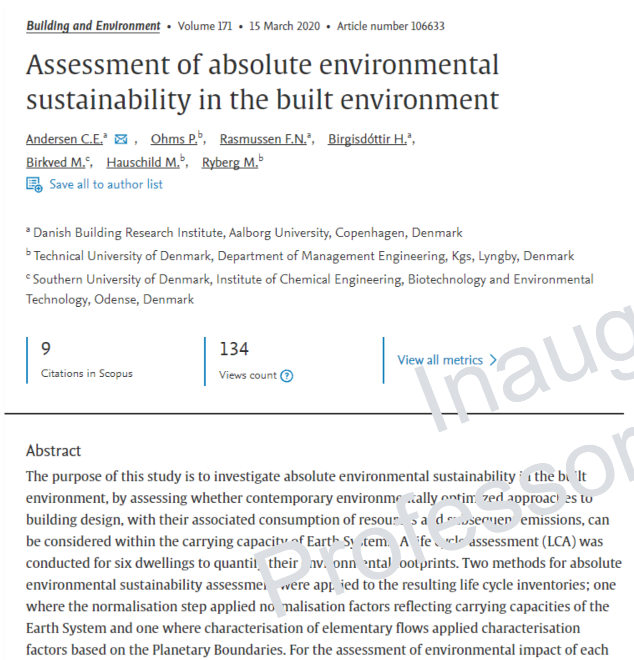
PLANETARY BOUNDARIES



Steffen et al. (2015). Planetary boundaries: Guiding human development on a changing planet. Science

Grafics: Adapted from Steffen, Will et al. 2015: Planetary boundaries: guiding human development on a changing planet. In: Science 347:6223

ABSOLUTE ENVIRONMENTAL SUSTAINABILITY
EXAMPLE OF: CLIMATE CHANGE



Building and Environment • Volume 171 • 15 March 2020 • Article number 106633

Assessment of absolute environmental sustainability in the built environment

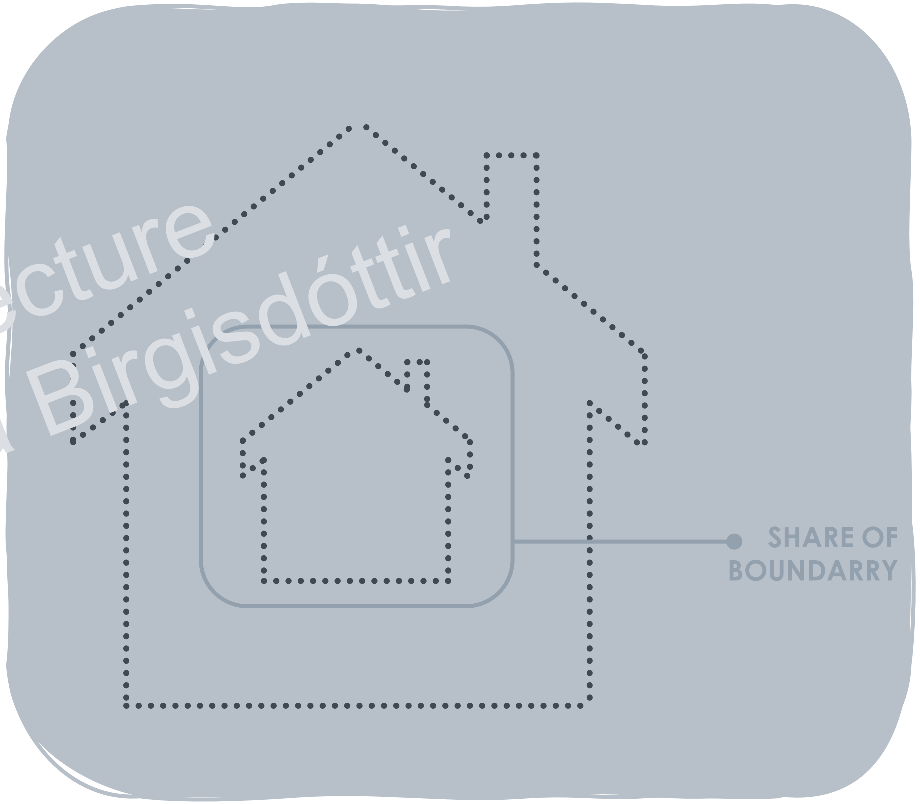
Andersen C.E.[a], Ohms P.[b], Rasmussen F.N.[a], Birgisdóttir H.[a], Birkved M.[c], Hauschild M.[b], Ryberg M.[b]

Save all to author list

[a] Danish Building Research Institute, Aalborg University, Copenhagen, Denmark
[b] Technical University of Denmark, Department of Management Engineering, Kgs, Lyngby, Denmark
[c] Southern University of Denmark, Institute of Chemical Engineering, Biotechnology and Environmental Technology, Odense, Denmark

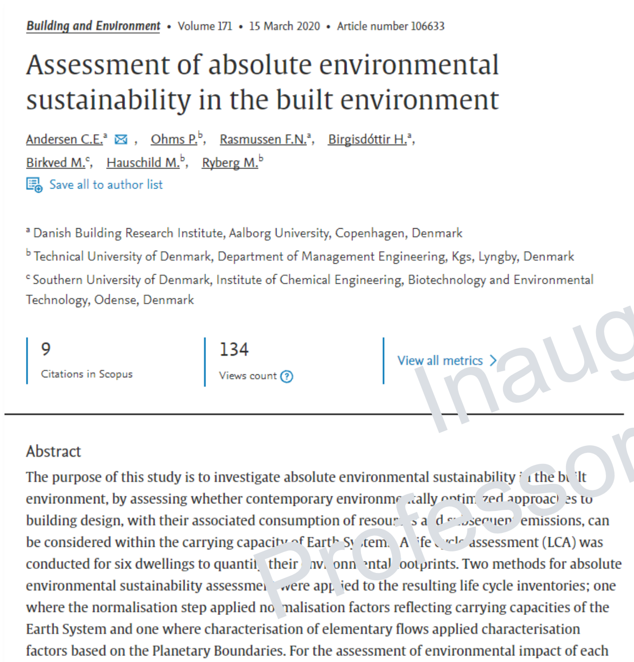
Abstract

The purpose of this study is to investigate absolute environmental sustainability in the built environment, by assessing whether contemporary environmentally optimized approaches to building design, with their associated consumption of resources and subsequent emissions, can be considered within the carrying capacity of Earth System. A life cycle assessment (LCA) was conducted for six dwellings to quantify their environmental footprints. Two methods for absolute environmental sustainability assessment were applied to the resulting life cycle inventories; one where the normalisation step applied normalisation factors reflecting carrying capacities of the Earth System and one where characterisation of elementary flows applied characterisation factors based on the Planetary Boundaries. For the assessment of environmental impact of each



M.Sc. Project of **Pernille Ohms, Camilla Andersen.**
Supervisors: Morten Rydberg, Michael Hauschild, Morten Birkved, Freja Nygaard Rasmussen, Harpa Birgisdottir

ABSOLUTE ENVIRONMENTAL SUSTAINABILITY
EXAMPLE OF: CLIMATE CHANGE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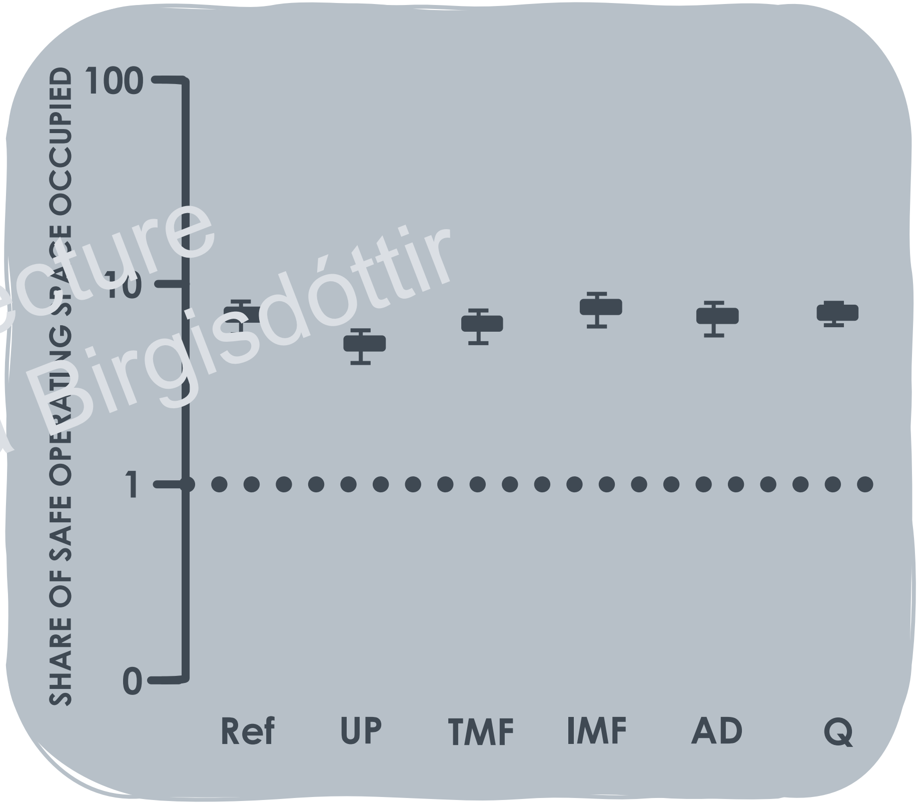

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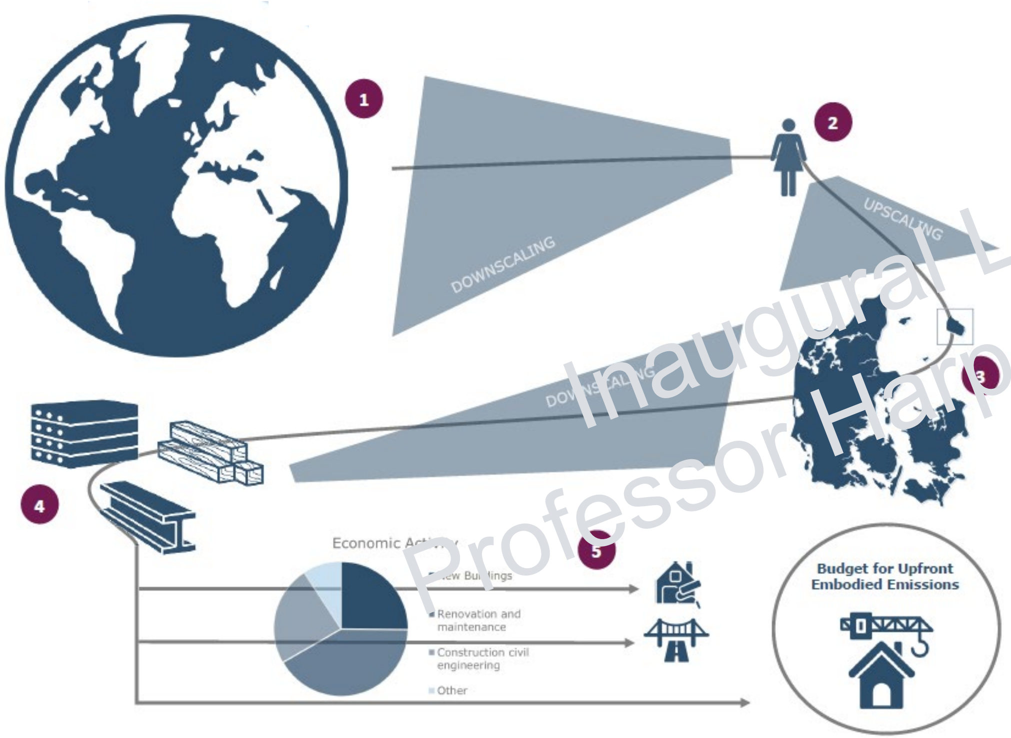
HOW FAR ARE THE CO_2 LIMITS IN BR FROM BUDGETS ACCORDING TO PARIS AGREEMENT?



Industrial Phd project: **Lise Hvid Horup Sørensen**, Rambøll
Supervisors: Morten Ryberg, Michael Hauschild, Harpa Birgisdottir, Christian Thuesen, Andreas Qvist Secher and Gitte Gylling

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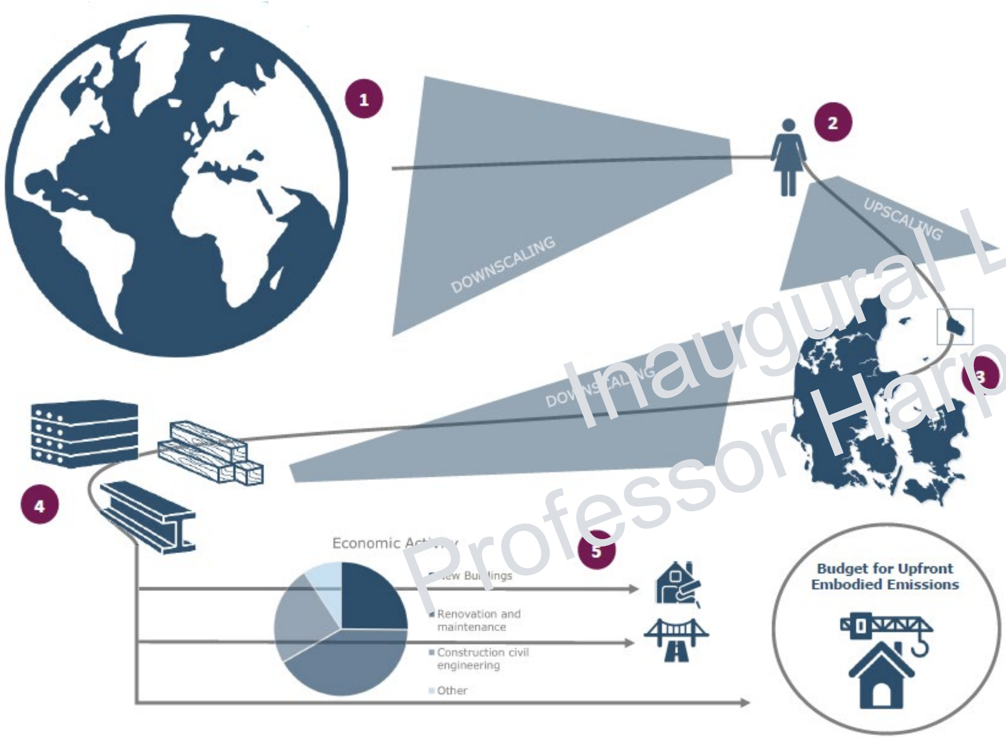
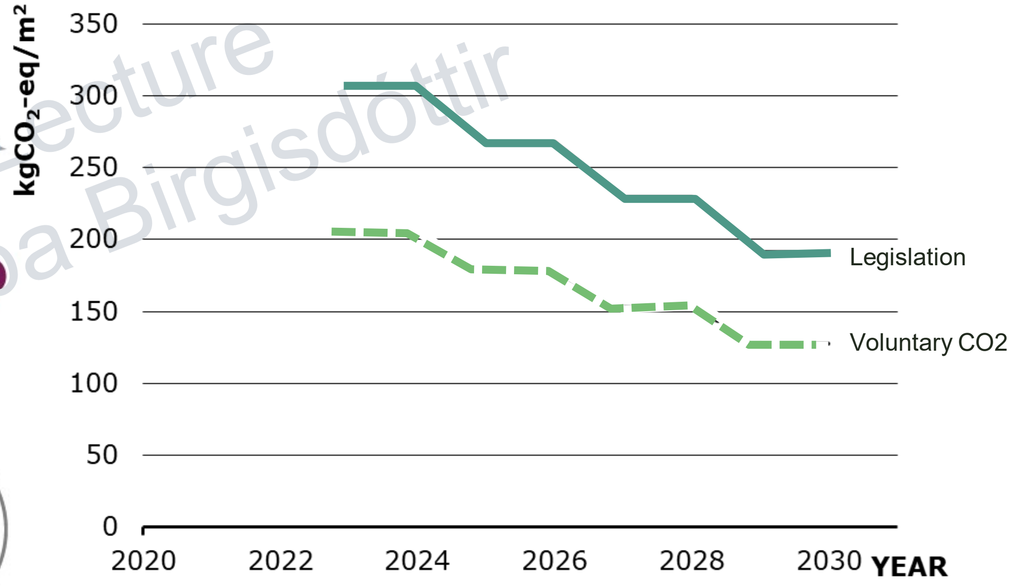


BUDGET FOR UPFRONT EMBODIED CARBON EMISSIONS PER m^2



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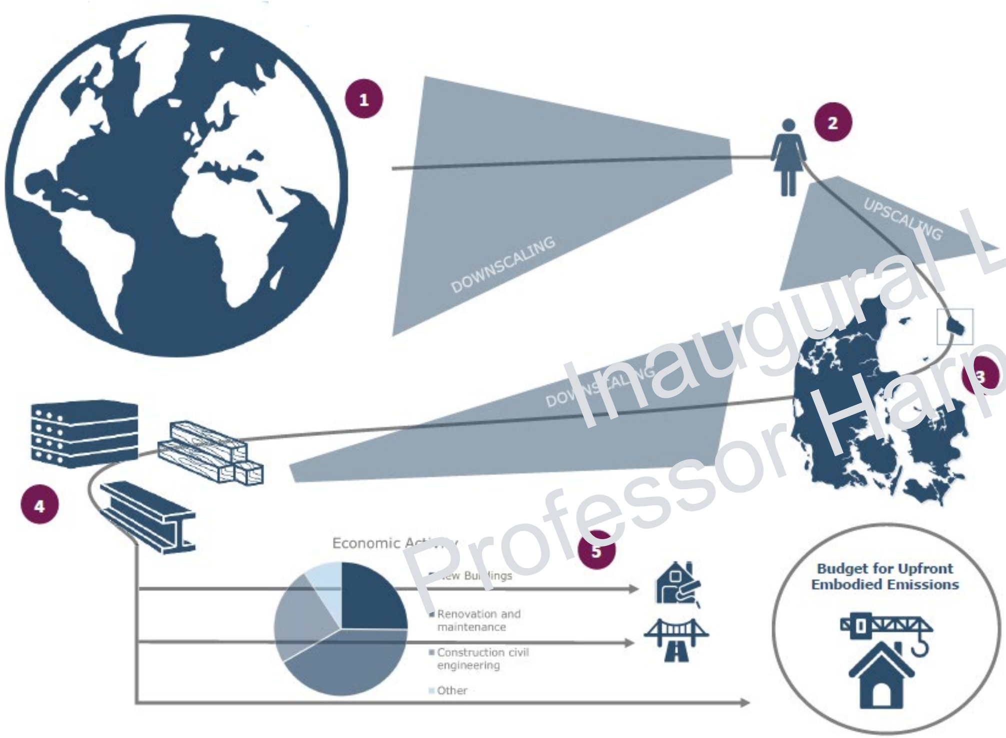
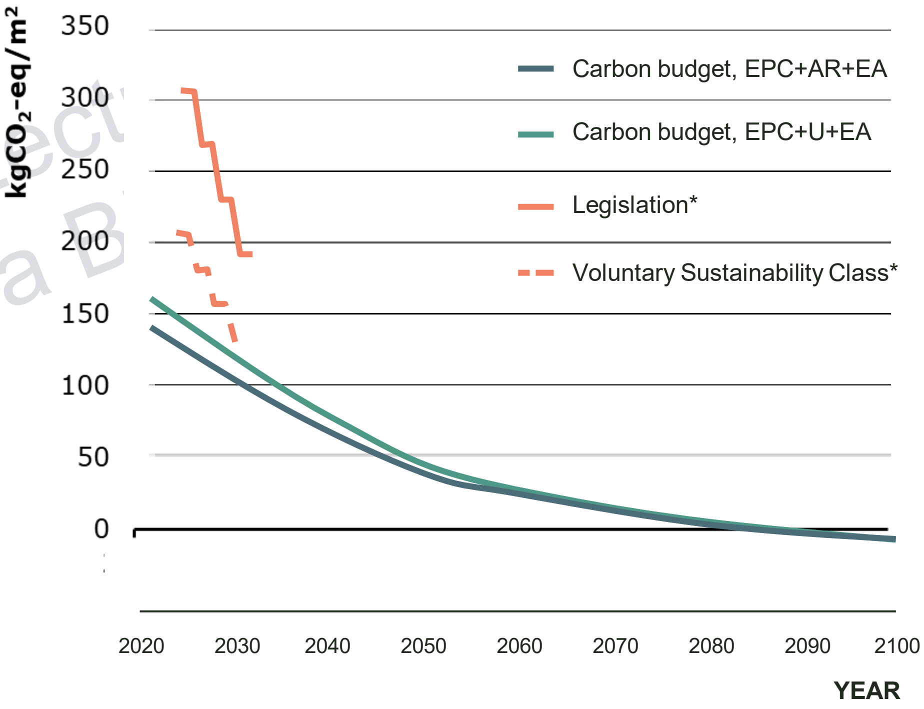


BUDGET FOR UPFRONT EMBODIED CARBON EMISSIONS PER m²

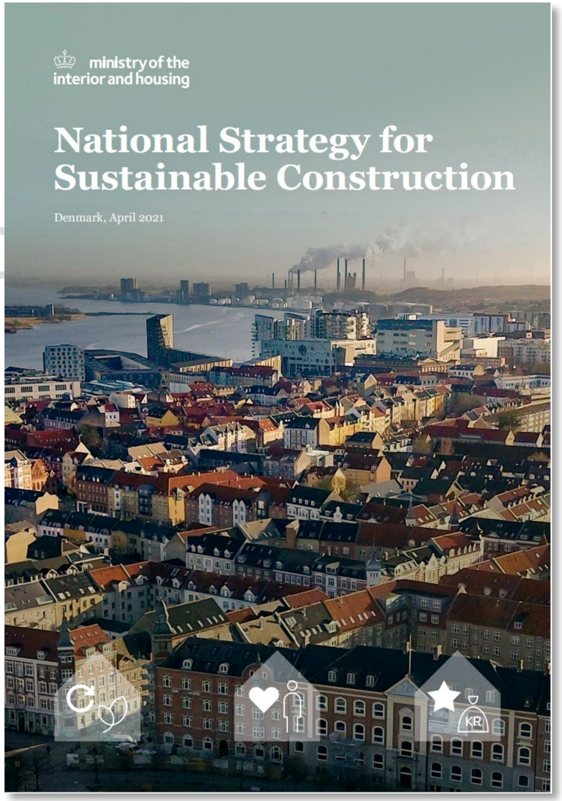


Industrial Phd project: **Lise Hvid Horup Sørensen**, Rambøll
Supervisors: Morten Ryberg, Michael Hauschild, Harpa Birgisdottir, Christian Thuesen, Andreas Qvist Secher and Gitte Gylling

FUTURE VISION

MY VISION FOR FURTHER RESEARCH

1. New constructions: Challenges, opportunities, reduction strategies
2. Existing buildings: Optimization of climate benefits of renovation and how to develop legal requirements for renovation
3. Continuously developing LCA tool: Early stages, digitalization, data
4. Harmonization



MY VISION FOR FURTHER RESEARCH

Roadmap development

- Transition to urgent need for reductions before 2030 and climate neutral construction sector in 2050
- Design strategies
    - Optimization
    - Geometry
    - Biogenic materials
    - Circular strategies
    - Future emissions
    - New materials
- Timing of emissions

MY VISION FOR TEACHING WITHIN THE FIELD

STUDENTS

- All students studying subjects related to the built environment should have a minimum knowledge of LCA and a large part needs deep knowledge

CONTINUING EDUCATION

- The Danish buildings sector needs to understand that extensive education is needed – which cannot be covered by 1-2 day courses

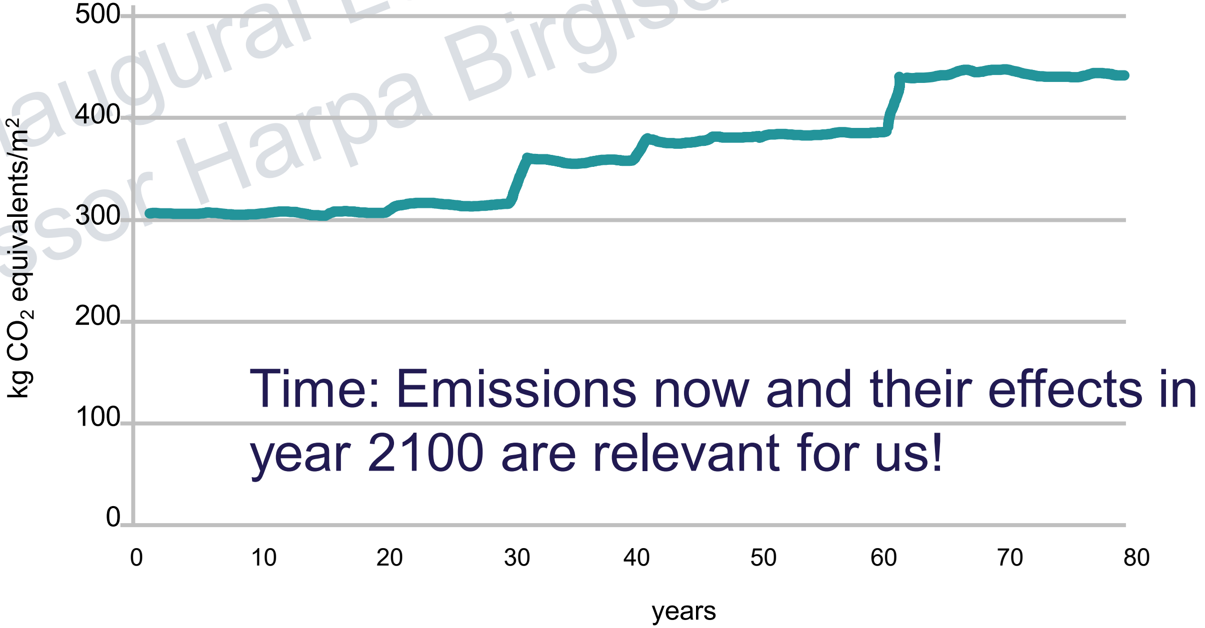
URGENCY - TIME

PRIVATE STORY

My grandmother: Born in 1925 – 96 years in 2021

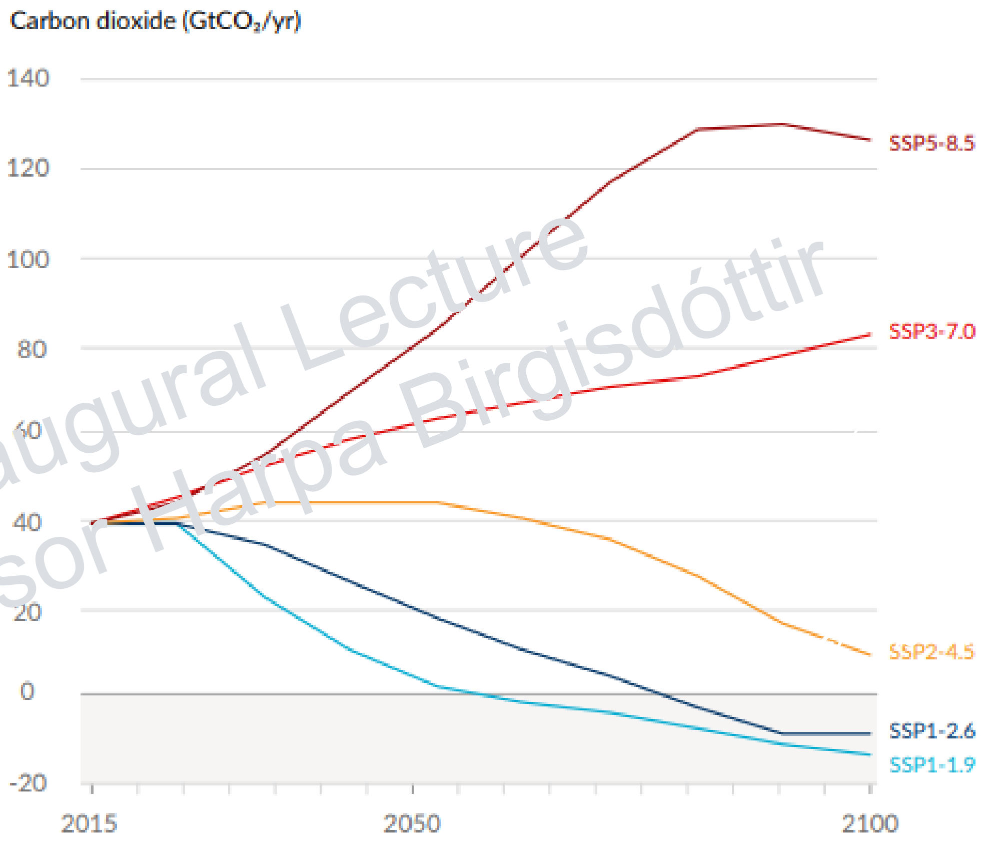
My children are born in 2007, 2013 and 2017

They can be 96 years in 2103, 2109 and 2113



IPCC

Which scenarios are we aiming for our future generations?



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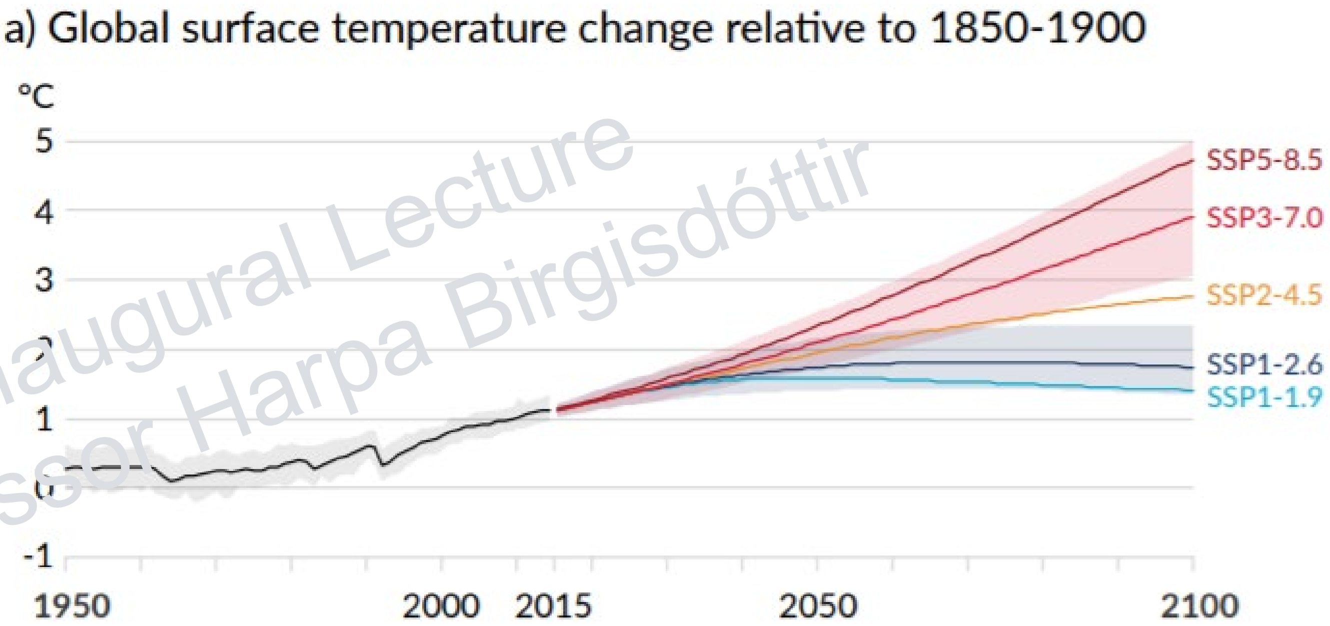

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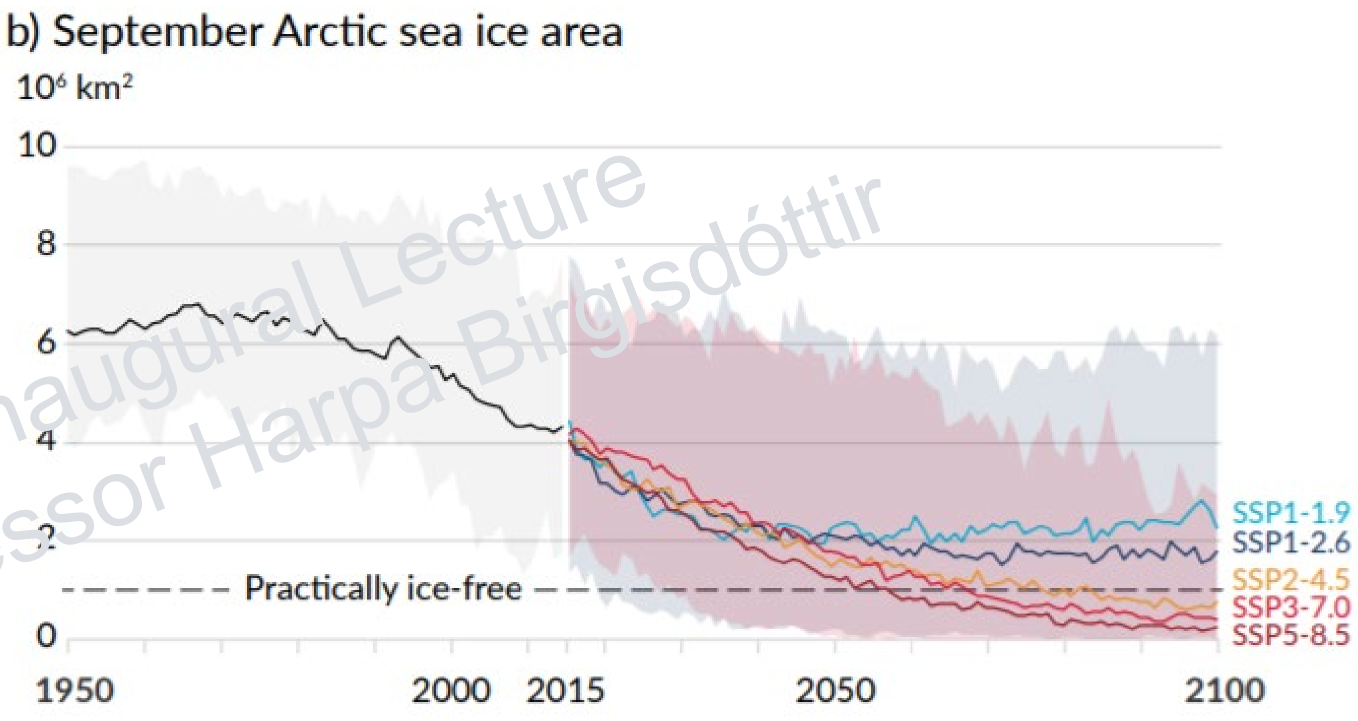

IPCC

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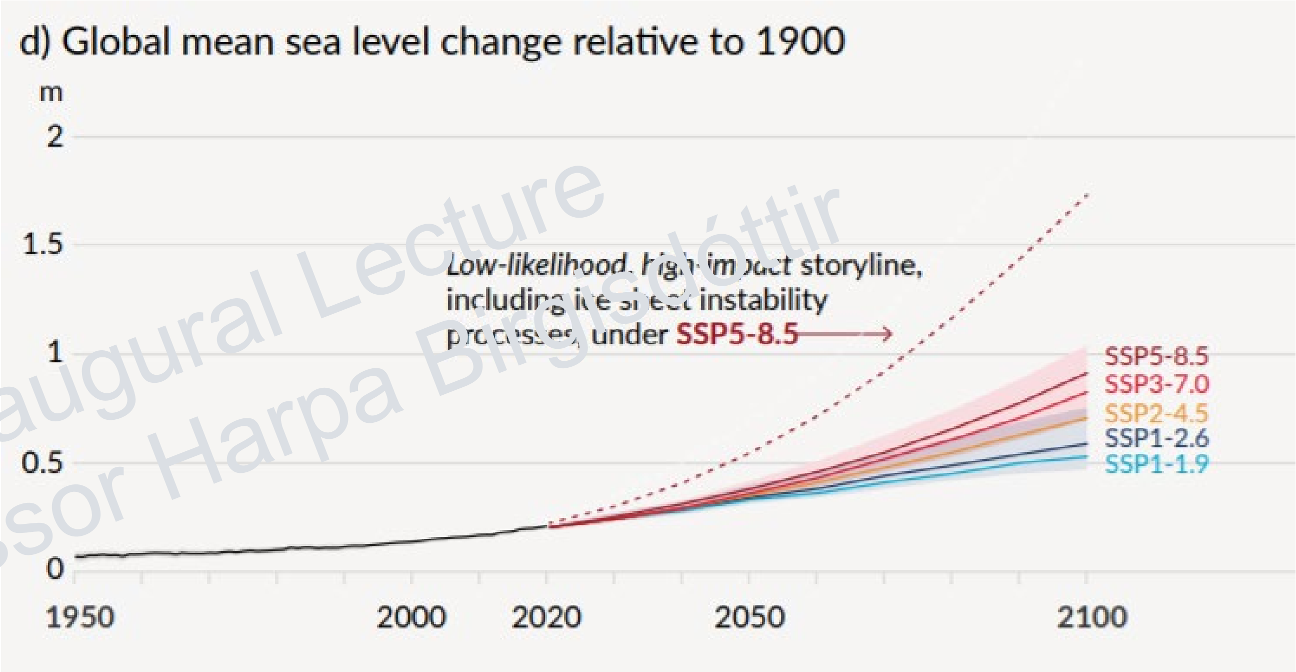

IPCC

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