Webinar on Climate declaration and use of life cycle analysis to reduce climate impact from new buildings

Date: 29th September, 2022 (10:00-12:15 Swedish time)
It is a free webinar
Link: https://umu.zoom.us/j/69086097653

Climate declaration of buildings is a new initiative on Sweden aimed to reduce the climate impact of buildings and also to raise knowledge on the topic. From 1st January 2022 onwards, the climate impact of new buildings should be reported in the climate declaration. An important step in climate declaration is to use LCA method for identifying and quantifying the buildings' climate impact.

The webinar brings together presentations by practitioners and researchers on a few important aspects on Swedish climate declaration and use of LCA to facilitate reduction of climate impacts from new buildings.

10:00-10:20: Industriella erfarenheter av energiberäkningar och miljömärkningar: Mats Håkansson, Contractor Bygg Holding Norr AB

10:20-10:45: Communication of life cycle assessment results - Life cycle key performance indicator: Helena Nydhal, Umeå University

10:45 -11:10: Life cycle analysis of cross-laminated timber multi-storey buildings - Synergy between structural engineering solutions and carbon footprint: Ambrose Dodoo, Linnaeus University

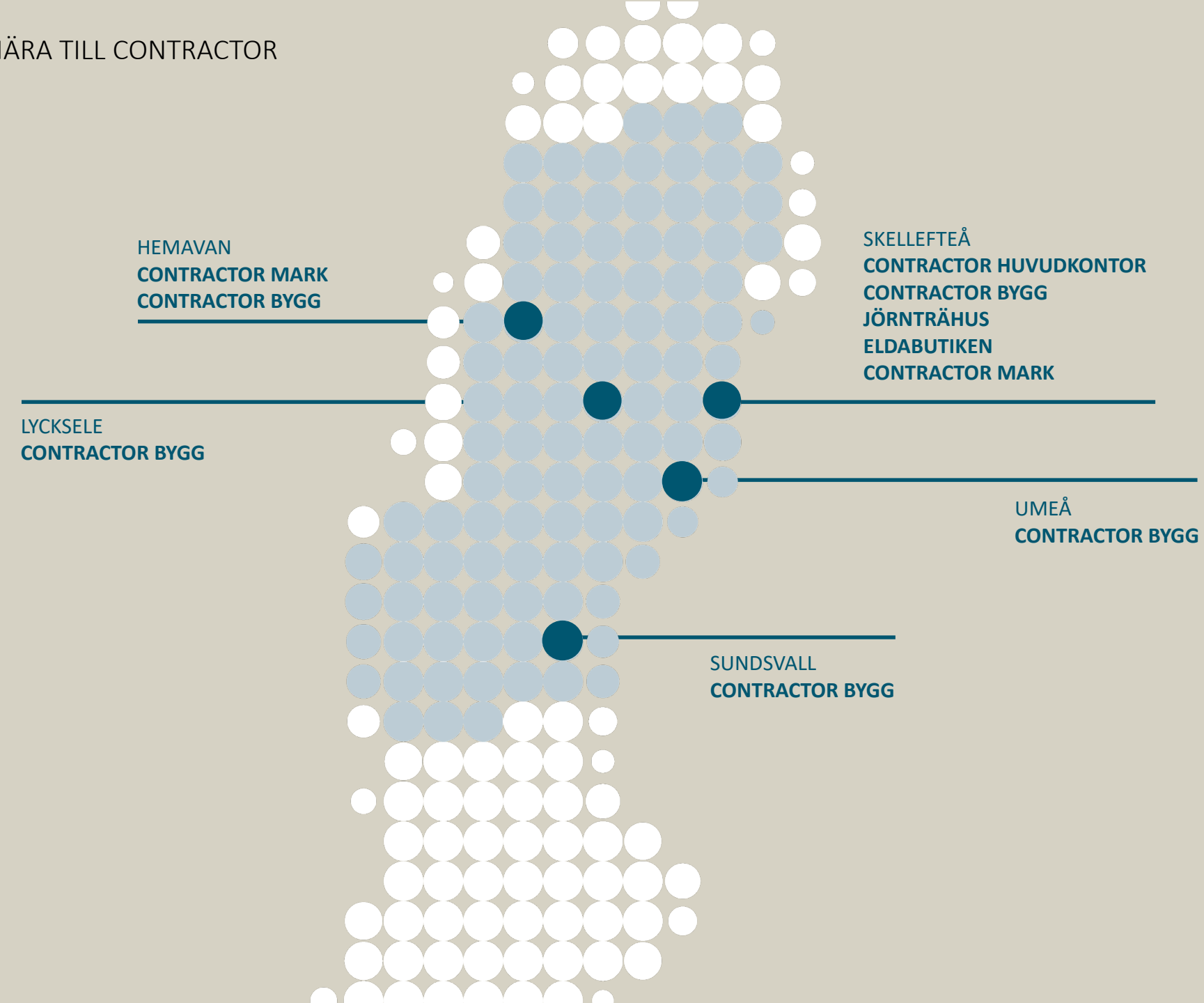
11:10-11:20: Pause

11:20-11:50: Climate declarations in practice – usefulness and obstacles: Anna Joelsson, Sweco Sverige AB

11:50-12:15: Digitalization as a means for sustainable urban development: Sofia Lidelöw, Luleå University of Technology

The webinar is organized within the framework of the project Enhanced Sustainability of Built Environment by Collaboration and Digitalization (https://www.esbe.io), which is supported by the European Regional Development Fund through Interreg Nord. The partner organizations of ESBE are Oulu University of Applied Sciences, Luleå University of Technology and Umeå University.


Contractor
VI BYGGER
ETT LEVANDE
NORRLAND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Vi har hjärtat i Norrland.

Aktivt hållbarhetsarbete

Ekonomiskt, Socialt och Miljö

SOCIALT
Systematiskt arbetsmiljöarbete
AFS 2001:1

KVALITET OCH MILJÖ
Utfasning av Povel
Certifiering pågår ISO 9001 och 14001.

Grundades för 112 år sen

1040

miljoner kronor i omsättning

"De är väldigt måna om att det ska bli bra för slutkunden."
- Projektledare

Ett levande Norrland,
byggt på visioner
och drömmar, av
lokala människor.

Klimatdeklaration och miljöcertifiering

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Boverkets regler om klimatdeklarationer

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Reglerna trädde i kraft 1 januari 2022

Kraven gäller endast nya byggnader

Det finns undantag..

Contractor

Undantaget gäller byggnader som

- har tidsbegränsade bygglov, vilka är avsedda att användas i högst två år
- inte kräver bygglov enligt 9 kap. 6, 7 eller 9 §§ PBL
- används för industri- eller verkstadsändamål
- är ekonomibyggnader för jordbruk, skogsbruk eller annan liknande näring
- inte har större bruttoarea än 100,0 m^2
- är avsedda för totalförsvaret och byggnader som är av betydelse för Sveriges säkerhet
- byggs av vissa statliga byggherrar
- byggs av privatpersoner och det inte sker inom näringsverksamhet

Vad ska beräknas och deklareras

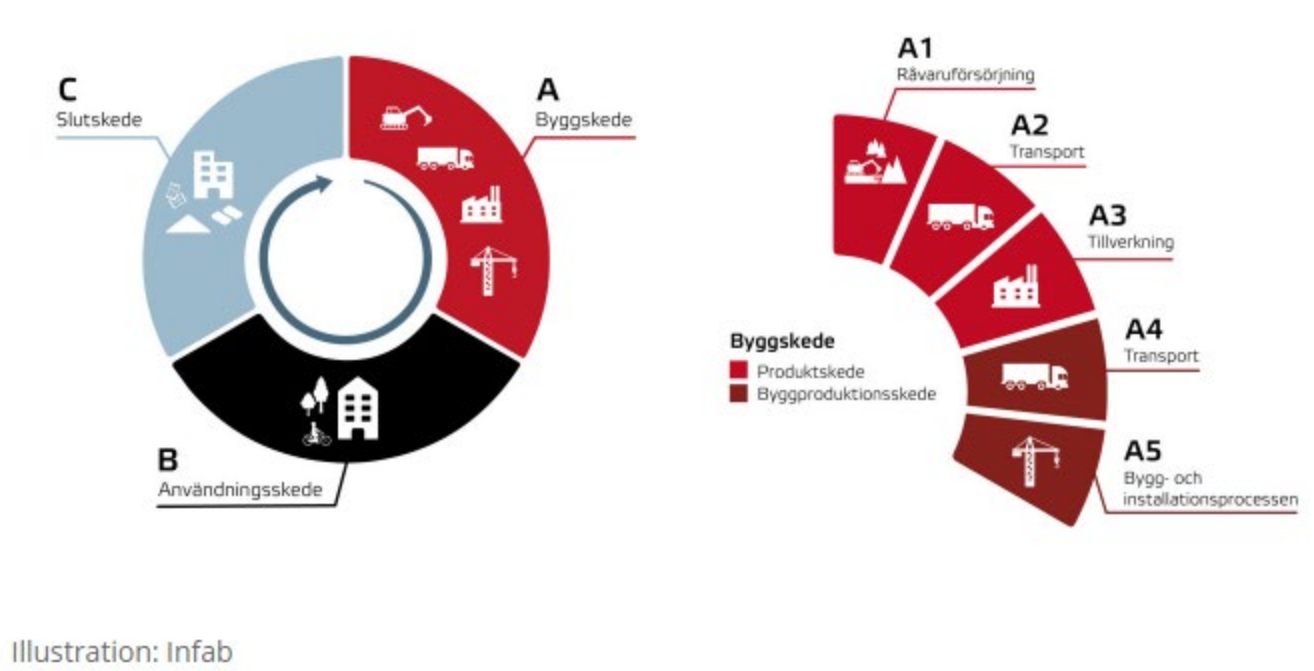

Illustration: Infab

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Byggnadsdelar som ska beräknas

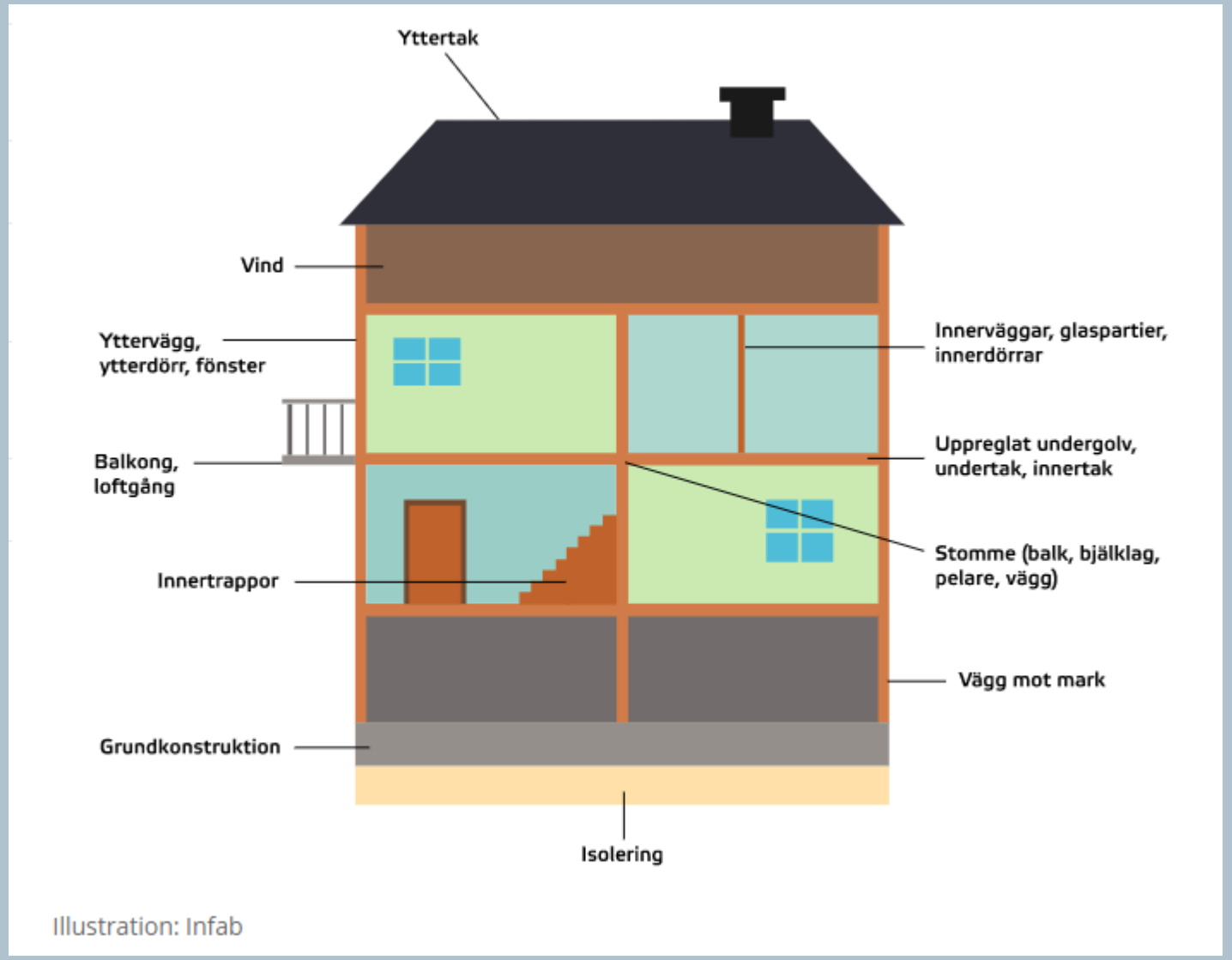

Illustration: Infab

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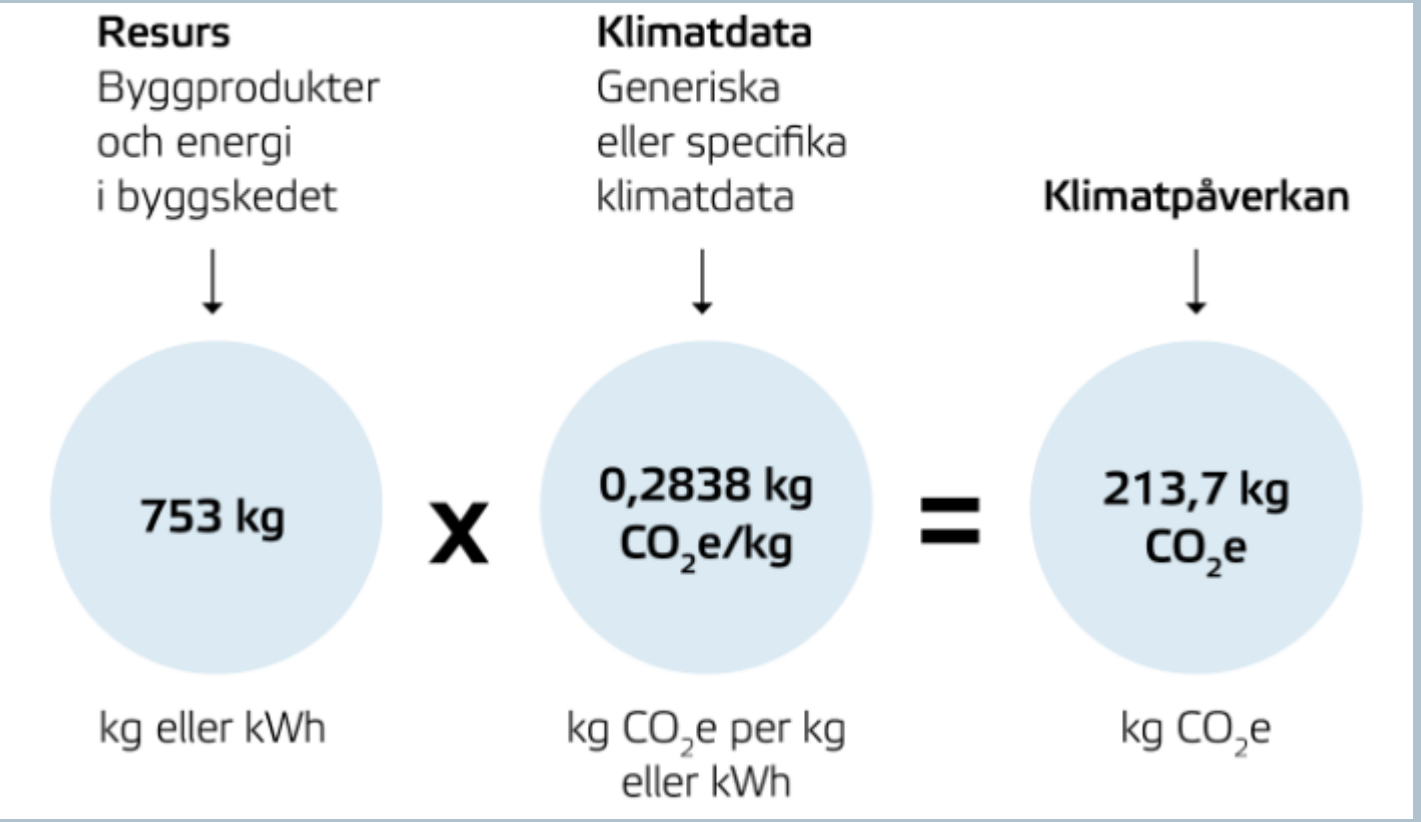
Byggnadsdelar som ska beräknas

Generiska data eller
EPD:er



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Vad blir då slutresultatet?

- Klimatdeklaration som ger insikt och möjlighet

att jämföra byggnaders klimatpåverkan

- Krav för att få slutbesked
- Ska registreras hos Boverket och dessutom sparas av byggherre i 5år

Krav på nivåer av klimatpåverkan?
Svaret är nej, det finns inga i nuläget.

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Miljöcertifieringar

SVANENMÄRKT

MILJÖ BYGGNAD

GreenBuilding

NollCO2
NETTONOLL KLIMATPÅVERKAN

MILJÖ BYGGNAD iDrift

BREEAM®

Contractor

Miljöcertifieringar

- Olika inriktningar
- Olika typer av byggnader möjliga att certifiera
- Möjlighet att certifiera befintliga byggnader

Contractor

Miljöcertifieringar

- Svanen
- Breeam
- Leed
- Miljöbygnad
- Miljbyggnad i drift
- Noll CO2

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Miljöcertifieringar

- Byggherrens incitament
  - Krav från hyresgäster
  - Marknadsvärde
  - Grön finansiering

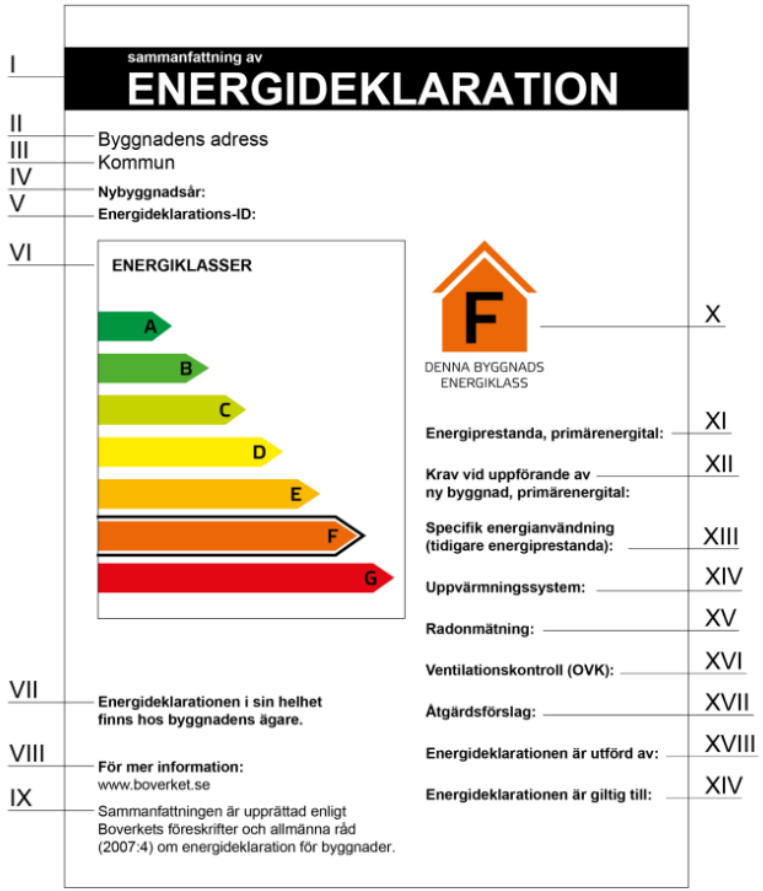
- Entreprenörens påverkan
  - Belysa möjligheter och utmaningar i tidiga skeden
  - Projektering (Styrning och kompetens)
  - Uppföljning löpande

Contractor

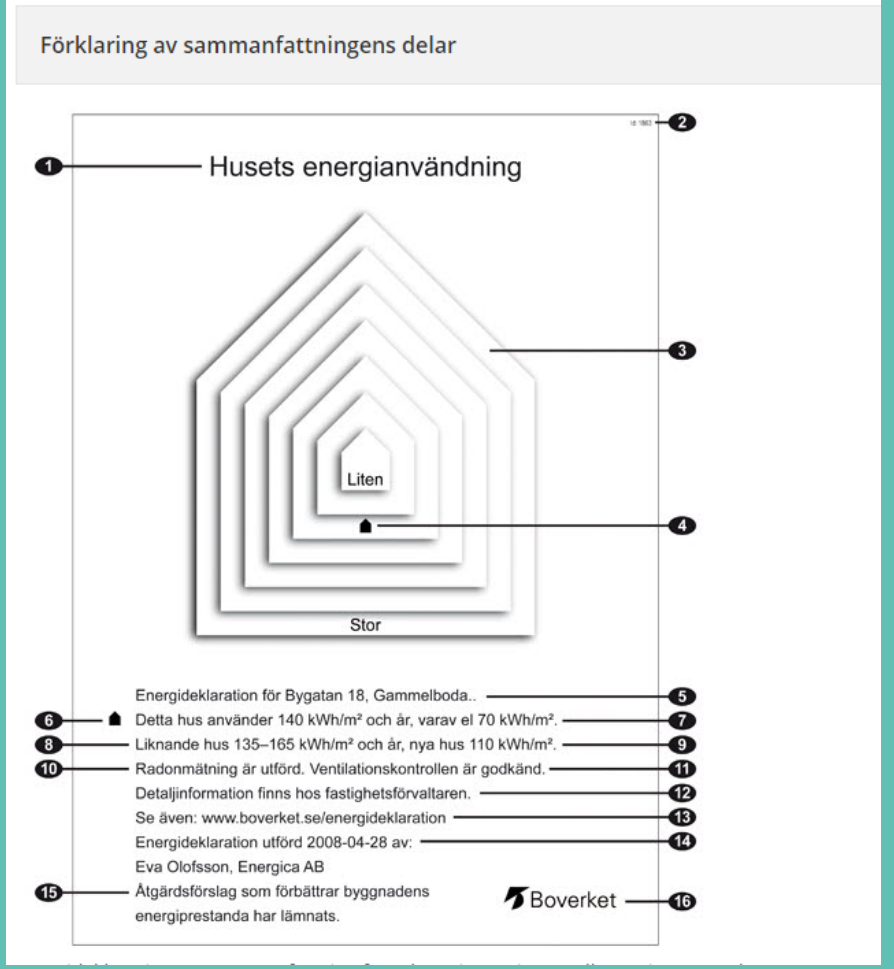
Boverket (2021). *Energideklarationens innehåll*. https://www.boverket.se/sv/energideklaration/energideklaration/energideklarationens-innehall/ Hämtad 2022-09-28.

Energideklaration av byggnader

Så här ser sammanfattningen ut från och med 1 januari 2019.



Energideklarationens sammanfattning som den såg ut under 2014–2018. Illustration: Boverket



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Energideklaration av byggnader

- Klassificeras A-G sedan 2019
- Beräknas med primärenergital

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Boverket (2021). *Energideklarationens innehåll*. https://www.boverket.se/sv/energideklaration/energideklaration/energideklarationens-innehall/ Hämtad 2022-09-28.

Energideklaration av byggnader
Gäller för:

När ska byggnader energideklareras?

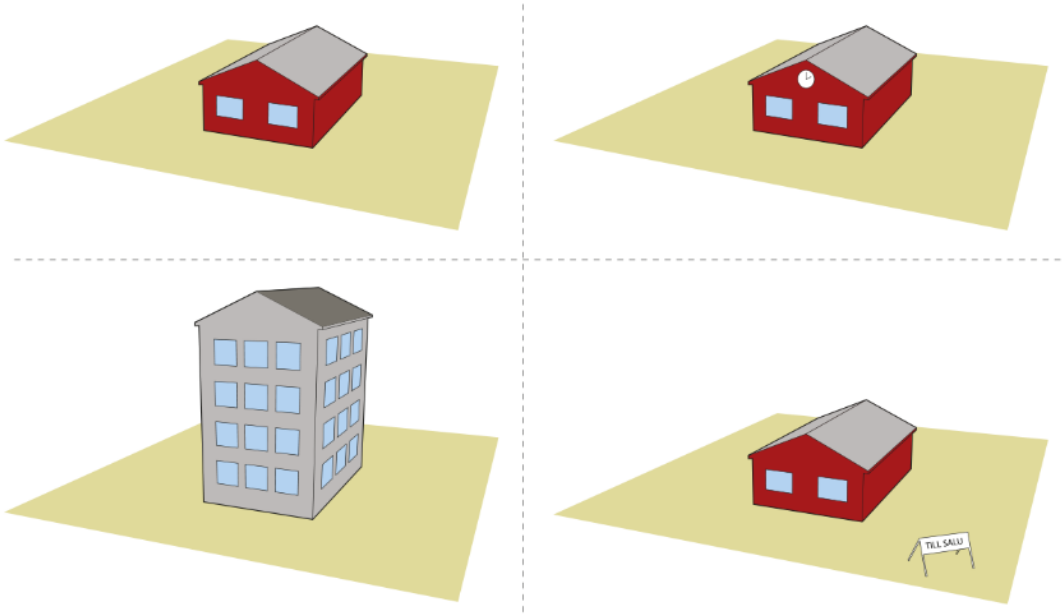

Illustration: Boverket / Altefur Development

Det finns fyra olika tillfällen då byggnader ska energideklareras:

- När byggnader är nya.
- När byggnadens golvarea är större än 250 kvadratmeter och ofta besöks av allmänheten.
- När byggnader upplåts med nyttjanderätt.
- När byggnader säljs.

Contractor

Boverket (2021). *Energideklarationens innehåll*. https://www.boverket.se/sv/energideklaration/energideklaration/energideklarationens-innehall/ Hämtad 2022-09-28.

Energideklaration av byggnader
Undantag:

Byggnader som är undantagna från kravet på energideklaration

Följande byggnader är undantagna från att energideklareras.

1. Byggnader som i huvudsak används för andakt eller religiös verksamhet.
2. Industrianläggningar och verkstäder.
3. Bostadshus som används eller är avsedda för användning
   a) mindre än fyra månader per år, eller
   b) under en begränsad del av året om energianvändningen beräknas vara mindre än 25 procent av en helårsanvändning.
4. Tillfälliga byggnader som är avsedda att användas högst två år.
5. Ekonomibyggnader med ett lågt energibehov som är avsedda för jordbruk, skogsbruk och därmed jämförlig näring.
6. Fristående byggnader med en total användbar golvarea som är mindre än 50 kvadratmeter.
7. Byggnader som är avsedda för totalförsvaret och som på grund av byggnadens utformning eller den verksamhet som bedrivs där är av hemlig natur.

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Bygger ett levande Norrland

Communication Of Life Cycle Assessment Results

Life Cycle Key Performance Indicators

Helena Nydahl

Industrial Doctoral School
Umeå University

UMEÅ UNIVERSITY

Bostaden

Photographer: Mostphotos

2.7 °C

Destroyed urban infrastructure

21.6 trillion EUR per year by 2025
7 trillion EUR per year by 2075

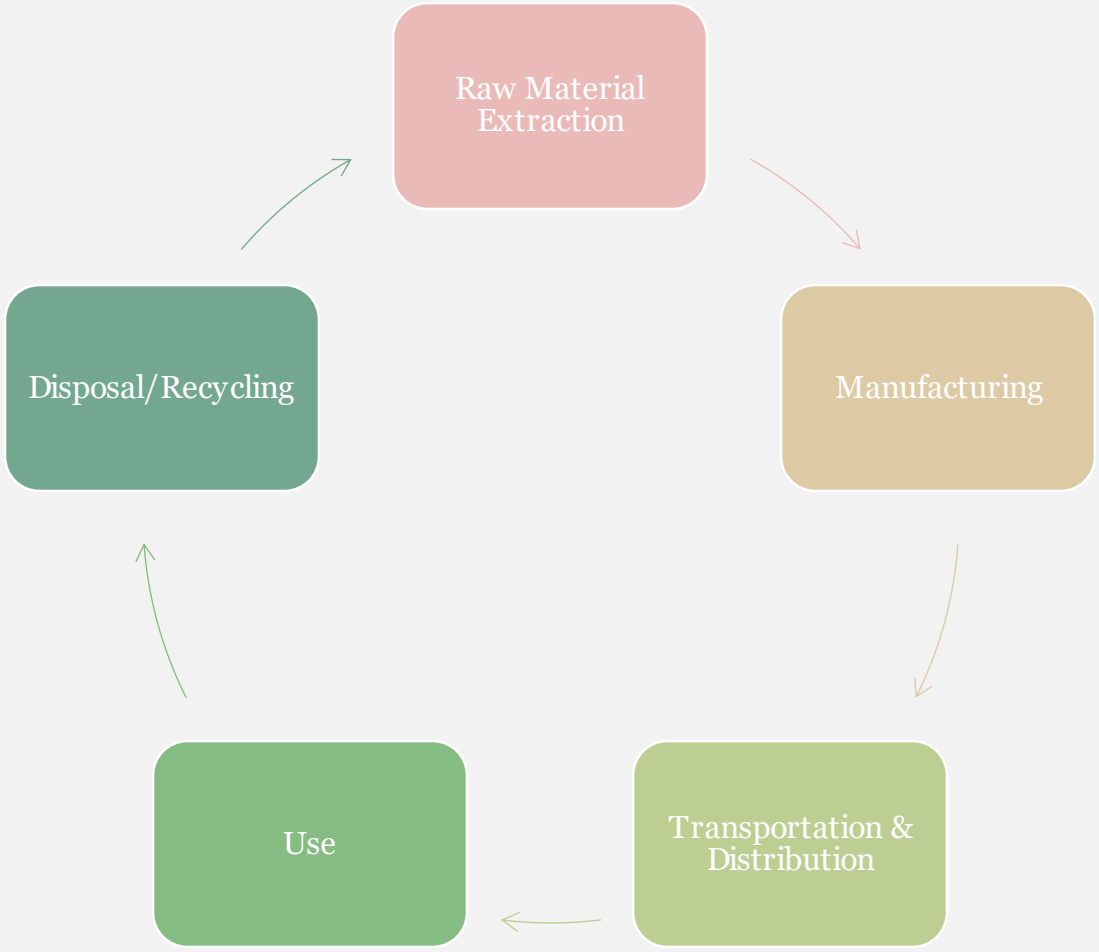
Reduced health

Reduced economic growth

Declining agricultural productivity

Photographer: Joshua Rawson-Harris

Is product A better than product B?



1 Goal & Scope

- Define the product/ company/service to measure.
- Define the system to measure in.
- Define what to exclude.

2 Life Cycle Inventory

- Collect and structure data.

Everything that goes into and out of the system is measured, e.g., raw material, energy use.

3 Impact Assessment

- Translate the data into impacts.

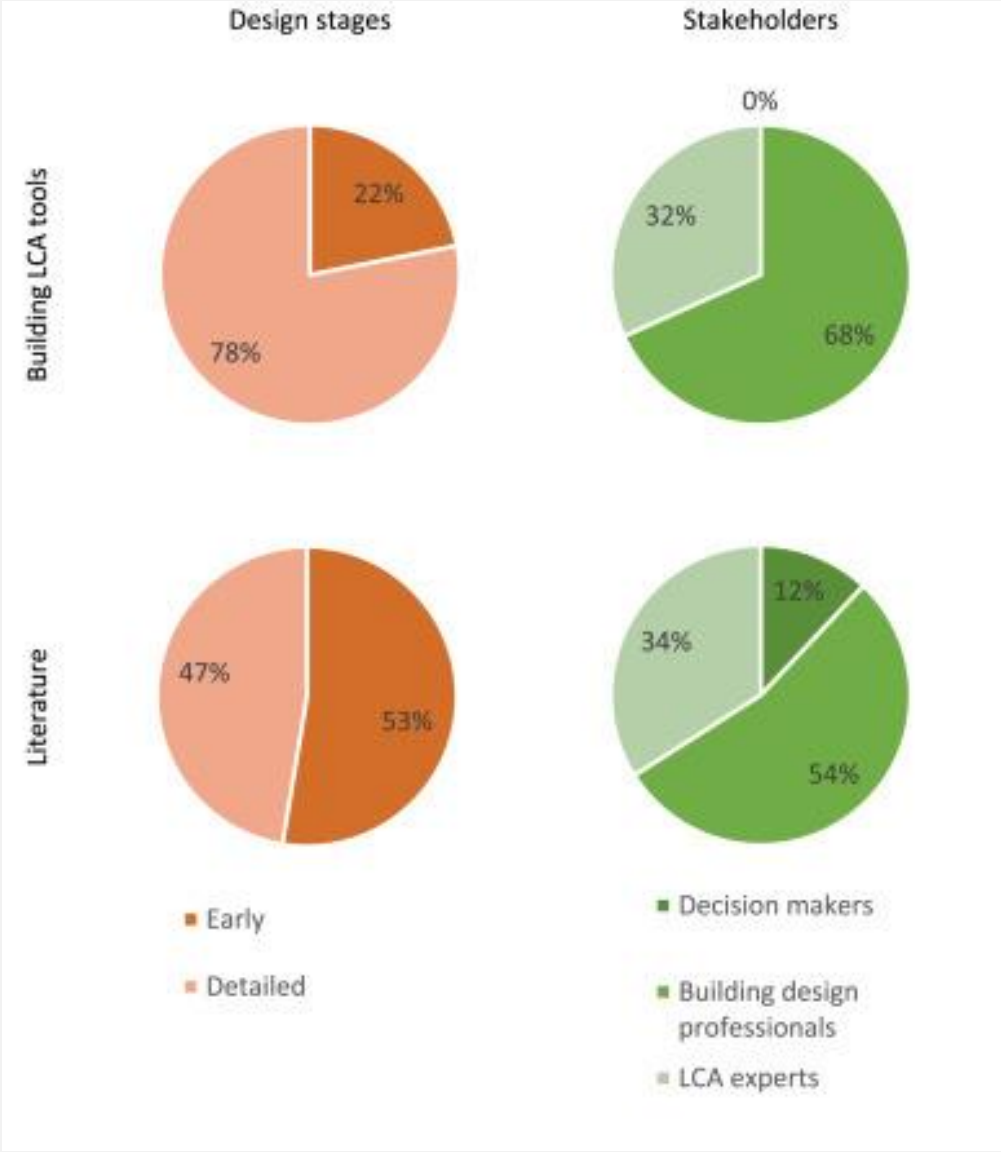
Associating inventory data with specific environmental impact categories and category indicators.

4 Interpretation

- What does it all mean?

The result should be consistent with the defined goal and scope and reach conclusions, explain limitations and provide recommendations.

Review of Visualising LCA Results in the Design Process of Buildings by Hollberg et al.



Photographer: Most photos

UMEÅ UNIVERSITY

Questions asked

- How can well-established economic KPIs be utilised to quantify environmental impact?
- How does incorporation of monetary valuation of environmental impacts and related environmental aspects affect the LCA-result and communication of results?

Life Cycle Key Performance Indicators

$$\mathrm{ROI} = \left(\frac{\sum_{i=1}^{IH} (\Delta \mathrm{G_i})}{\mathrm{LC\_I}} \right)_{\mathrm{Eco,Env}} \quad (1)$$

$$\mathrm{AY} = \left(\mathrm{ROI}^{1/IH} \right)_{\mathrm{Eco,Env}} \quad (2)$$

ROI	Return on invested life cycle economic or environmental impact
AY	Annual life cycle economic or environmental impact yield
ΔG_i	Annual economic or environmental gain, year i
LC_I	Present value of life cycle economic or environmental investment
IH	Investment horizon

$$\mathrm{PVEC} = \frac{FEC_i}{(1+\mathrm{SDR})^{(i-1)}} \tag{3}$$

PVEC	Present value of environmental costs and benefits
FEC	Future costs or benefits of environmental impact, year i
SDR	Social discount rate

$$\mathrm{ROI}_{\mathrm{Economy+}} = \frac{\sum_{i=1}^{IH}\left((\Delta \mathrm{G_i})_{\mathrm{Eco}} + \left((\Delta \mathrm{G}_i)_{\mathrm{Env}} \times \mathrm{PVEC}(1+\mathrm{SDR})^{(i-1)}\right)\right)}{\mathrm{LC\_I_{Eco}} + (\mathrm{LC\_I_{Env}} \times \mathrm{PVEC})} \tag{4}$$

$\mathrm{ROI}_{\mathrm{Economy+}}$	Return on invested life cycle economic and environmental impact
$\Delta \mathrm{G_i}$	Annual economic or environmental gain, year i
PVEC	Present value of environmental cost and benefits
SDR	Social discount rate
$\mathrm{LC\_I_{Eco}}$	Present value of life cycle economic investment
$\mathrm{LC\_I_{Env}}$	Life cycle environmental impact investment

$$\mathrm{ELCCA} = (\mathrm{LC\_I_{Eco}} + \mathrm{PV_{OP}}) + \left((\mathrm{LC\_I_{Env}} + \mathrm{LCEIA_{OP}}) \times \mathrm{PVEC}\right) \tag{5}$$

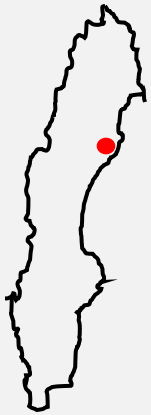
ELCCA	Extended life cycle cost assessment
$\mathrm{LC\_I_{Eco}}$	Present value life cycle economic investment
$\mathrm{PV_{OP}}$	Present value of recurring operation
$\mathrm{LC\_I_{Env}}$	Life cycle environmental impact investment
$\mathrm{LCEIA_{OP}}$	Life cycle environmental inventory assessment of recurring operation
PVEC	Present value of environmental cost

Cost of Carbon

830 EUR tCO_2-eqv^{-1}

0 EUR tCO_2-eqv^{-1}

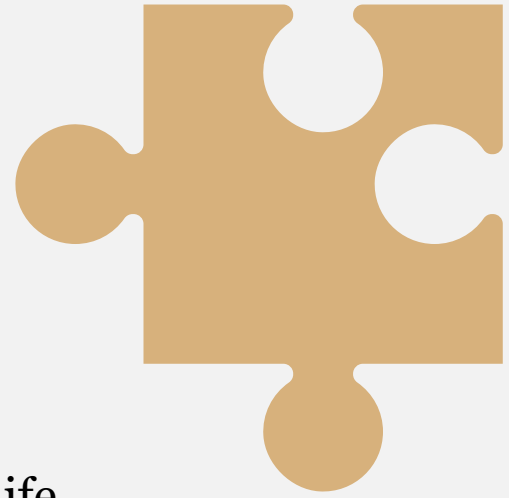
- Integrated Assessment Models (IAMs)
  - Population, economic and technological pathways to achieve specific climate change mitigation goals



Comparative Assessment of Refurbishment and New Construction

		Original Building [EUR HFA^{-1}]		Refurbishment [EUR HFA^{-1}]		New Construction [EUR HFA^{-1}]	
		SCC3	**SCC4**	**SCC3**	**SCC4**	**SCC3**	**SCC4**
LCCA	C	-	-	67	67	100	100
	A_{new}	-	-	788	788	3155	3155
	B6	4434	4434	2065	2065	1139	1139
	Total	**4434**	**4434**	**2920**	**2920**	**4394**	**4394**
$LCCA_{GHGe}$	C	-	-	0.7	2.4	1.6	5.5
	A_{new}	-	-	13	43	58	197
	B6	143	491	72	247	39	134
	Total	**143**	**491**	**85**	**292**	**98**	**337**
ELCCA	**Total**	**4577**	**4924**	**3005**	**3212**	**4492**	**4731**

Key Issues Addressed



- The global temperature rise that we are on track for will be extremely costly – we must act now
- Life cycle assessment is an essential tool to enable decision making with regard to climate change and life cycle interpretation is the most crucial step
- Decision makers are rarely the targeted stakeholder in LCA result interpretation
- Economic tenability
- Monetary valuation can express various environmental impact categories with a single LC-KPI
- With the ELCCA KPI, the LCA result does not change compared to traditional economic assessment

Conclusion

- The LC-KPIs address the “cognitive logics” of a wide range of stakeholders and provides an approach for communication of LCA-results.
- ROI and AY is shown to be suitable LC-KPIs for building refurbishment – but rarely used
- Contribute to the research field of monetary valuation in LCA by introducing and testing two different approaches, $ROI_{Economy+}$ and ELCCA.
  - The case study result defines further scope for research on the subject of monetary valuation in LCA and inquire for a wider spectrum of LC-KPIs that utilizes monetary valuation

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Umeå University

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Bostaden

Life Cycle Analysis of Cross-laminated Timber Multi-storey Building

Synergies in Structural Engineering Solutions and Carbon Footprint

Linnéuniversitetet
Kalmar Växjö

September 29, 2022

1

Outline

- Background and motivations
- Carbon footprint of CLT and light timber frame buildings
- Concluding remarks

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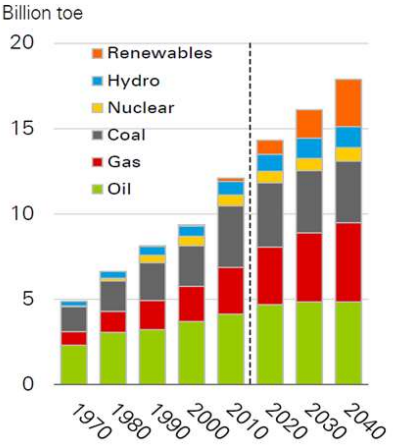
Kalmar Växjö

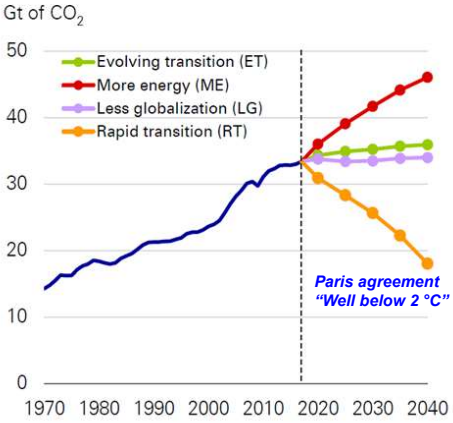
2

Our world's challenge - more energy, less carbon!

Primary energy consumption by fuel



CO_2 emissions



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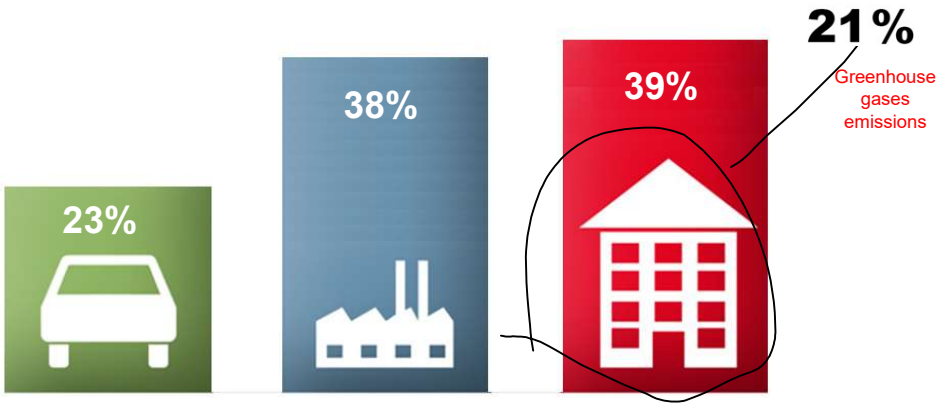
Source: BP Energy Outlook: 2019

3

Why the building and construction sector matter – Sweden



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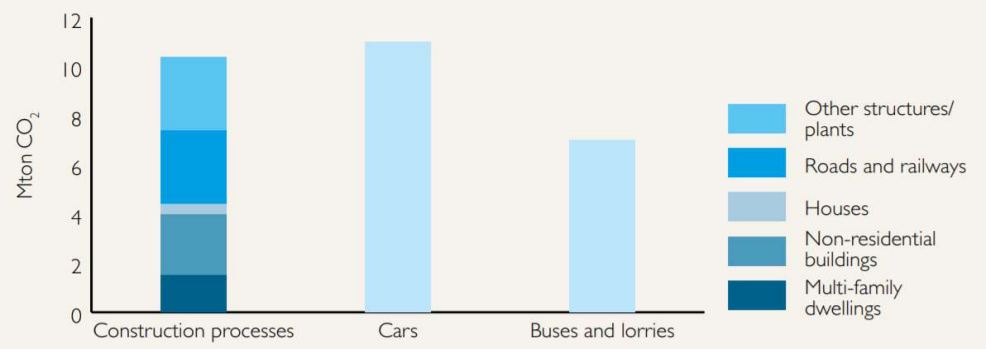
Source: Energimyndigheten, 2020

4

Annual carbon emission from activities – Sweden



(Source: IVA, 2014)

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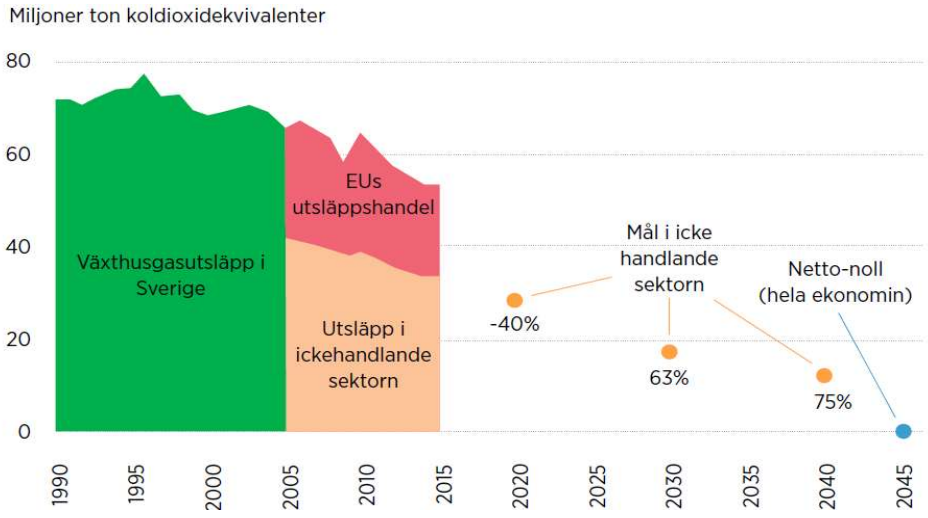
Greenhouse gas emissions and climate targets – Sweden



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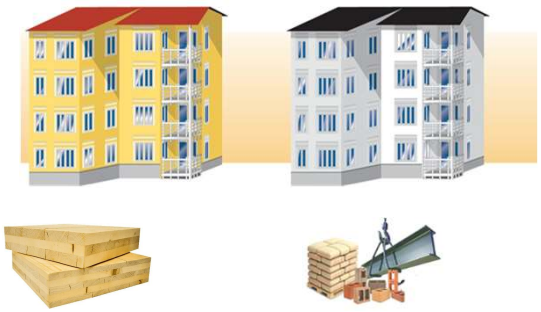
source: Naturvårdsverket.

6

Reducing climate impacts of building and construction

- Different possibilities exist, e.g.
  - Build sustainable buildings using:
    - Wooden material, e.g., CLT?
    - Reinforced concrete?
    - Steel?
  - Which is better for the climate & environment?
    - LCA is needed to compare



- A life cycle perspective is needed to understand and reduce energy and climate impacts of buildings

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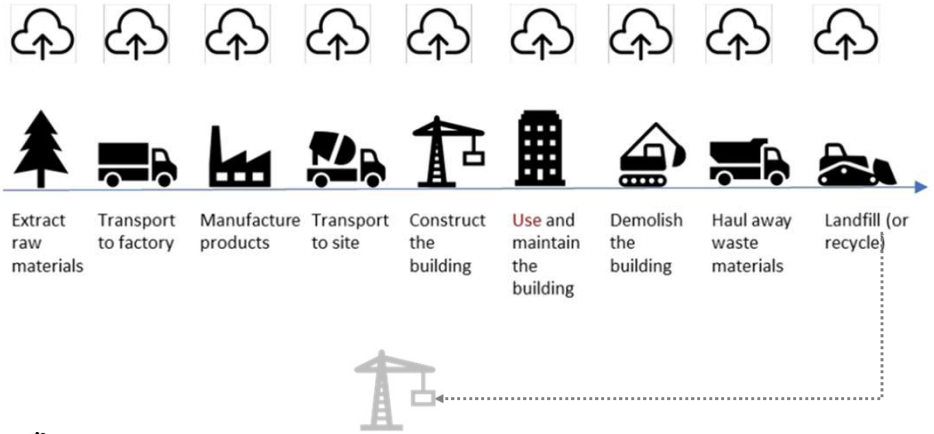
Life cycle perspective with circularity approach



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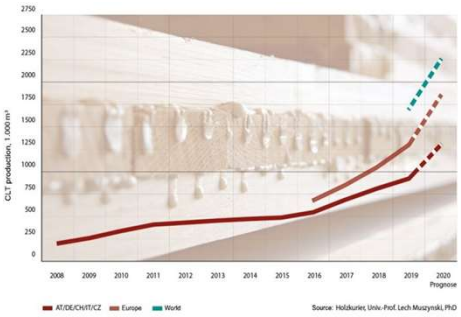
Cross-laminated timber (CLT) in multi-storey buildings



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Project

Improving the competitive advantage of CLT-based building systems through engineering design and reduced carbon footprint

Core research question

How can **engineering design** of CLT-based building systems be improved to **increase competitiveness** of the technology and set the path towards a **green transformation** of the building sector in Sweden?

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Motivation for life cycle analysis (LCA) of CLT buildings

- Regulation on climate declaration of new building construction from January 2022
  - Requires assessment and reporting of carbon footprint of buildings' production and construction stages, initially
- Existing knowledge is very limited on carbon footprint of CLT buildings, from a complete life cycle perspective
  - CLT was developed in the early 1990s
  - Existing CLT buildings are yet to reach mid service-life
- Need for new knowledge to optimize carbon footprint of CLT buildings is essential

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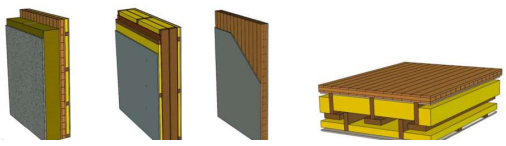
11

Life cycle carbon footprint analysis of a reference CLT buildings

Limnologen, Växjö



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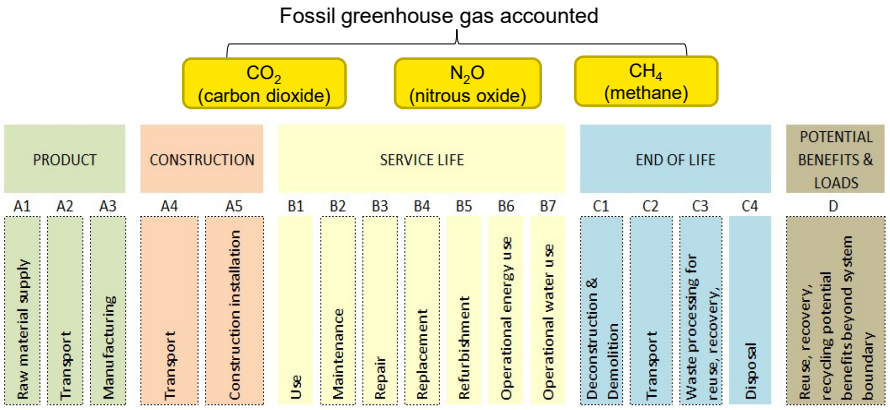
Dodoo, A., Nguyen, T., Dorn, M., Olsson, A., Bader, T. K., *Exploring the synergy between structural engineering design solutions and life cycle carbon footprint of cross-laminated timber in multi-storey buildings.* Wood Material Science & Engineering, 2022: p. 1-13.

12

Life cycle carbon footprint analysis

- Analysis follows European standard: EN 15978 - sustainability of construction works
- Carbon footprint calculated as global warming potential for a 100-years period
- Fossil greenhouse gases emissions included, biogenic emissions are excluded



The dash borders show what is covered in the analysis

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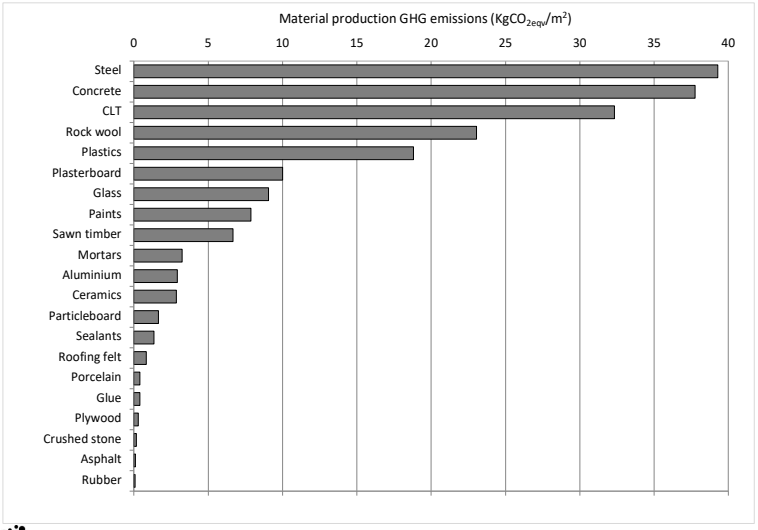
Dodoo et al. 2022. Wood Material Science & Engineering.
https://doi.org/10.1080/17480272.2021.1974937

13

Carbon footprint of the reference building's materials in the product stage



(Calculations based on Ecoinvent 3.7.1. dataset)

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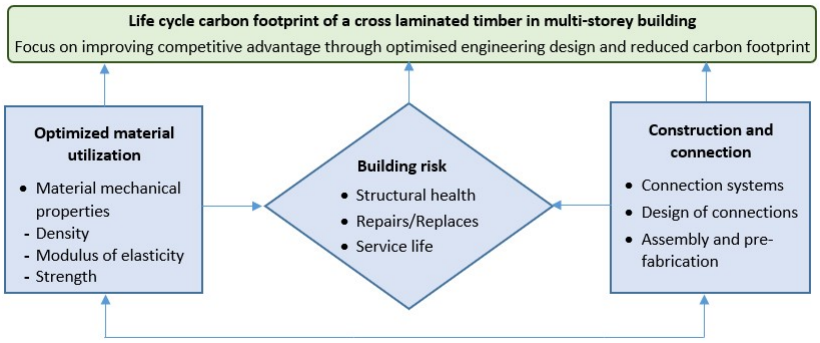
Dodoo et al. 2022. Wood Material Science & Engineering.
https://doi.org/10.1080/17480272.2021.1974937

14

Synergy between structural engineering solutions and the carbon footprint of the reference building is explored



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15

Life cycle carbon footprint and GHG balances of reference building and synergy effect of engineering design

Module/ stage	Carbon flow ($kgCO_{2eq}/m^2$)		Carbon savings	
	Reference	Synergy	$kgCO_{2eq}/m^2$	%
Production & construction stage:				
Module A1-3	203.4	199.2	4.2	2
Module A4-5	40.4	40.4	-	-
Service life stage:				
Module B2-4	32.2	23.9	8.3	26
End of life stage:				
Module C1-3	4.5	4.5	-	-
Potential benefits & burden:				
Module D				
CLT/ wood recovery of energy	-152.4	-181.3	28.9	19
Concrete & steel recycling	-35.7	-34.3	-1.4	-4
Life cycle balance (With module D)	**92.4**	**52.4**	**40**	**43**
Life cycle balance (No module D)	**280.5**	**268.0**	**12.5**	**4**

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Dodoo et al. 2022. Wood Material Science & Engineering.
https://doi.org/10.1080/17480272.2021.1974937

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Carbon footprint reductions/ changes for synergy effect aspects compared to the reference building

Module/ stage	Optimized CLT utilization	Efficient connection & construction	Service life risk management
Production (A1-3)	-2.0%	-0.7%	-
Construction (A4-5)	-	-	-
Service life (B2-4)	-	-	-25.8%
End-of-life (C1-3)	-	-	-
Post-use benefits of CLT (D)	7.5%	-27.9%	-

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Synergy approach for a low-carbon CLT-based building

+

Optimized material utilization

Building systems & efficient connections

Service-life risk management

LCA: **281*/ 92**** **kgCO$_{2eqv}$/m^2**

LCA: **268 / 52**** **kgCO$_{2eqv}$/m^2**

4-43% reduction in carbon footprint

* Excluding post-use benefits & burden
** Including post-use benefits & burden/ circularity strategies

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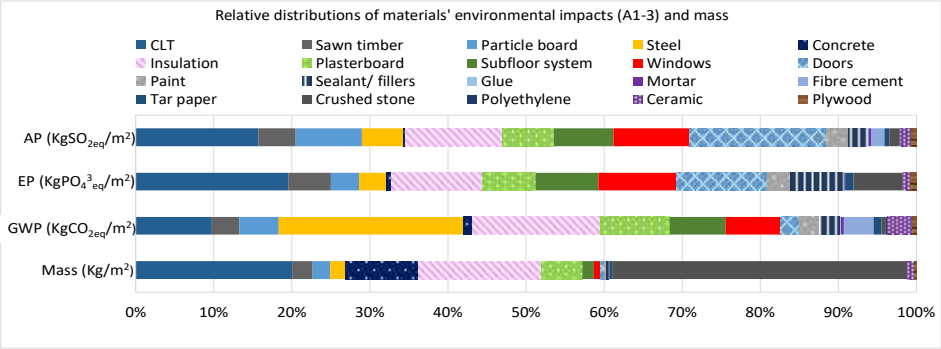
Input material, global warming potential (GWP), eutrophication (EP) and acidification (AP) in the product phase



(Calculations based on EPD input data)

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Al-Najjar, A., Dodoo, A. (2022). Modular multi-storey construction with cross-laminated timber (CLT): Life cycle environmental implications. Wood Material Science & Engineering.

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Carbon footprint CLT production from EPDs of different manufacturers

Manufacturer	Geographic scope	CLT unit weight (kg/m^3)	GWP, excluding biogenic (kg CO_{2eq}/m^3)	GWP, including biogenic* (kg CO_{2eq}/m^3)
Södra Building Systems	Sweden	430	34	-670
Stora Enso	Austria	470	60	-671
KLH Massivholz GmbH	Austria	480	192.9	-601.3
Binderholz Bausysteme GmbH	Germany	471	200	-761
Egoin	France	500-550	174.1**	-685.5
Xlam	Australia	480	447	-293
Schilliger Holz AG	Switzerland	424	70	-623
SmartLam North America	Alabama, US	561	126	-779
SmartLam North America	Montana, US	561	178	-727
Nordic X-Lam	Quebec, Canada	411	121.9	-591
Structurlam	BC, Canada	420	89.8	-678.3
Average	-	**476**	**154**	**-648**

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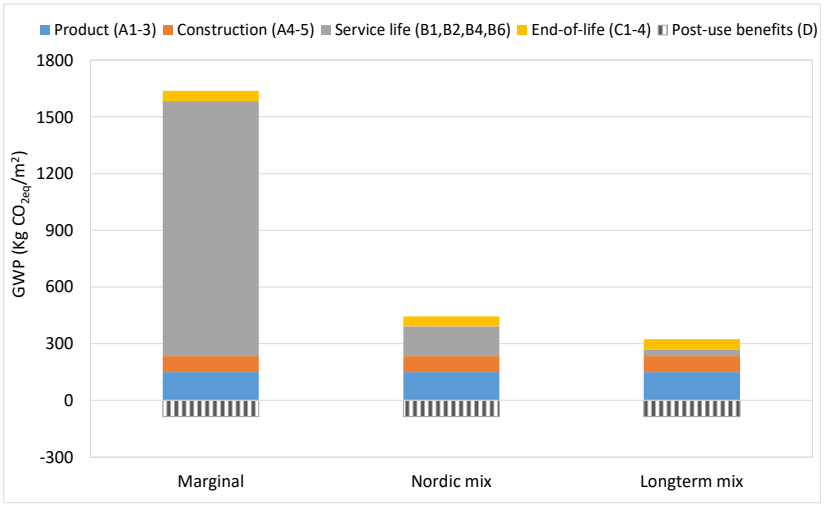
Source: Younis, A., Dodoo, A. (2022). Cross-laminated timber for building construction : A life-cycle-assessment overview. Journal of Building Engineering. Elsevier. 52.

20

GWP (carbon footprint) for production, operation (50 years) with different energy supplies and dismantling of the house



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Al-Najjar, A., Dodoo, A. (2022). Modular multi-storey construction with cross-laminated timber (CLT): Life cycle environmental implications. Wood Material Science & Engineering.

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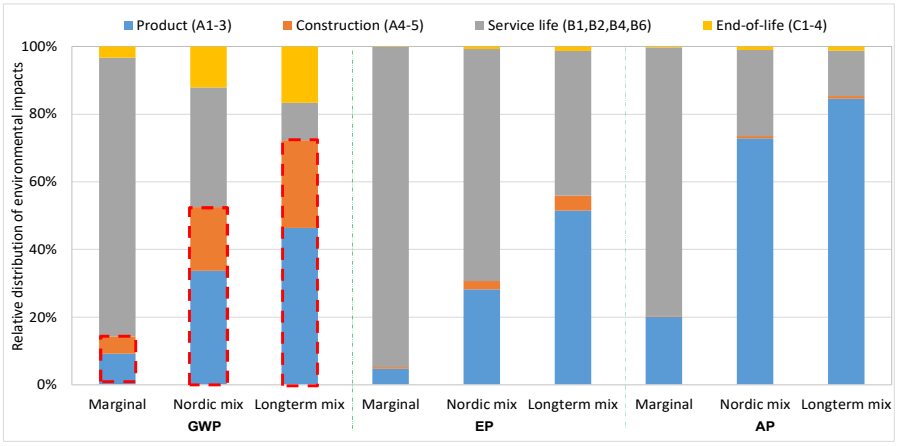
Relative contributions to life cycle environmental impact over 50 years, with different energy supplies



Global uppvärmningspotential (GWP), övergödning (EP) och försurning (AP)

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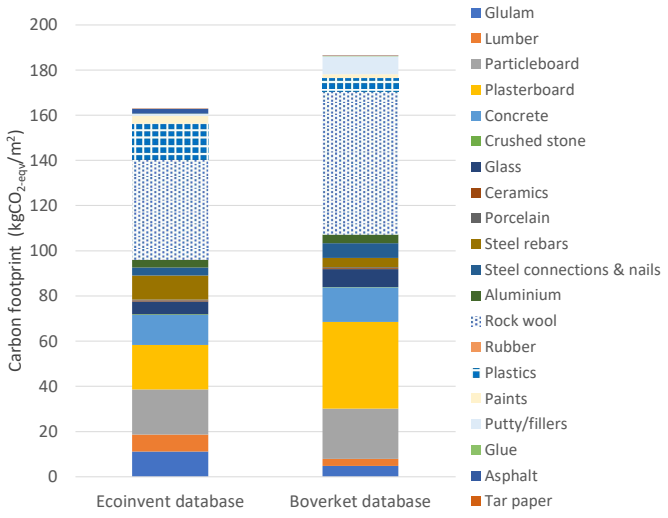
Al-Najjar, A., Dodoo, A. (2022). Modular multi-storey construction with cross-laminated timber (CLT): Life cycle environmental implications. Wood Material Science & Engineering.

22

Carbon footprint of product stage – Impact of databases



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Dodoo, A. (2022). Ongoing work

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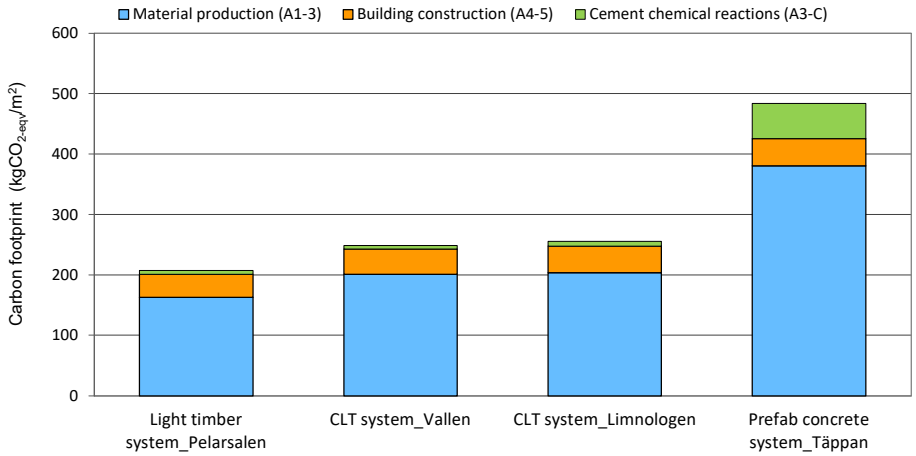
Carbon footprint of building systems - Production stage



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Dodoo, A. (2022). Ongoing work

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Concluding remarks

- Lifecycle perspective is needed to reduce buildings' climate impact
- Life cycle carbon footprint of CLT building is reduced when employing the explored synergy approach involving
  - Optimized material utilization, Efficient connection systems, and Service life risk management

    4% carbon footprint reduction when excluding end-of-life benefits

    43% carbon footprint reduction when including end-of-life benefits
- Synergy approach holds promise to further improve the carbon footprint of CLT buildings
- New knowledge and research are crucial

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Some publication from sub-project

- Dodoo, A., Truong, N.L., Dorn, M., Olsson, A., Bader, T.K. (2022). Exploring the synergy between structural engineering design solutions and life cycle carbon footprint of cross-laminated timber in multi-storey buildings. Wood Material Science & Engineering. 17 (1). 30-42.
- Younis, A., Dodoo, A. (2022). Cross-laminated timber for building construction : A life-cycle-assessment overview. Journal of Building Engineering. Elsevier. 52.
- Al-Najjar, A., Dodoo, A. (2022). Modular multi-storey construction with cross-laminated timber: Life cycle environmental implications. Wood Material Science & Engineering. 1-15.
- Dodoo, A., Dorn, M., Olsson, A., Bader, T.K. (2022). Structural engineering and carbon footprints of CLT buildings: Commentary. Buildings & Cities. https://www.buildingsandcities.org/insights/commentaries/clt-buildings.html
- Younis, A., Dodoo, A. (2022). Comparative carbon-footprint analysis of residential buildings with different structural materials. Proceedings of International Structural Engineering and Construction, 9(1), 2022.
- Dodoo, A., Muszyński, L. (2021). End-of-life management of cross laminated timber multi-storey buildings : A case for designing for post-use material recovery and environmental benefits. Proceedings of the World Conference on Timber Engineering, August 09 - 12, Santiago, Chile.

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DIGITALIZATION AS A MEANS FOR SUSTAINABLE URBAN DEVELOPMENT? Insights from the real-life planning situation for Kronandalen, Luleå, Sweden

Sofia Lidelöw, Susanne Engström,
Niklas Törnå

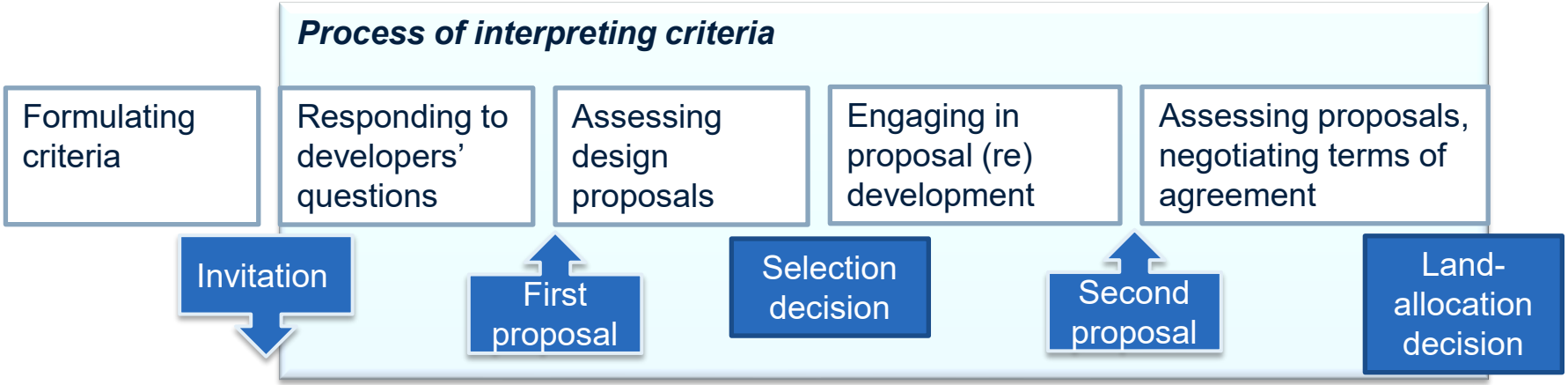
LULEÅ UNIVERSITY OF TECHNOLOGY

Case Kronan, Luleå

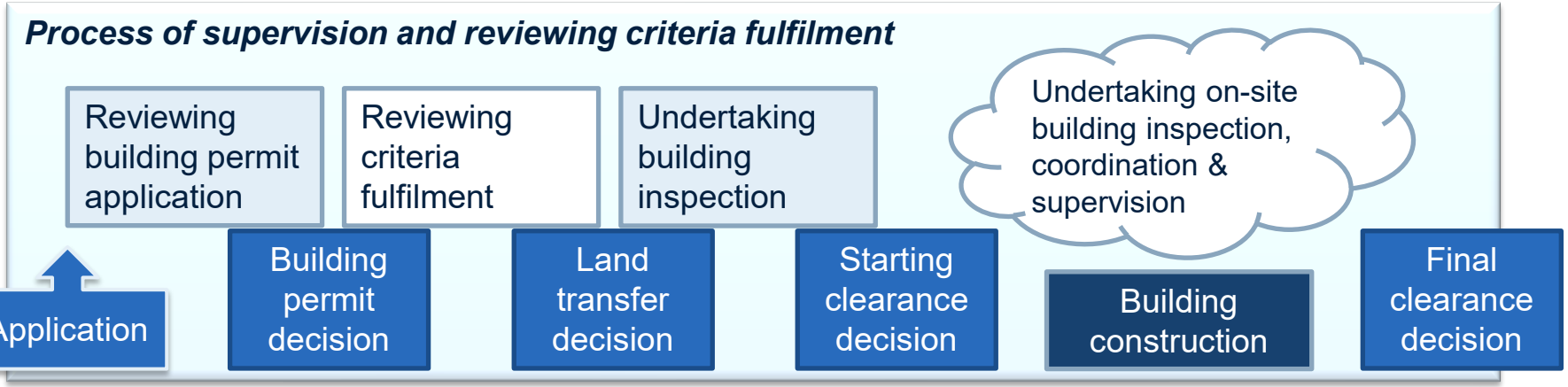
- Urban development project:
  - Strong sustainability vision
  - Dialogues process btw municipality and developers

- Focus of study:
  - The process of interpreting, reviewing and fulfilling architectonic and sustainability criteria
  - How digitalization can support this process

Managing towards the vision:
Criteria formulation and interpretation



Managing towards the vision:
Formal supervision and reviewing criteria-fulfillment



Challenges in managing towards the vision

Assessment group's view

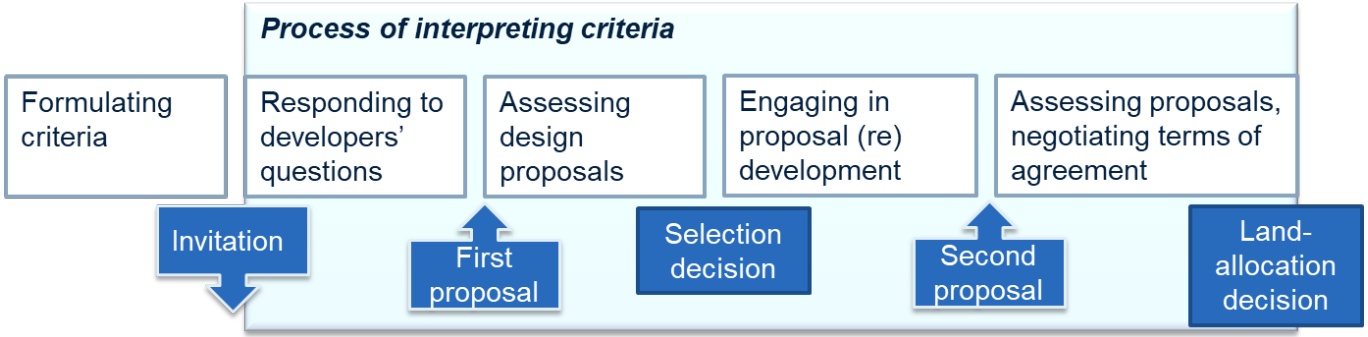
- Criteria not reviewed in building permit process
- Final design proposals do not meet expectations based on early proposals

Developers' view

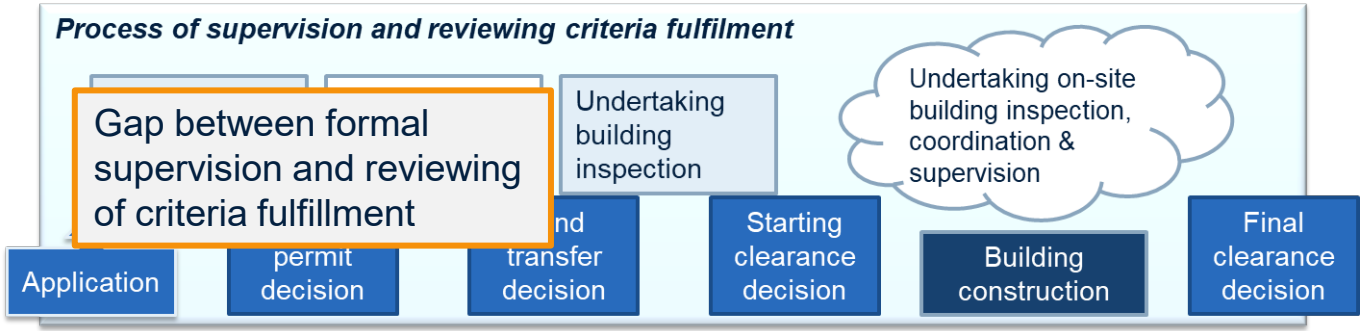
- Drifts and contradictions in criteria interpretation during the process
- Inadequate follow-up of criteria fulfilment

Three major gaps identified based on workshops and interviews with municipality and developer representatives

Intra-organizational gaps in local planning authority and developers



Gap between criteria for selection and criteria fulfilment



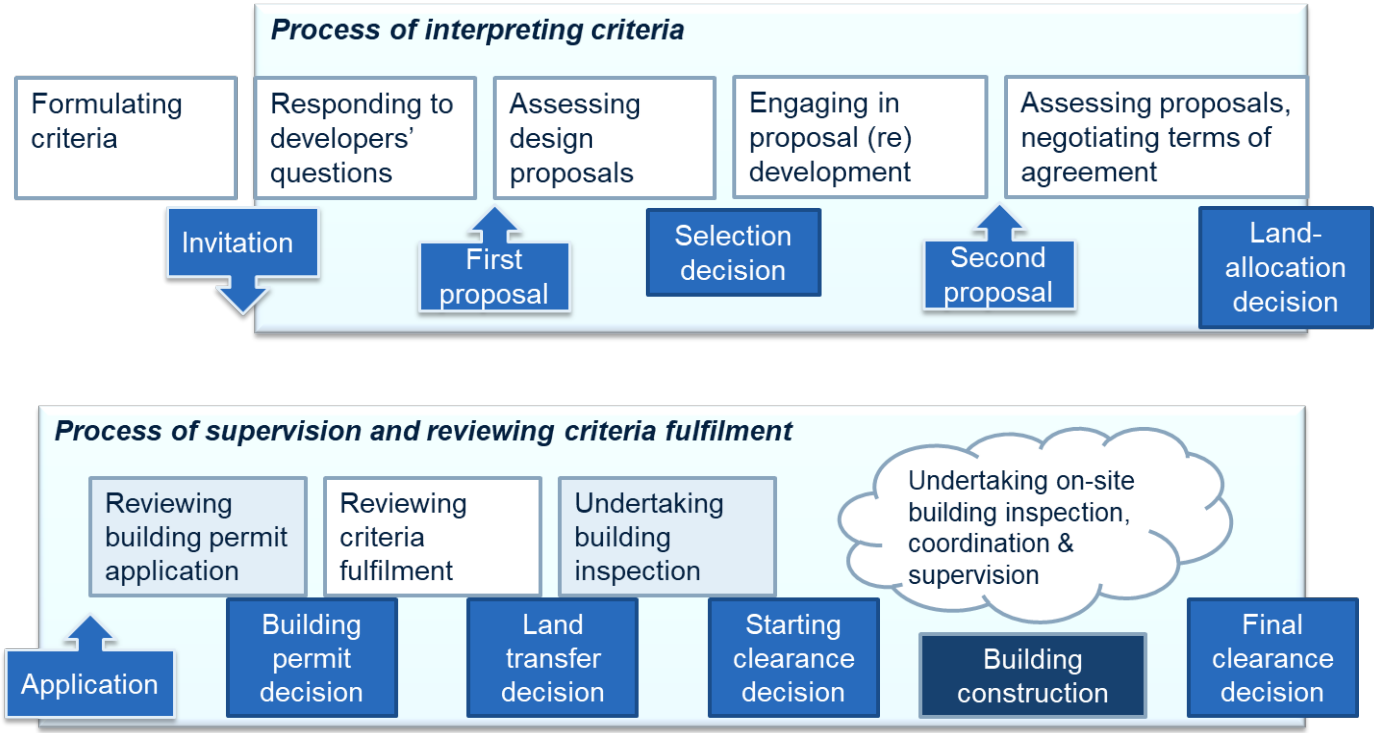
Gap between formal supervision and reviewing of criteria fulfillment

Digital means and opportunities

Virtual meetings

Digital models and modelling

Richer basis for assessments



Digitalization as a means for sustainable urban development?

Main insights from the Kronan case:

Yes **Virtual meeting** opportunities support dialogue process involving stakeholders with different competencies and interests

No **Digital models and modelling** are not understood to support dialogue process in the early pre-planning phase

? Needs for a **richer basis for assessments** that could be enabled by digital methods/tools are unclear and second to identified gaps

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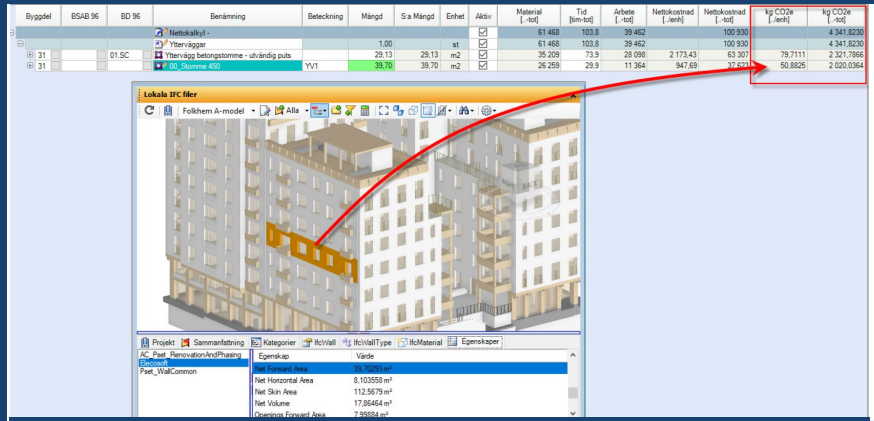
Examples of developments in digital climate calculations



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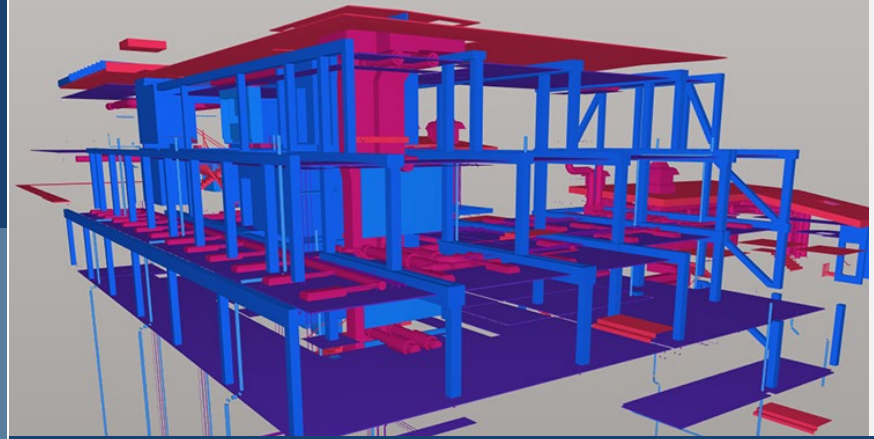
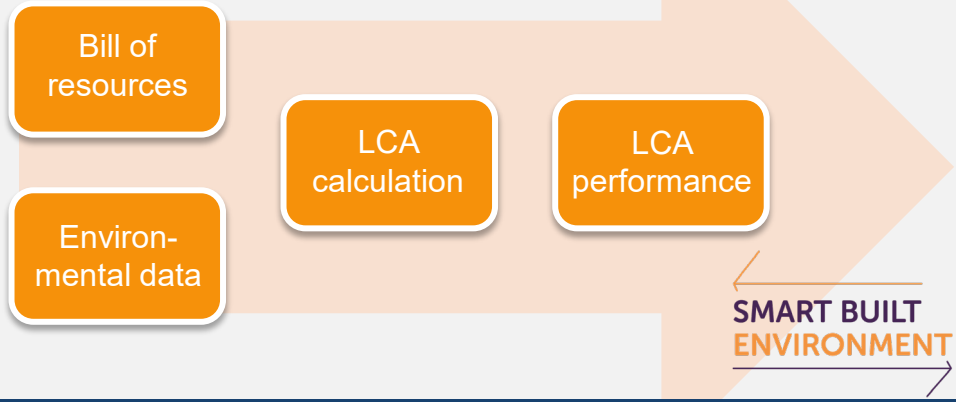


Sweco (2021). Nu blir klimatkalkyler enklare att förstå. https://www.sweco.se/nyheter/nyhetsartiklar/2021/nu-blir-klimatkalkyler-enklare-att-forsta/ Retrieved 2021-03-29

Simplified information flow model for digital LCA



Byfors K, Erlandsson M, Sveder Lundin J (2019). Synthesis: Life-cycle perspective 2016-2018. https://www.smartbuilt.se/library/5210/rapport-syntes-livscykelperspektiv-2016-2018.pdf Retrieved 2022-05-16

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