

Webinar for Konstruktørforeningen 14. November 2023

Klimavenlige konstruktioner

Forskningscenter Byggeri, Klima, vandteknologi og digitalisering

Mette Falbe-Hansen, civilingeniør, lektor

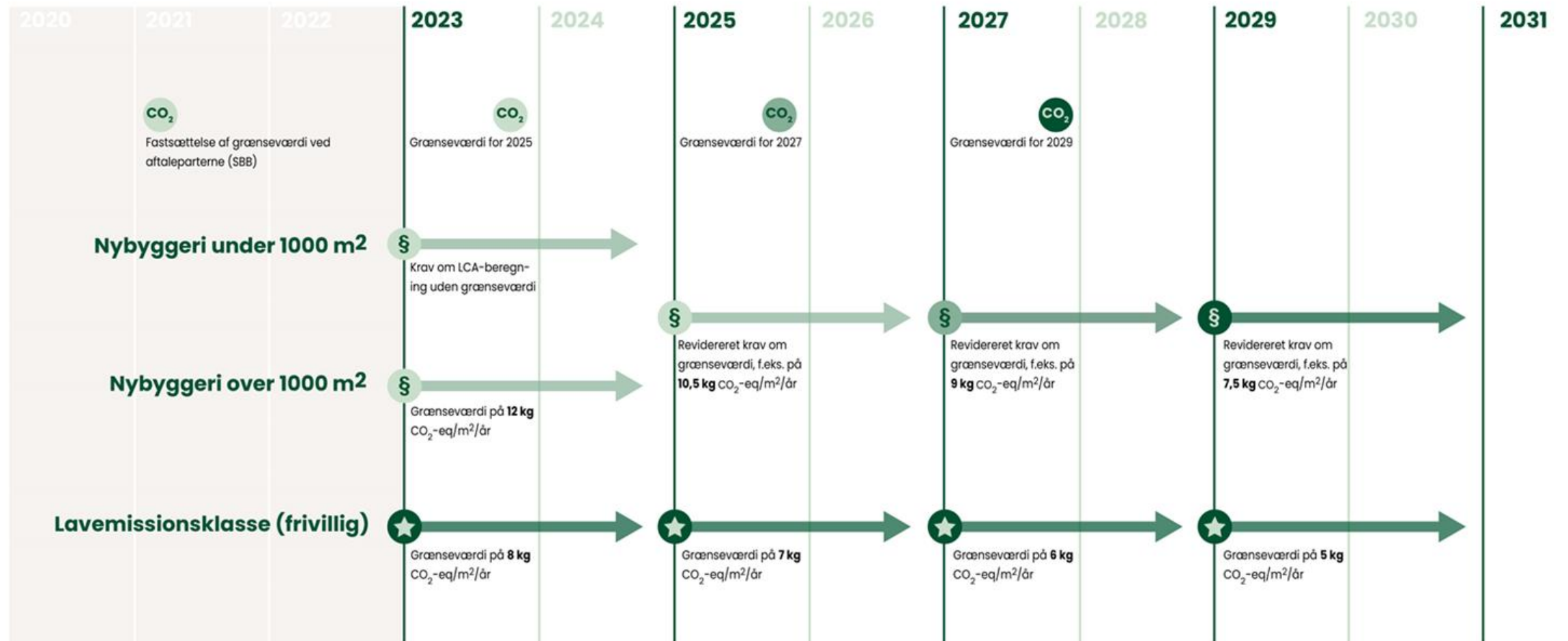
Mona Abd Elhamid, civilingeniør, adjunkt

Olav Langenkamp, arkitekt, lektor

Knud Højer, bygningsingeniør, lektor

Baggrund

Lovgivning – National strategi



Bibliografi / litteratur review

- [1] R. Azari and N. Abbasabadi, "Embodied energy of buildings: A review of data, methods, challenges, and research trends," *Energy Build*, vol. 168, pp. 225–235, Jun. 2018, doi: 10.1016/J.ENBUILD.2018.03.003.
- [2] G. Grazieschi, F. Asdrubali, and G. Thomas, "Embodied energy and carbon of building insulating materials: A critical review," *Cleaner Environmental Systems*, vol. 2, p. 100032, Jun. 2021, doi: 10.1016/J.CESYS.2021.100032.
- [3] "Bringing embodied carbon upfront", Accessed: Mar. 18, 2023. [Online]. Available: www.worldgbc.org/embodied-carbon
- [4] R. Giordano, V. Serra, E. Demaria, and A. Duzel, "Embodied Energy Versus Operational Energy in a Nearly Zero Energy Building Case Study," *Energy Procedia*, vol. 111, pp. 367–376, Mar. 2017, doi: 10.1016/J.EGYPRO.2017.03.198.
- [5] E. G. Dascalaki, P. Argiropoulou, C. A. Balaras, K. G. Droutsas, and S. Kontoyiannidis, "Analysis of the embodied energy of construction materials in the life cycle assessment of Hellenic residential buildings," *Energy Build*, vol. 232, p. 110651, Feb. 2021, doi: 10.1016/j.enbuild.2020.110651.
- [6] W. Chen, S. Yang, X. Zhang, N. D. Jordan, and J. Huang, "Embodied energy and carbon emissions of building materials in China," *Build Environ*, vol. 207, Jan. 2022, doi: 10.1016/J.BUILDENV.2021.108434.
- [7] E. W. Frank, H. Dahy, and K. S. Vibæk, "Challenges in creating a sustainable building certificate for single-family housing in Denmark through an Actor-Network Theory (ANT) lens," *Current Research in Environmental Sustainability*, vol. 4, p. 100144, Jan. 2022, doi: 10.1016/J.CRSUST.2022.100144.
- [8] "Nu får familieshuse deres egen DGNB-certificering | Dagens Byggeri." <https://www.dagensbyggeri.dk/artikel/119640-nu-far-enfamilieshuse-deres-egen-dgnb-certificering> (accessed Mar. 20, 2023).
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- [10] "Boligbyggeri fra 4 til 1 planet." <https://www.4til1planet.dk/> (accessed Mar. 30, 2023).
- [11] "National strategi for bæredygtigt byggeri," 2021.
- [12] L. Horup *et al.*, "Aalborg Universitet Towards embodied carbon benchmarks for buildings in Europe #3 Defining budget-based targets: A top-down approach (updated version 1.1) Towards embodied carbon benchmarks for buildings in Europe #3 Defining budget-based targets: A top-down approach Towards embodied carbon benchmarks for buildings in Europe #3 Defining budget-based targets: A top-down approach Disclaimer", doi: 10.5281/zenodo.6411884.
- [13] "Byggeriets klimaanalyse - katalog over de vigtigste fokusområder for en accelereret grøn omstilling af byggeriet | CONCITO." <https://concito.dk/udgivelser/byggeriets-klimaanalyse-katalog-over-vigtigste-fokusomraader-accelereret-groen> (accessed Sep. 04, 2023).
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- [15] H. Birgisdóttir, Tilgængelighed og betydning af EPD'ER - BUILD rapport. Build, 2021.
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State of the art/ litteratur review

Stor fokus på CO₂-udledninger fra

- den samlede bygning,
- de enkelte bygningsdele
- materialerne

Manglede fokus om hvordan

- nye konstruktionsopbygninger etableres
- disse konstruktionsopbygninger sammen bygges.
- fra bygningsdrift

State of the art/ litteratur review

Kompetencer og holdninger

- Små og mellemstore virksomheder mangler ressourcer til at opbygge viden om, hvordan LCA bedst håndteres
- Bygningsreglementet ændres til at regulere boligstørrelsen

Forskningsspørgsmål

- Kan den danske parcelhusarkitektur bevares med de nye og kommende krav til grænseværdier for CO₂?
- Hvordan optimeres konstruktionsopbygningen i forhold til klimabelastning?

Formål

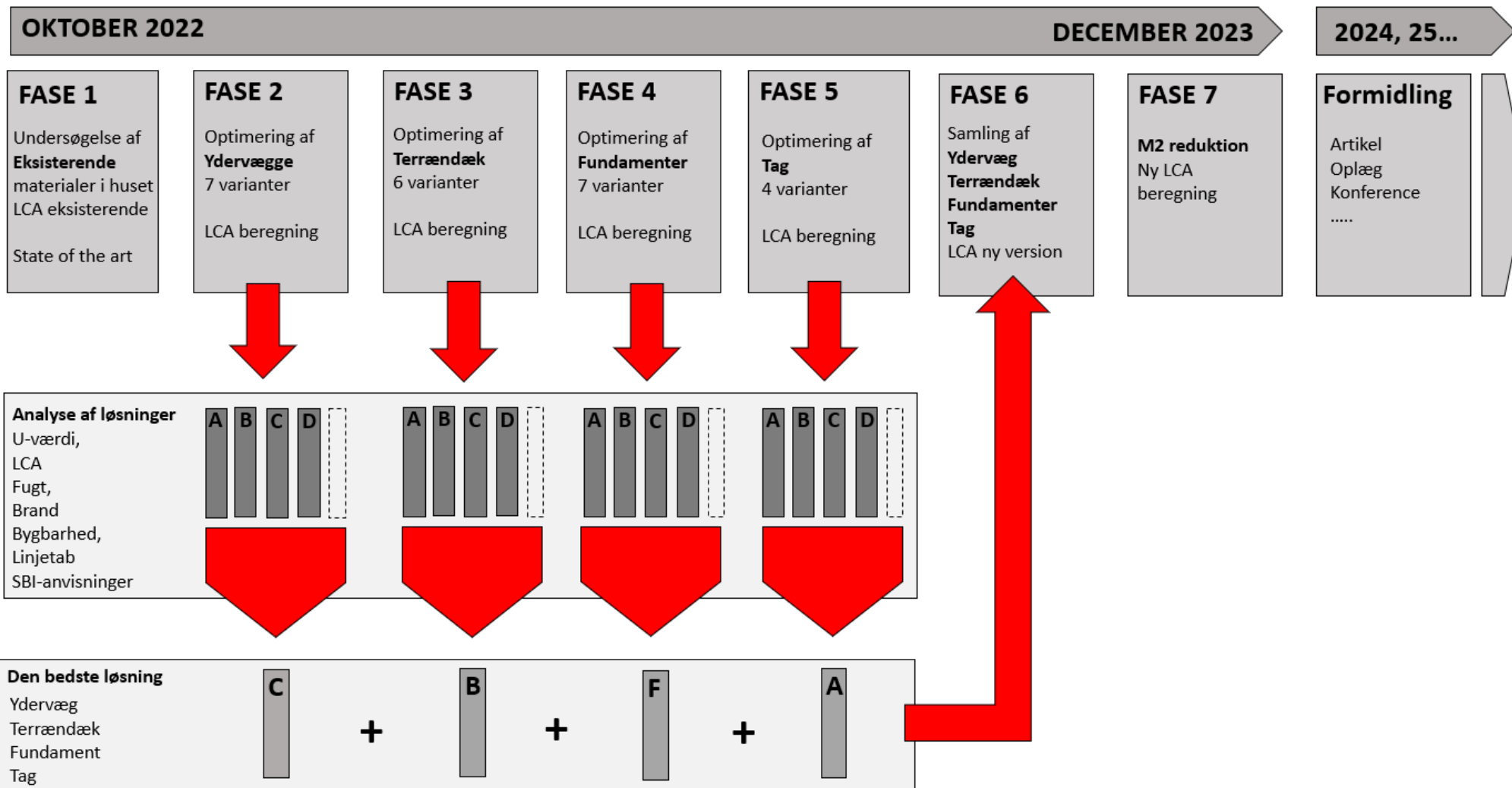
- Guideline for SMV'er for udførende, rådgivere og studerende

Afgrænsning

- Primært generiske data for EPD'er
- Økonomi
- Statiske beregninger
- Linjetab ikke beregnet på alle fundamenter
- Materialerne er ikke nødvendigvis produkter som kan købes i dag

Forskningsdesign

REDSKAB TIL VALG AF KLIMAVENTLIGE KONSTRUKTIONER

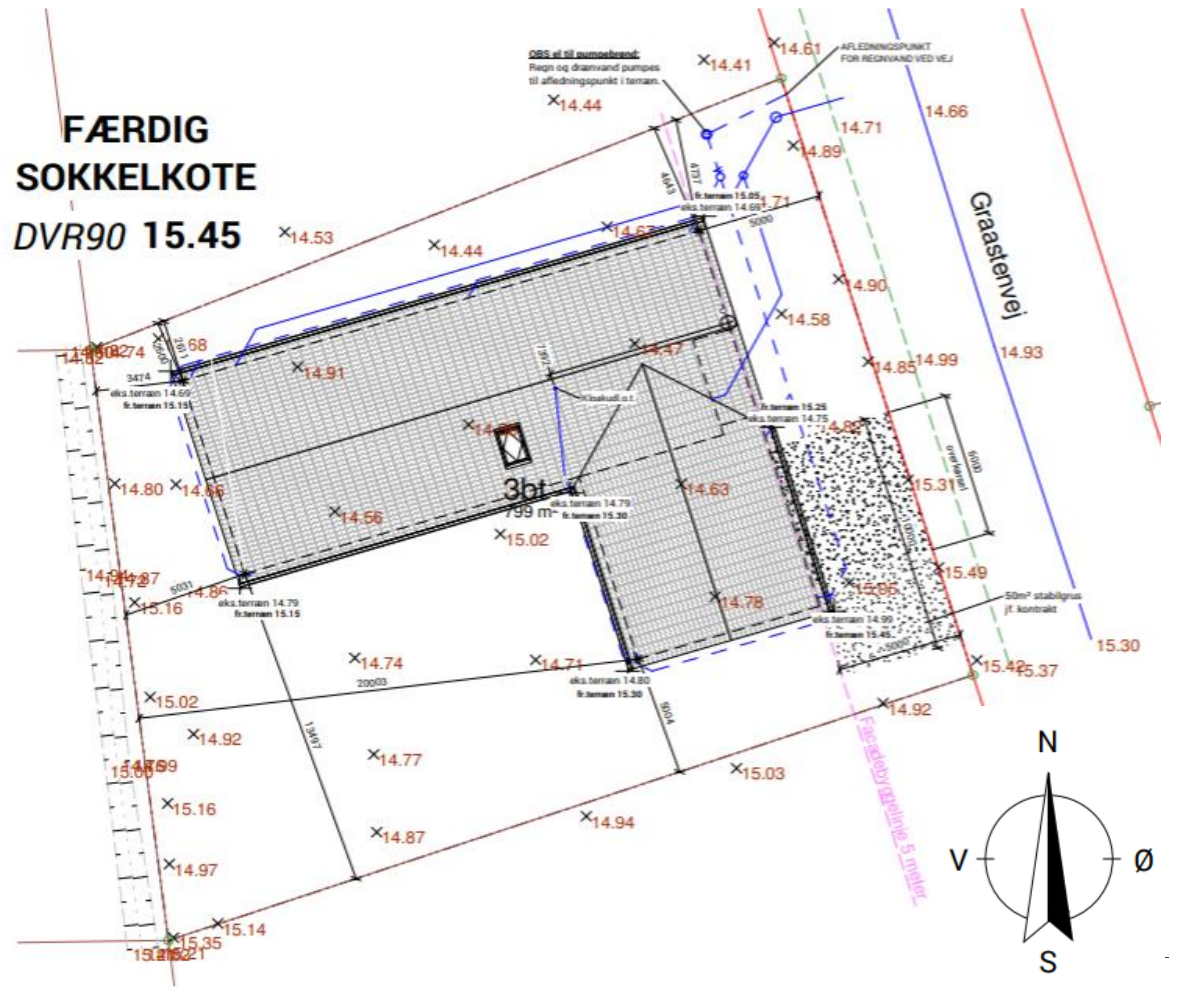


Referencehus

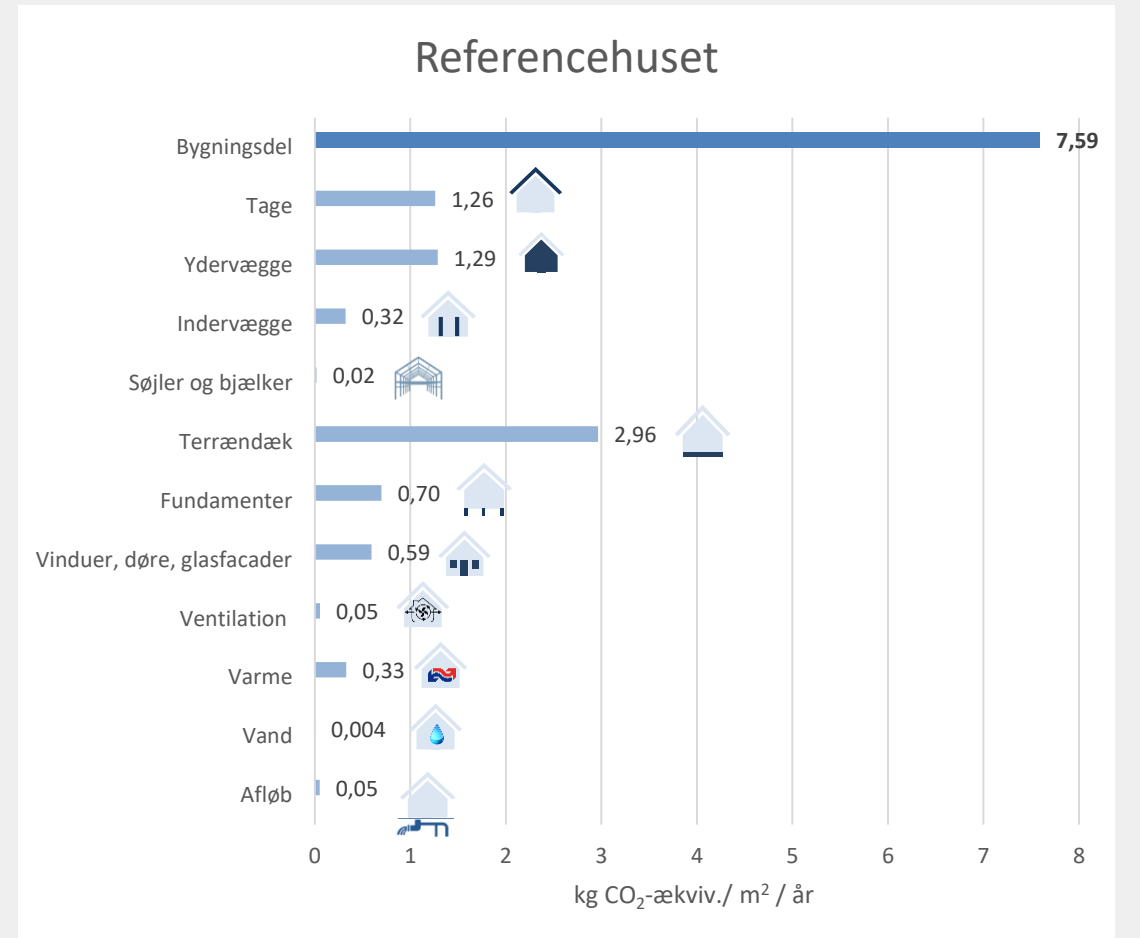
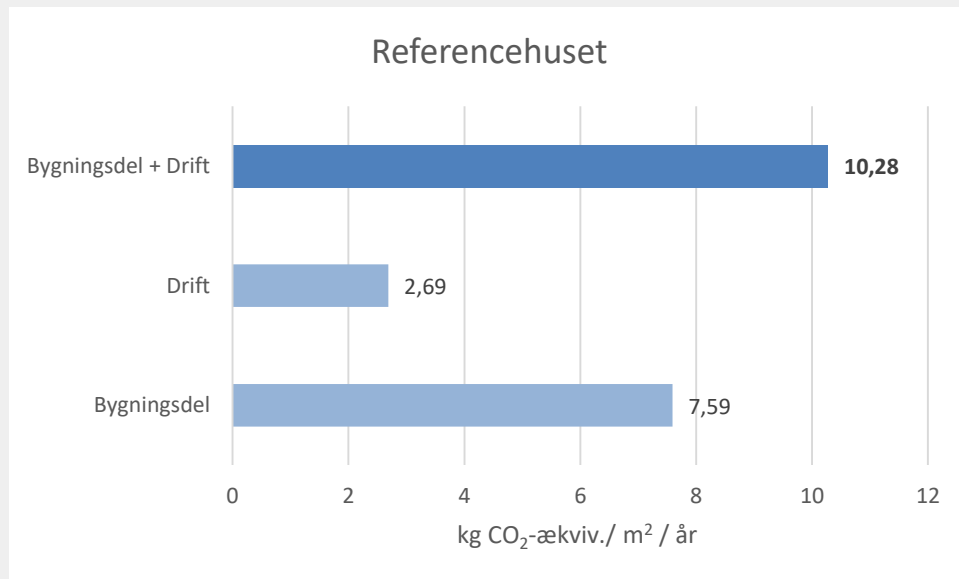


5.80 m*

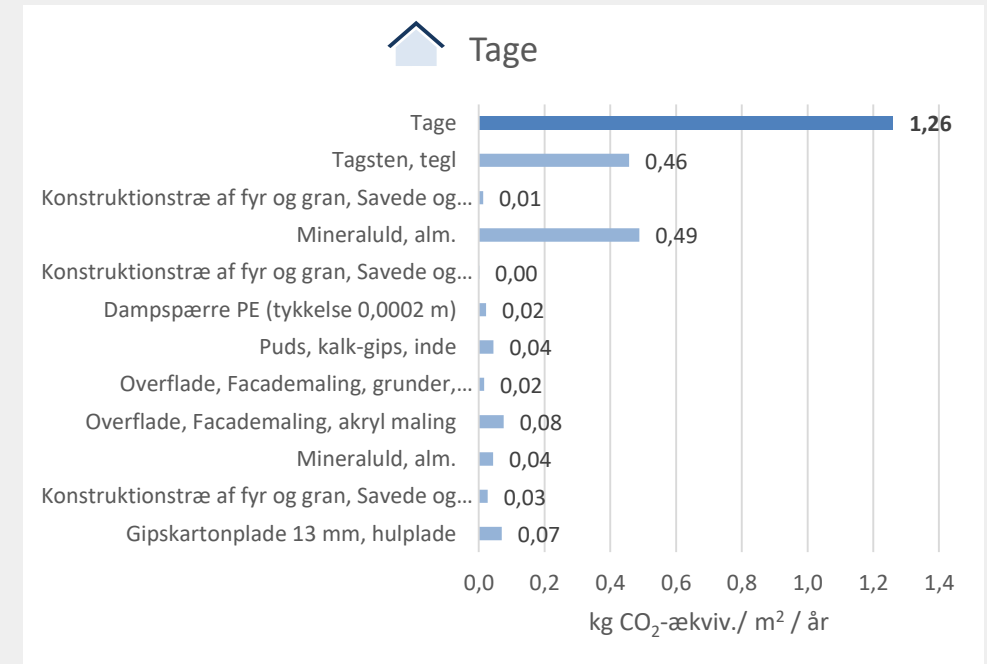
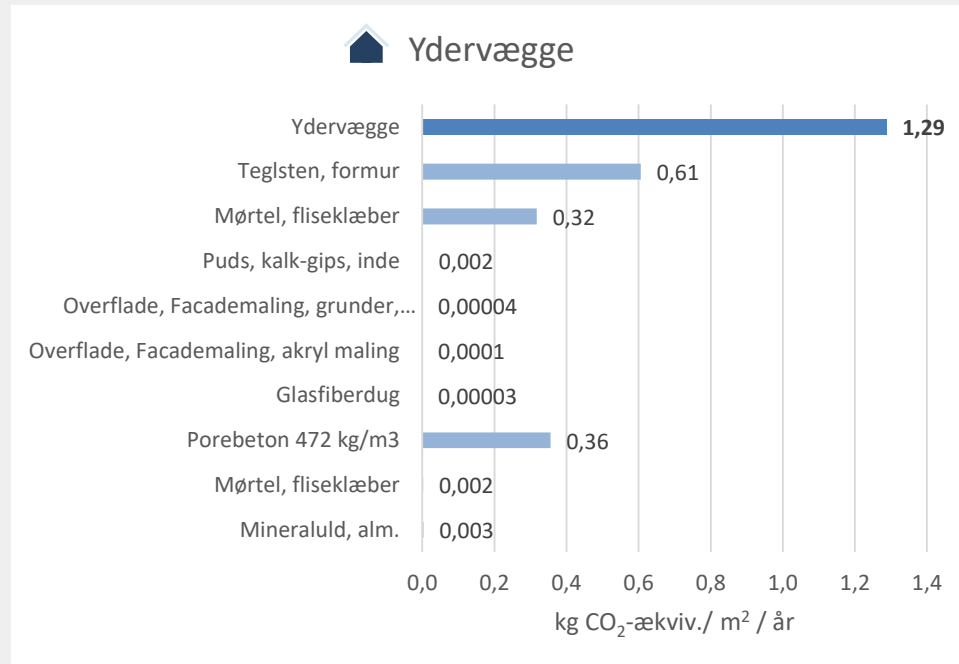
**FÆRDIG
SOKKELKOTE
DVR90 15.45**



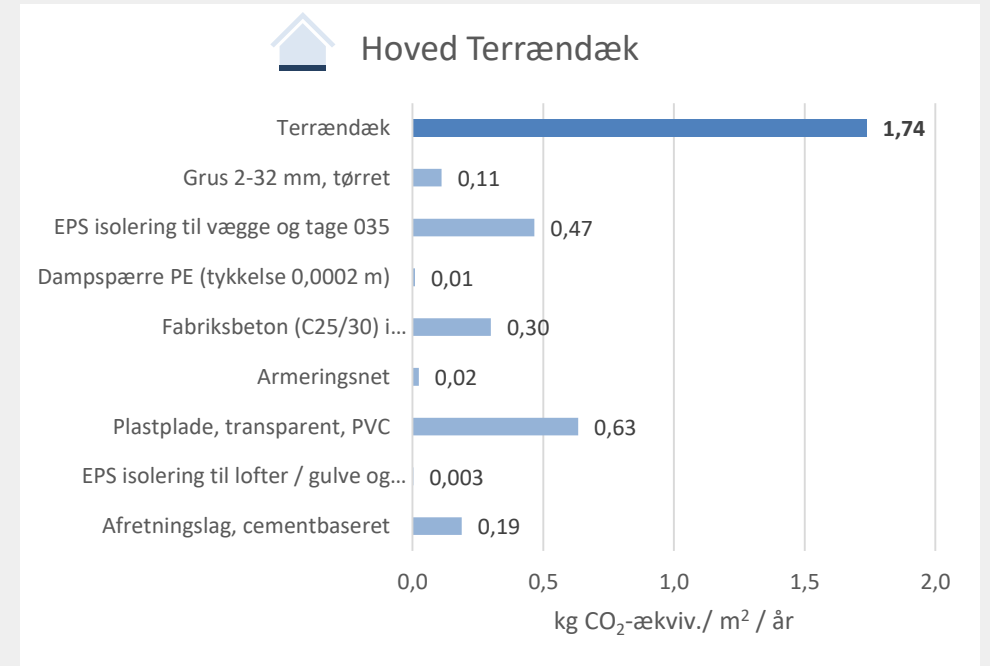
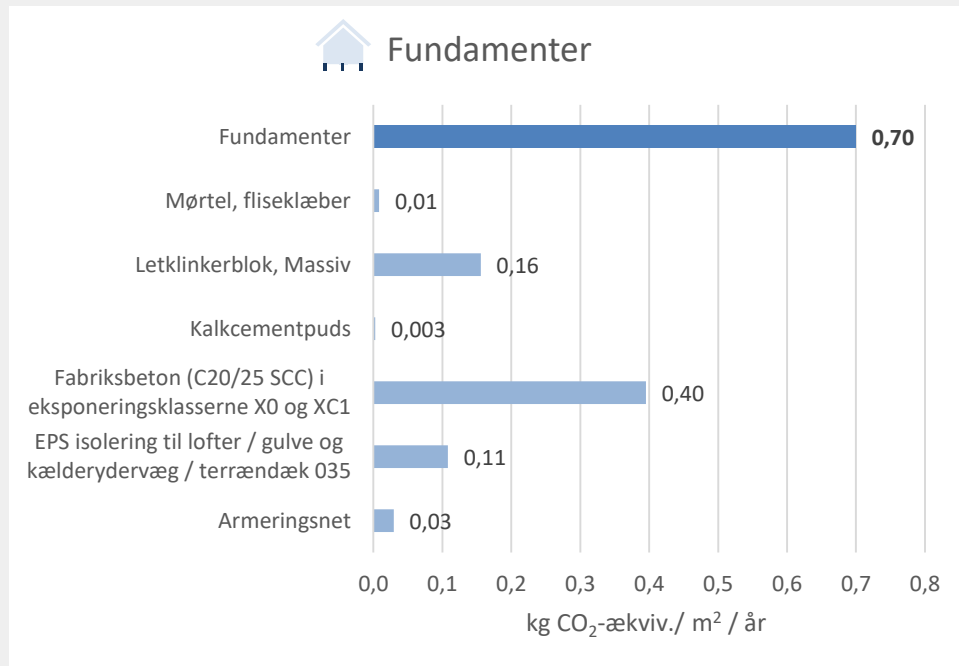
Fase1 – Referencehus LCA-Bygningsniveau



Fase1 – Referencehus LCA-Materialeniveau



Fase1 – Referencehus LCA-Materialeniveau

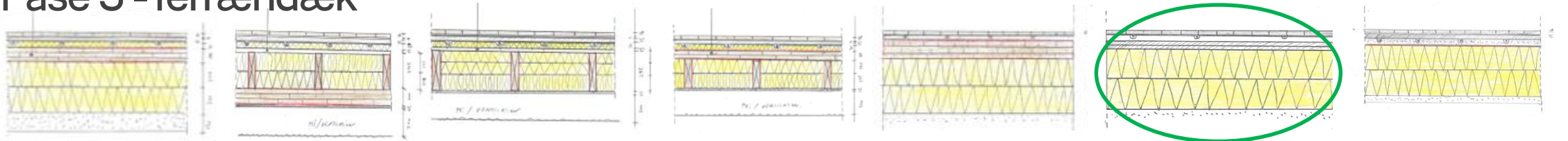


Fase 2-5 Alternative konstruktioner

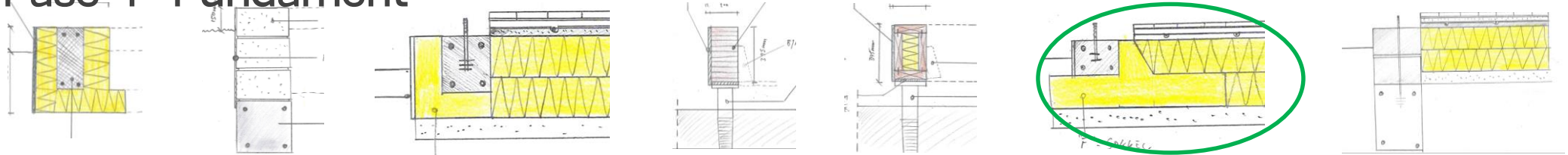
Fase 2 - Ydervæg



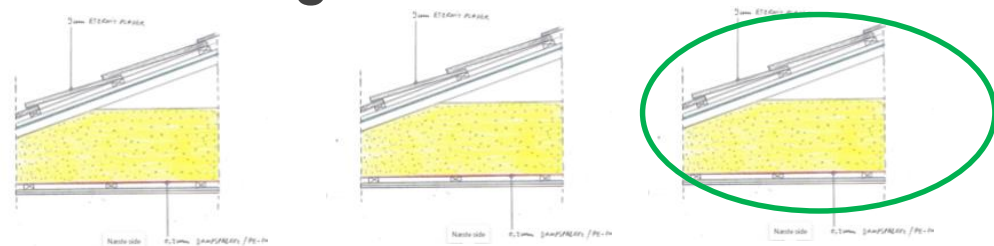
Fase 3 - Terrændæk



Fase 4 - Fundament

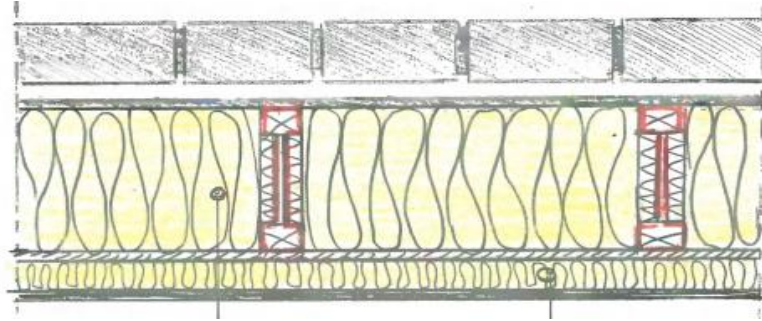


Fase 5 - Tag



Fase 2 - Ydervægge

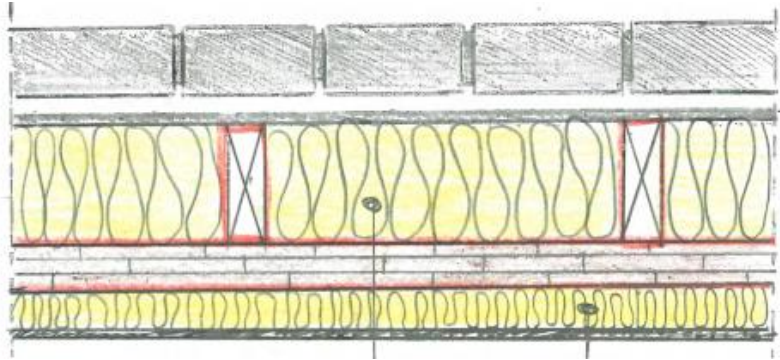
B



428 mm

108 mm mursten
30 mm
mellemrum
(ventilation)
9 mm windpanel
240 x 45 I-bjælke
+ isolering
15 OSB-plade
45 mm forskalling
+ isolering
12 mm gipsplade

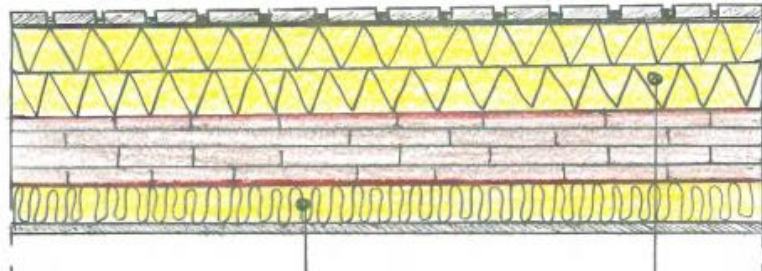
E



462 mm

108 mm mursten
30 mm mellemrum (ventilation)
9 mm windpanel
170x45 mm stolper + isolering
60 mm CLT
45 mm forskalling + isolering
12 mm gipsplade

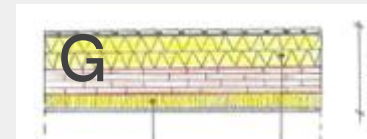
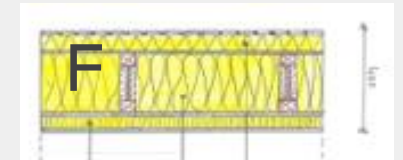
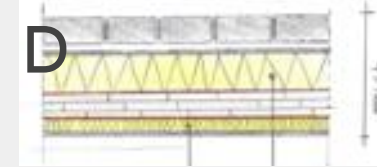
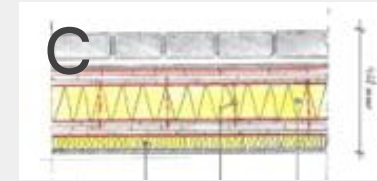
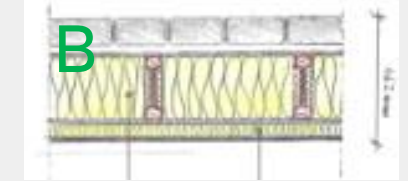
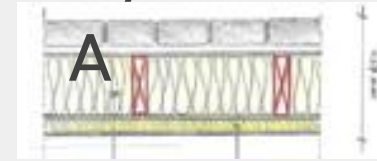
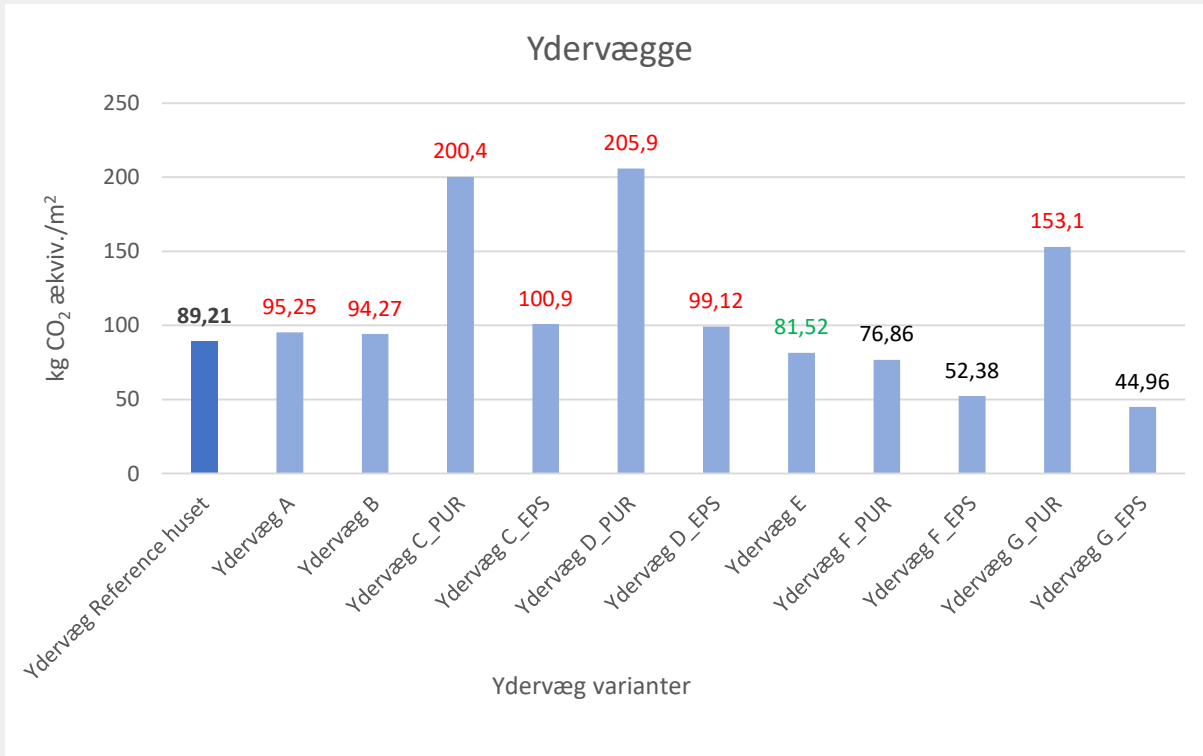
G



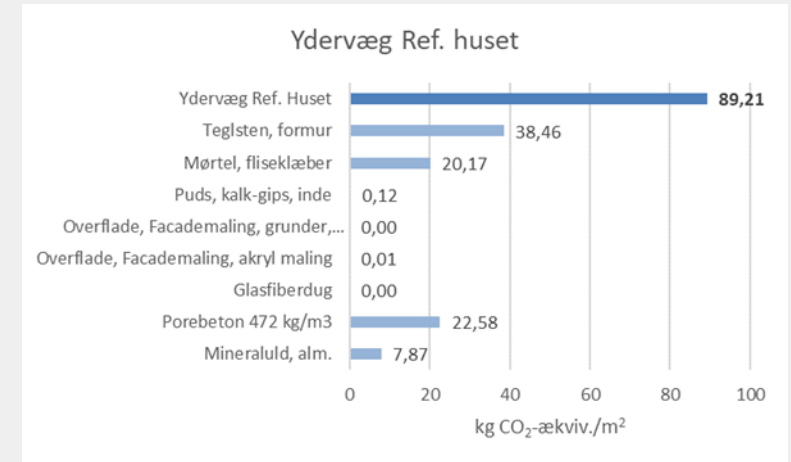
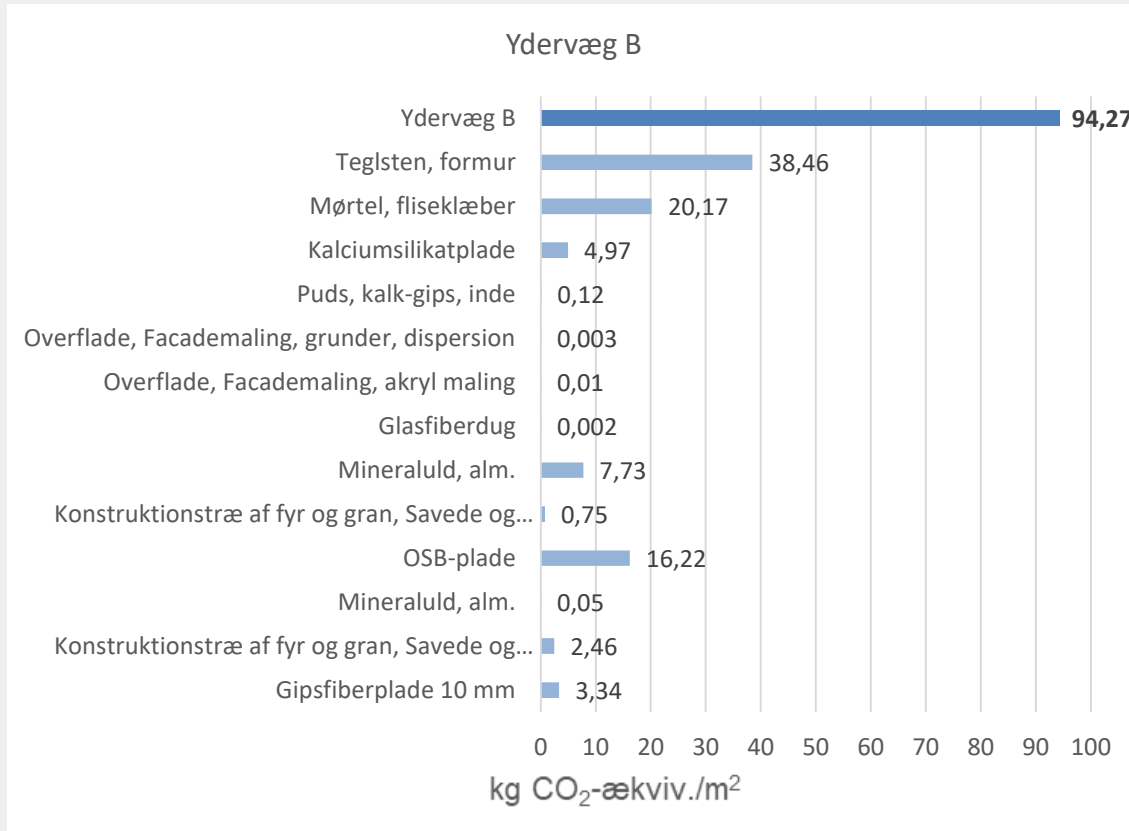
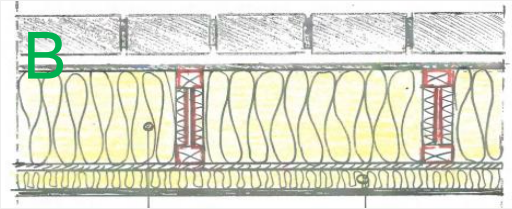
297 mm

20 mm murstenskaller
60 mm PUR-isolering
60 mm PUR-isolering
100 mm CLT
45 mm forskalling + isolering
12 mm gipsplade

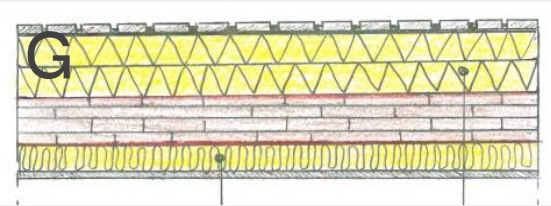
Fase 2 - Ydervægge- Klimaaftryk



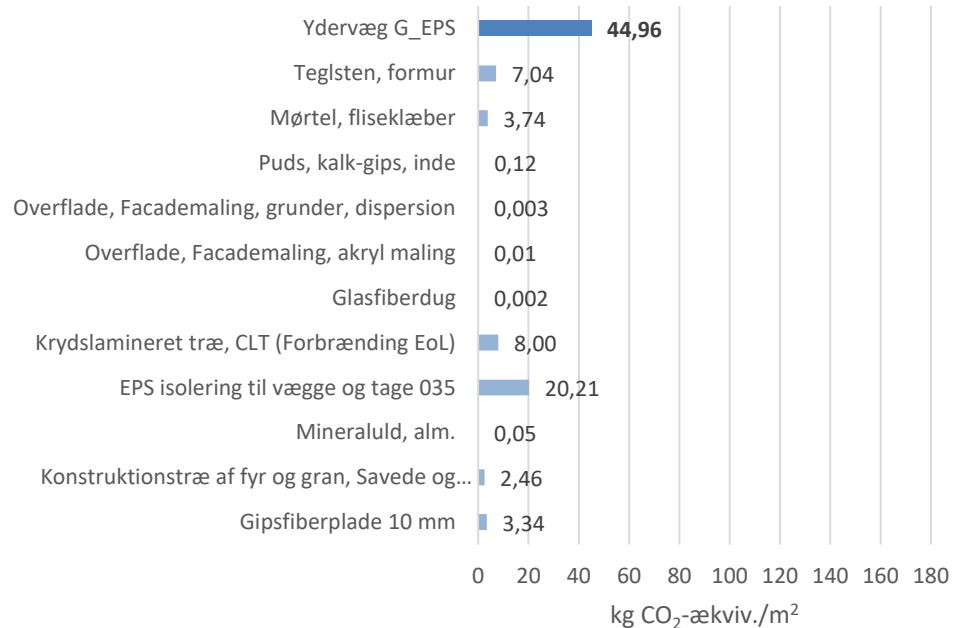
Fase 2 - Ydervægge B - materialeniveau



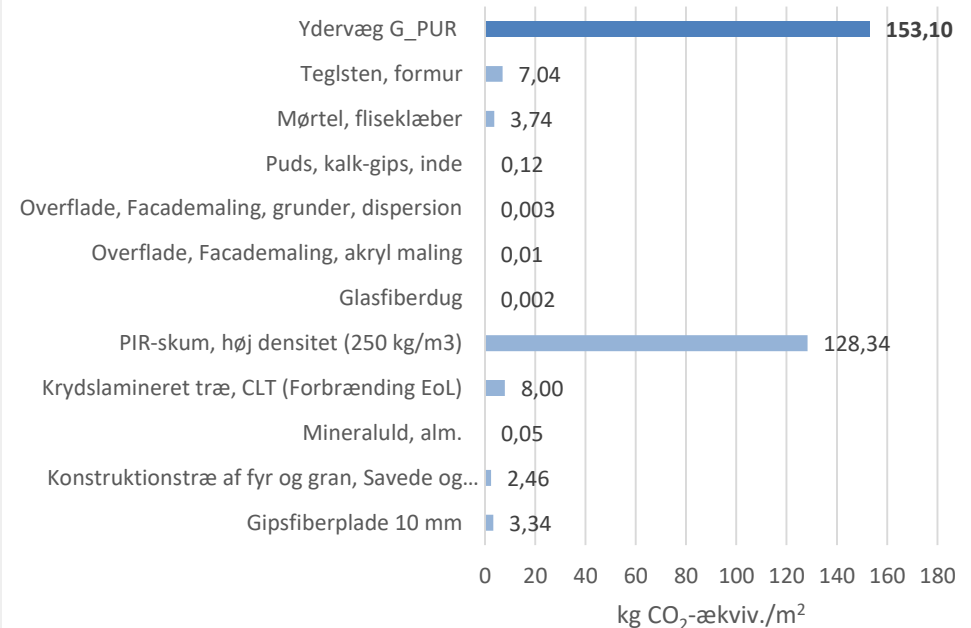
Fase 2 - Ydervægge G – materialeniveau



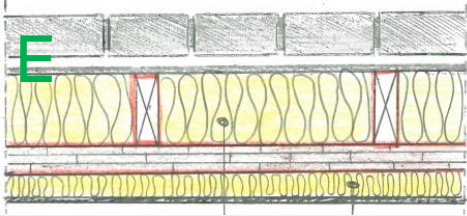
Ydervæg G_EPS



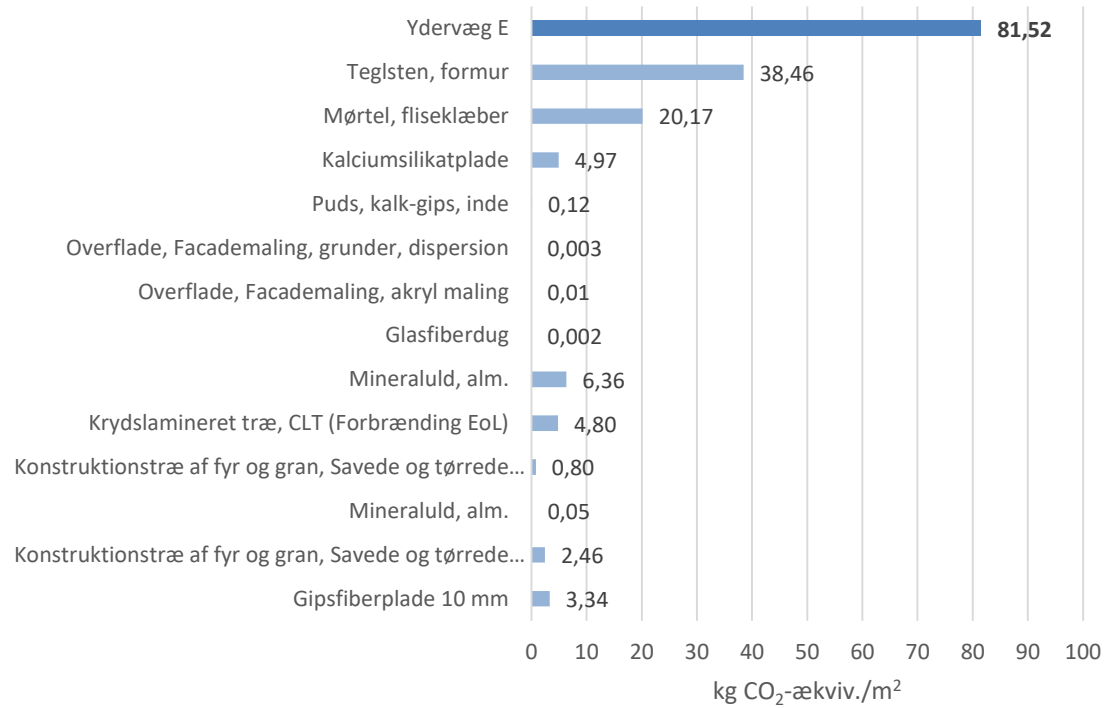
Ydervæg G_PUR



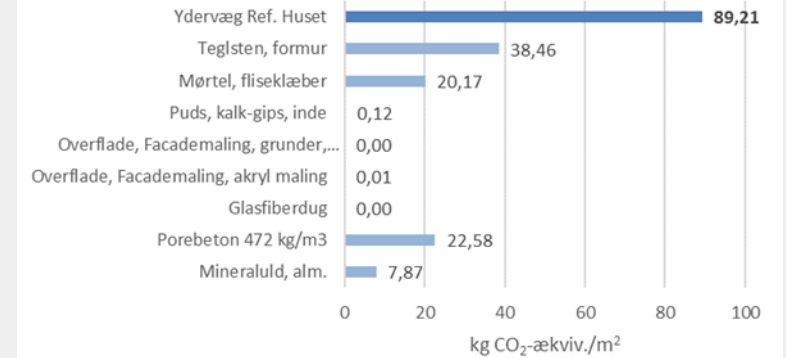
Fase 2 - Ydervægge E - materialeniveau



Ydervæg E

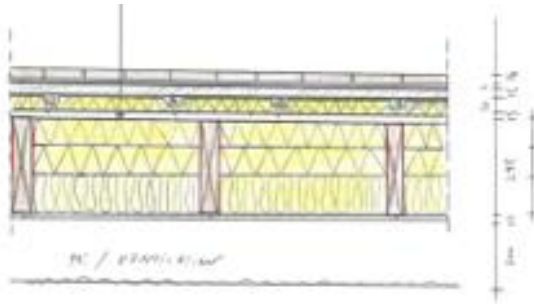


Ydervæg Ref. huset



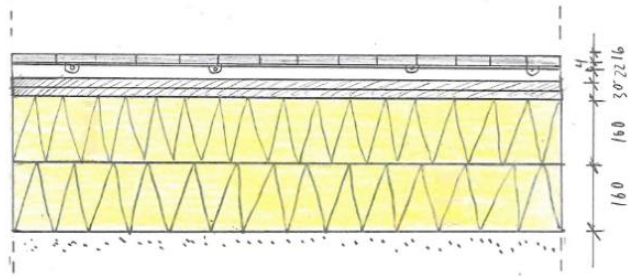
Fase 2 - Terrændæk

B



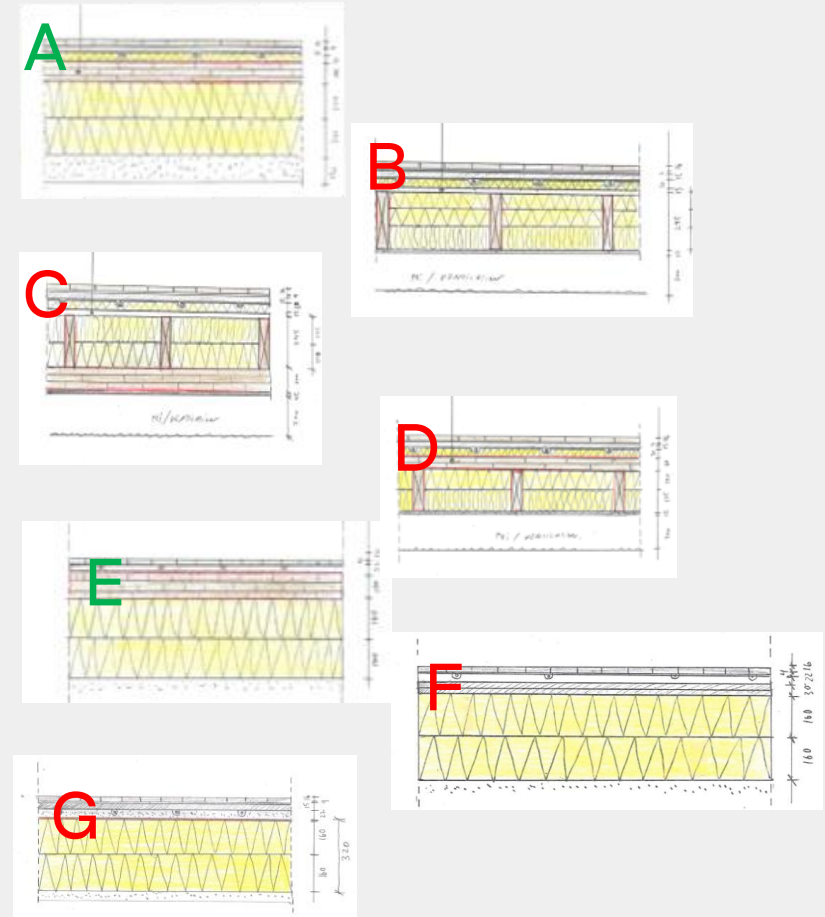
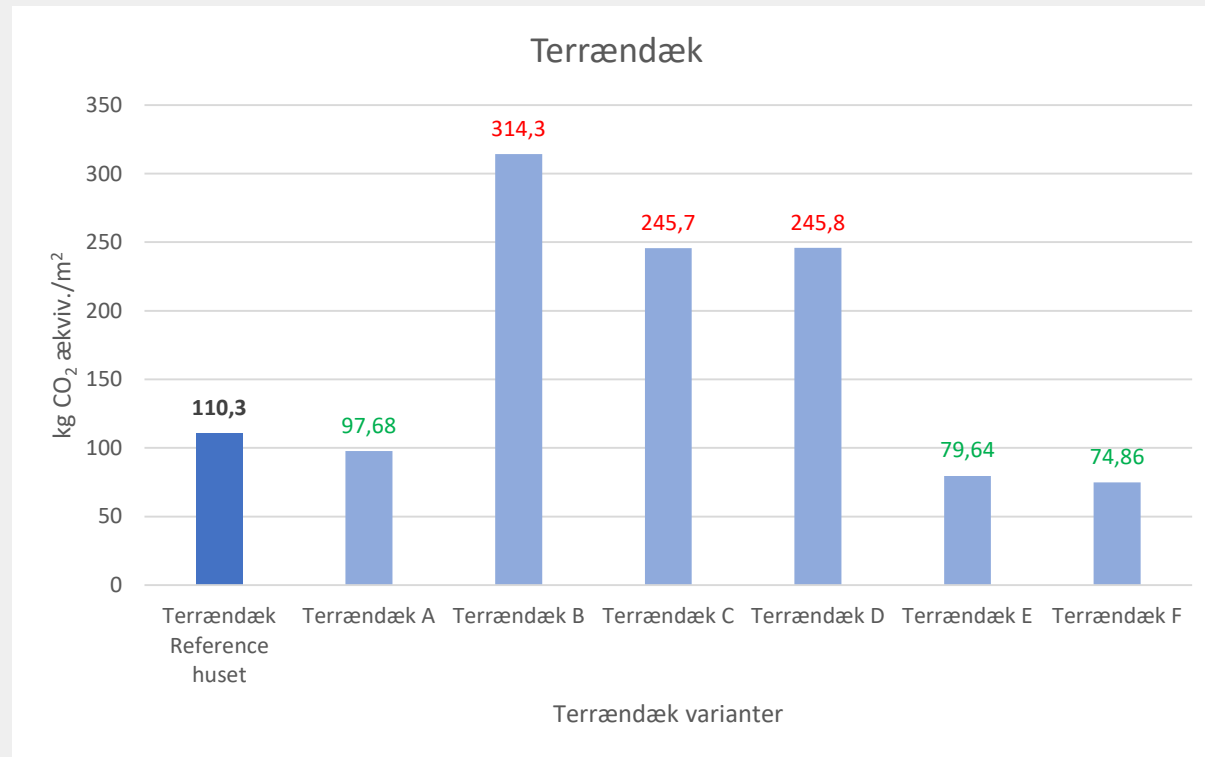
16 mm trægulv
4 mm trinlydslag
13 mm fermacell (limet)
30 mm EPS-gulvvarmeplader
15 mm OBS/4plade
245x45 mm Bjælker
80 mm PUR 0.022
80 mm PUR 0.022
125 mm iso 0,03
12 mm Amroc plade

F



16 mm trægulv
4 mm trinlydslag
22 mm Novopan klimagulv
2x15 mm fermacell
320 mm EPS (2x160)/0,032
Afretning

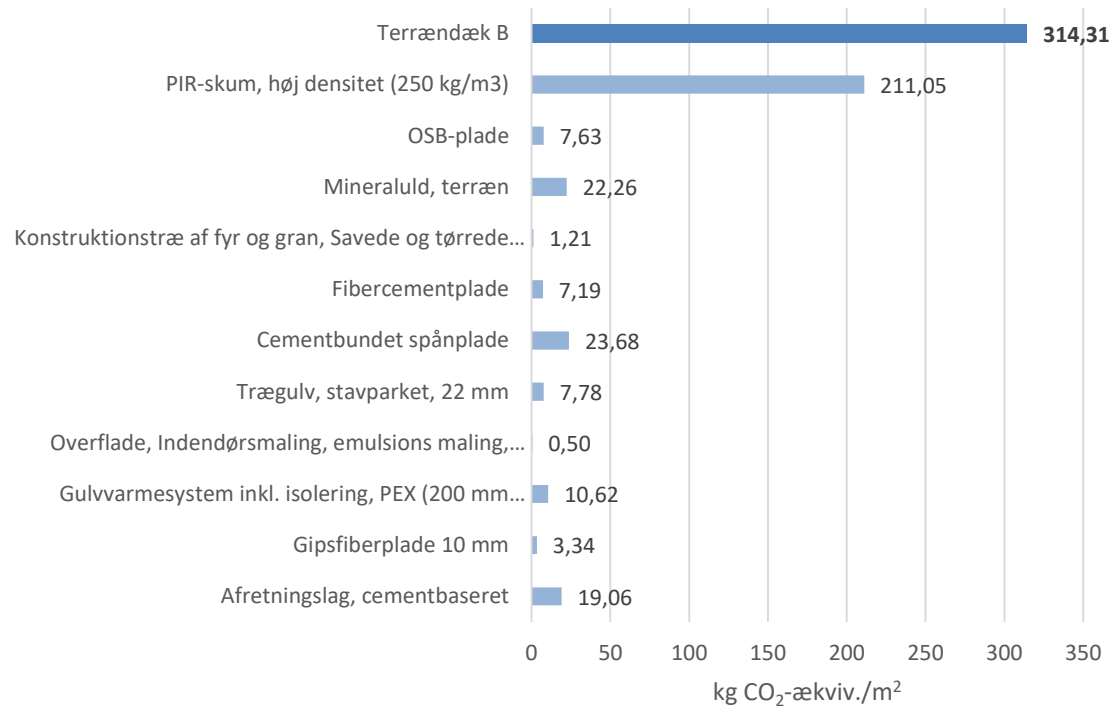
Fase 3 - Terrændæk- Klimaaftryk



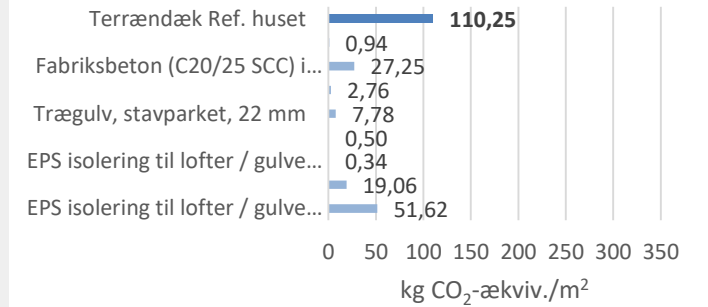
Fase 3 - Terrændæk B - materialeniveau



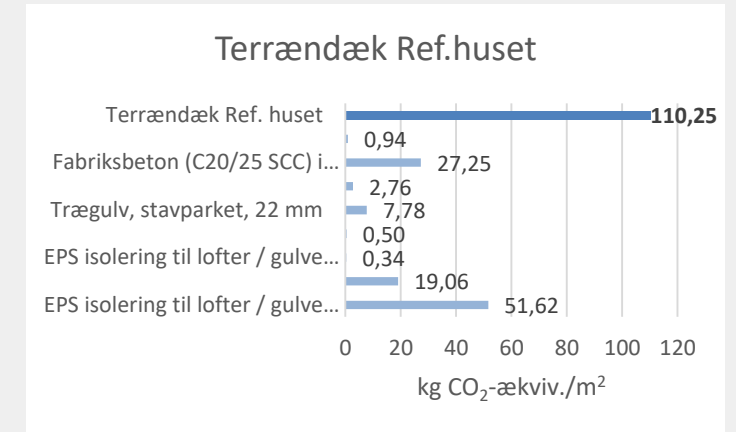
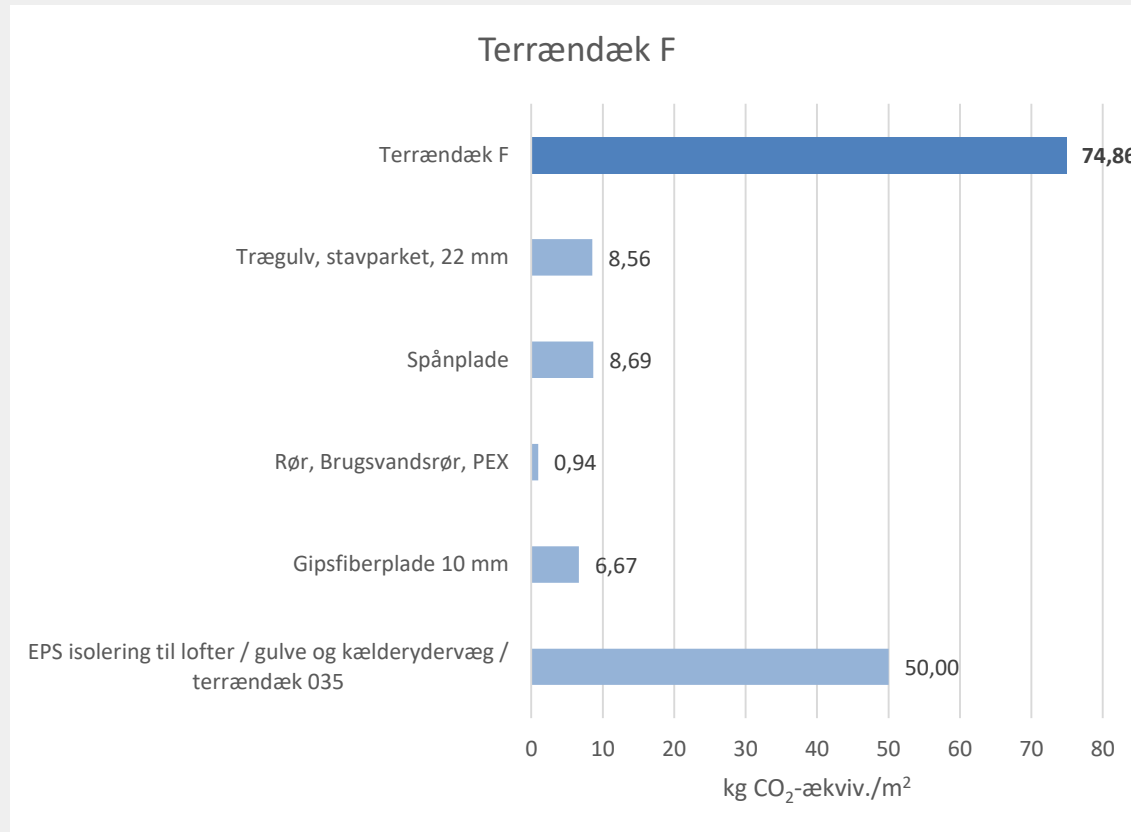
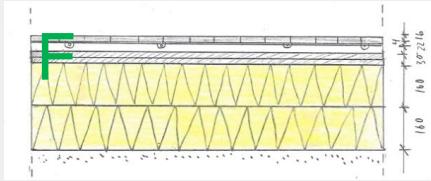
Terrændæk B



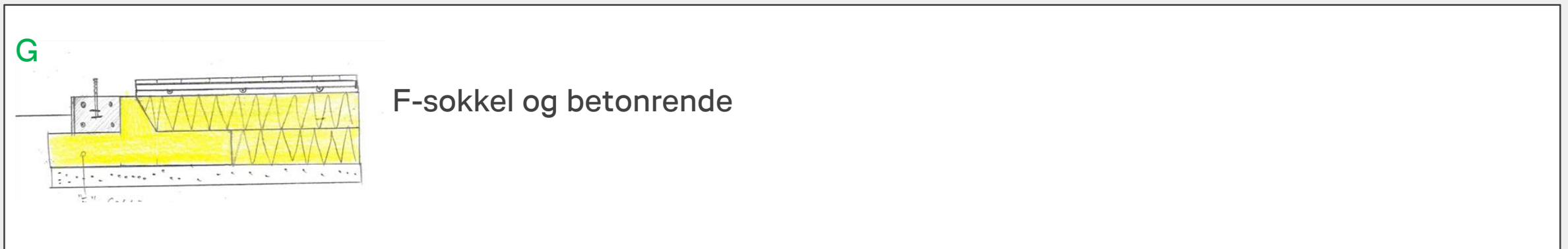
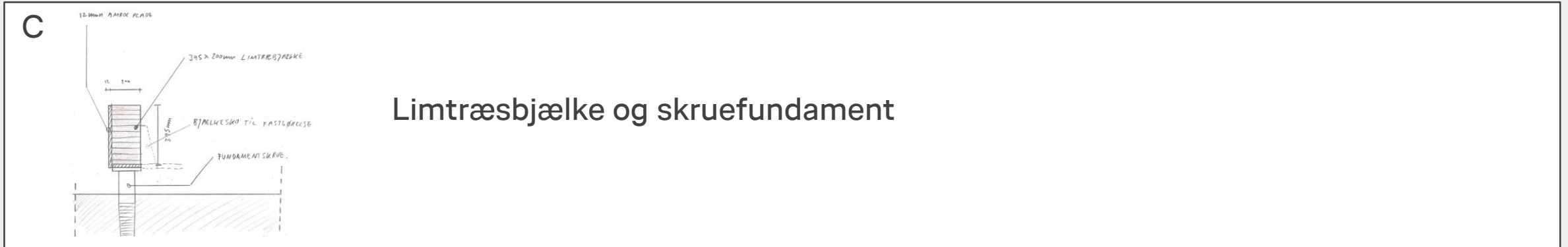
Terrændæk Ref.huset



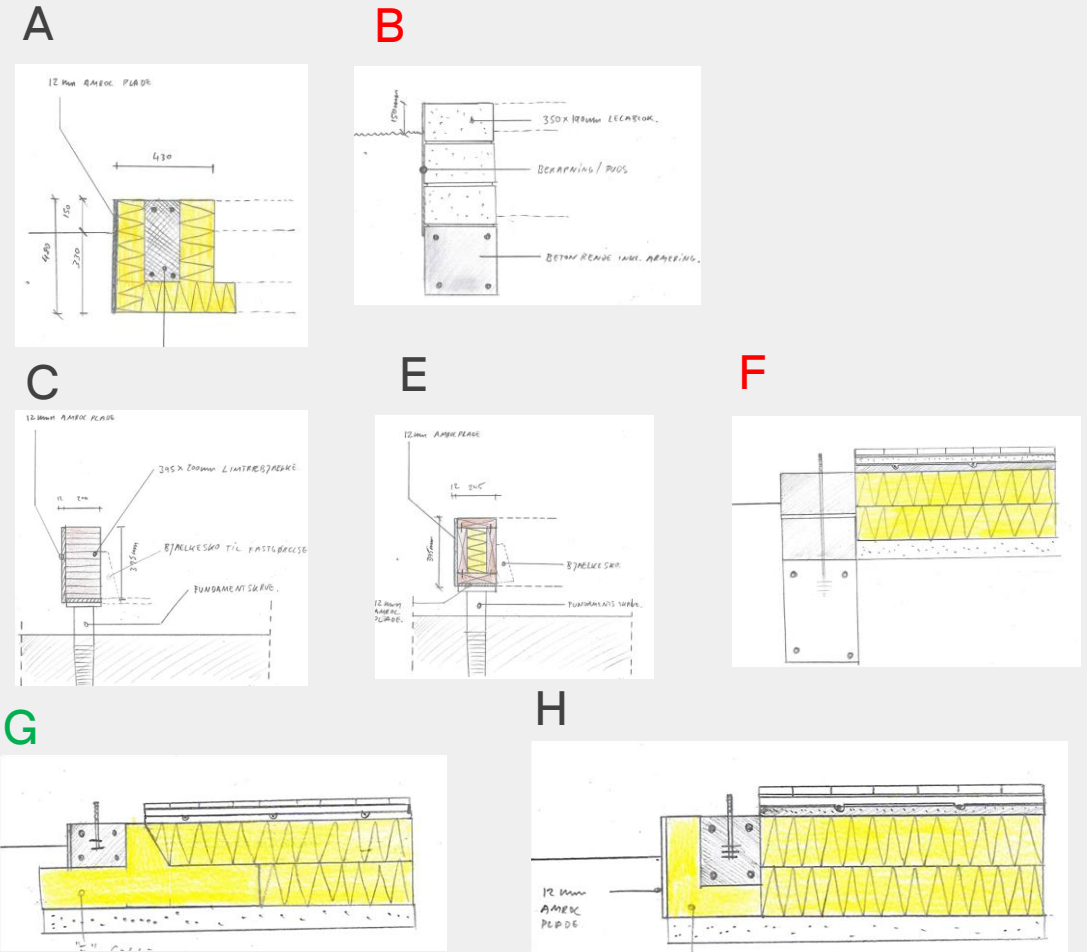
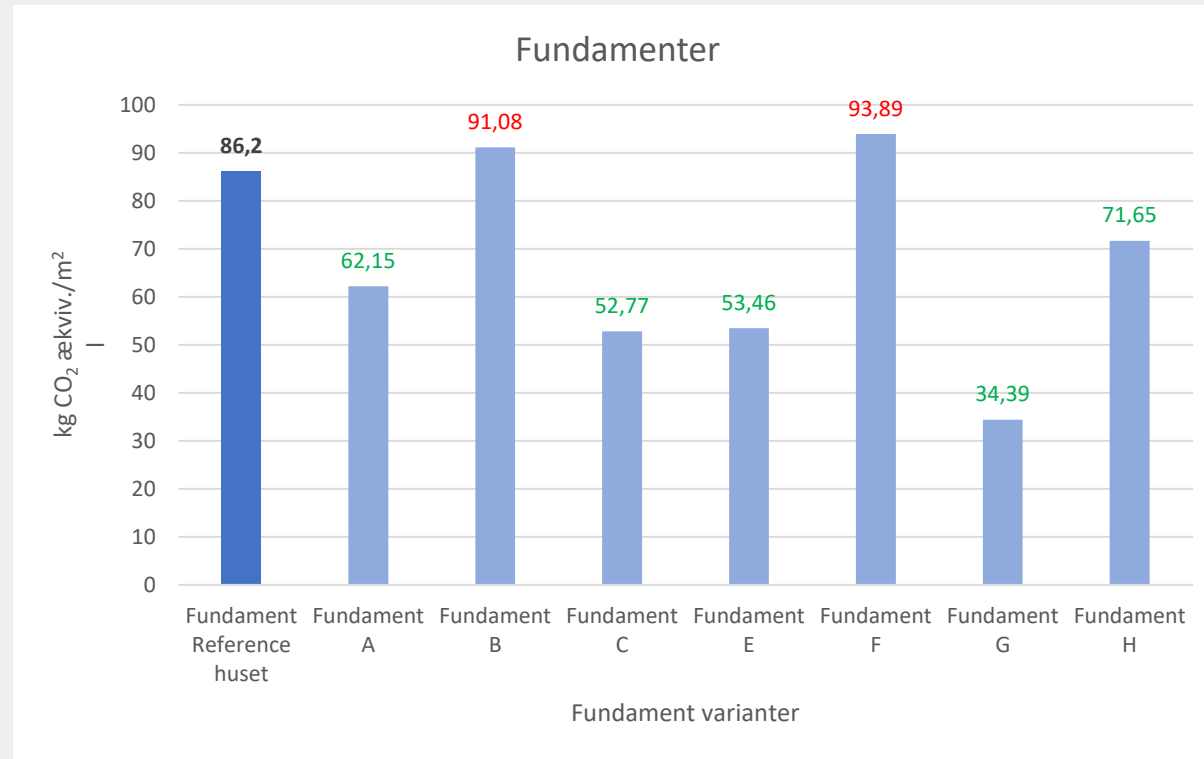
Fase 3 – Terrændæk F - materialeniveau



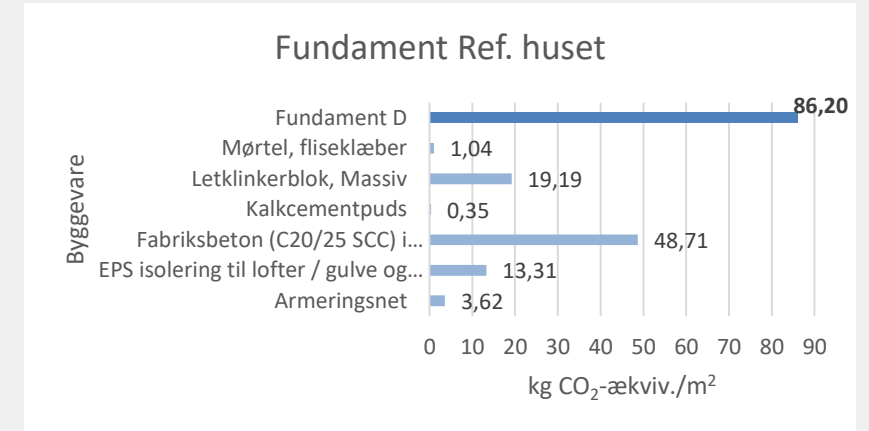
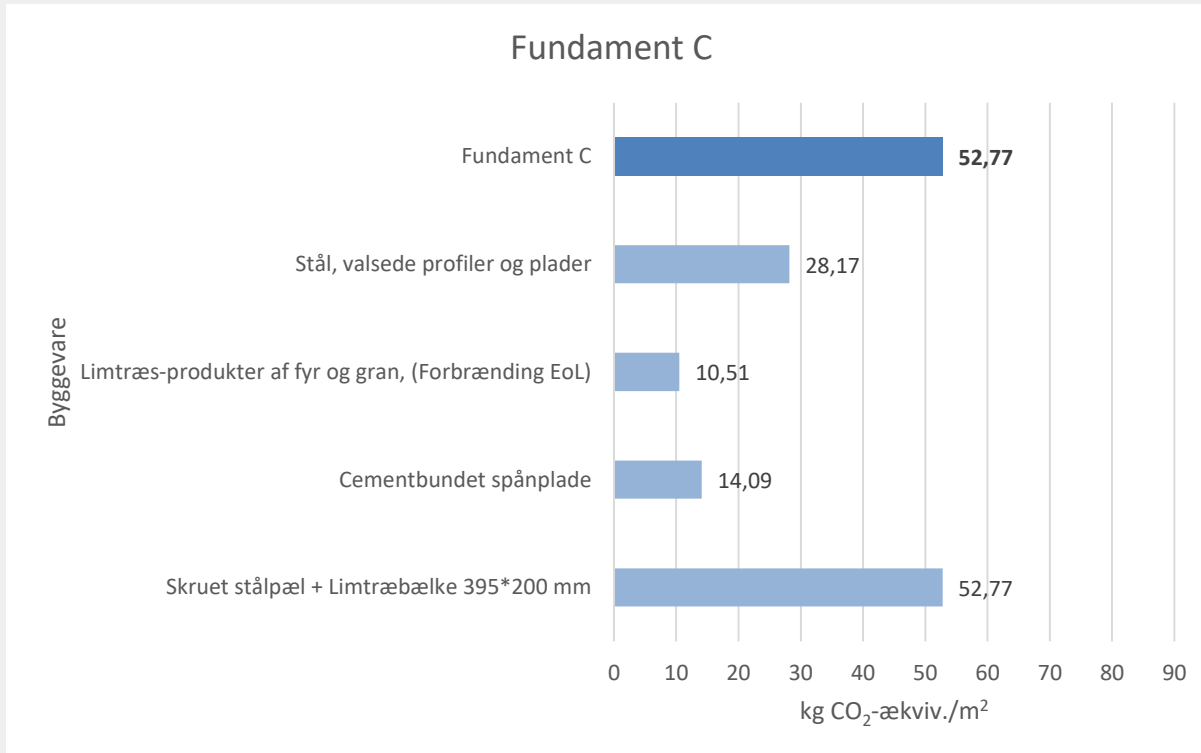
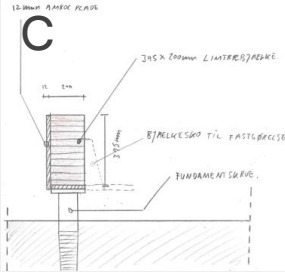
Fase 4 – Fundament



Fase 4 Fundament

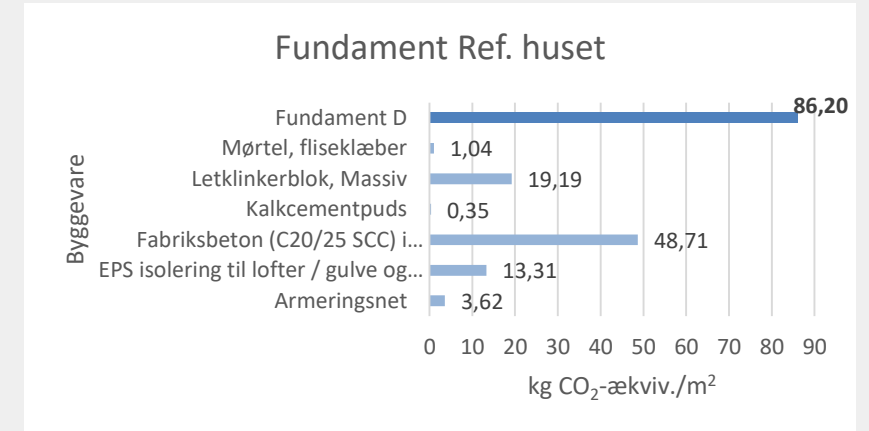
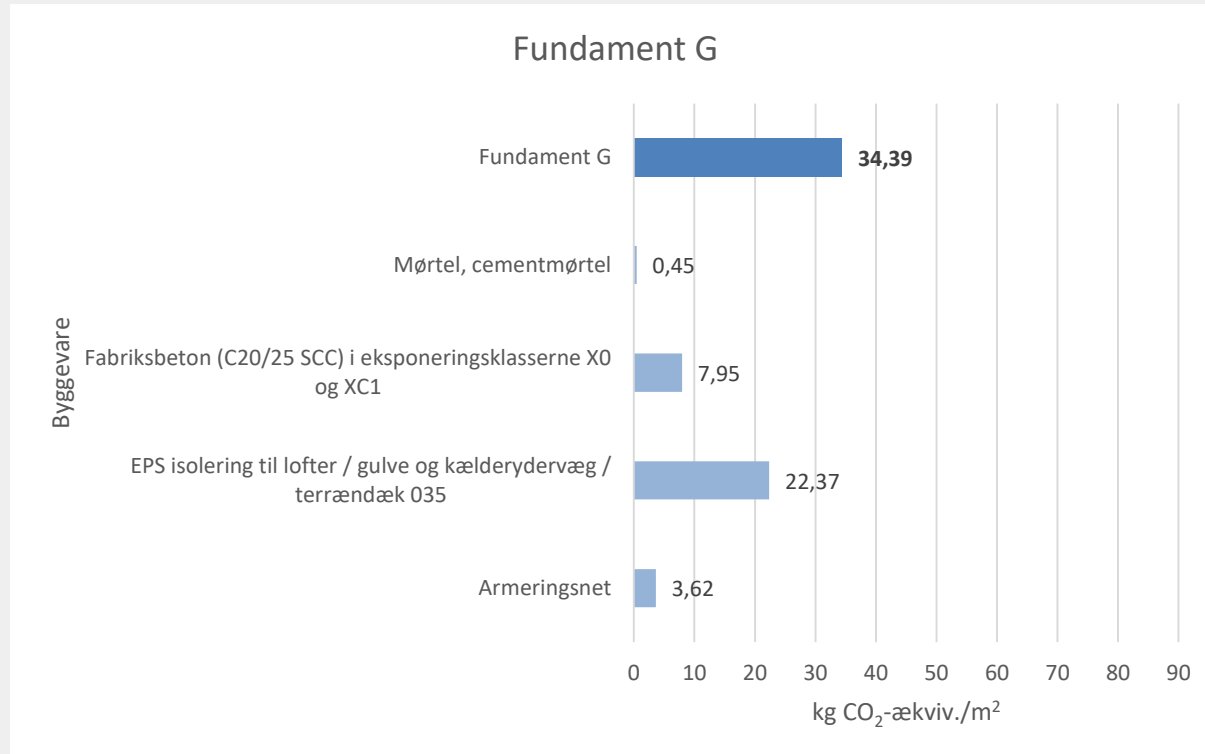
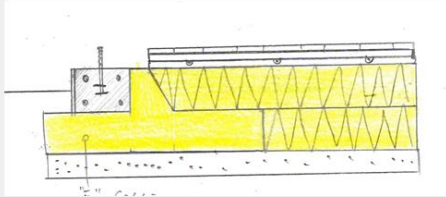


Fase 4 – Fundament C - materialeniveau

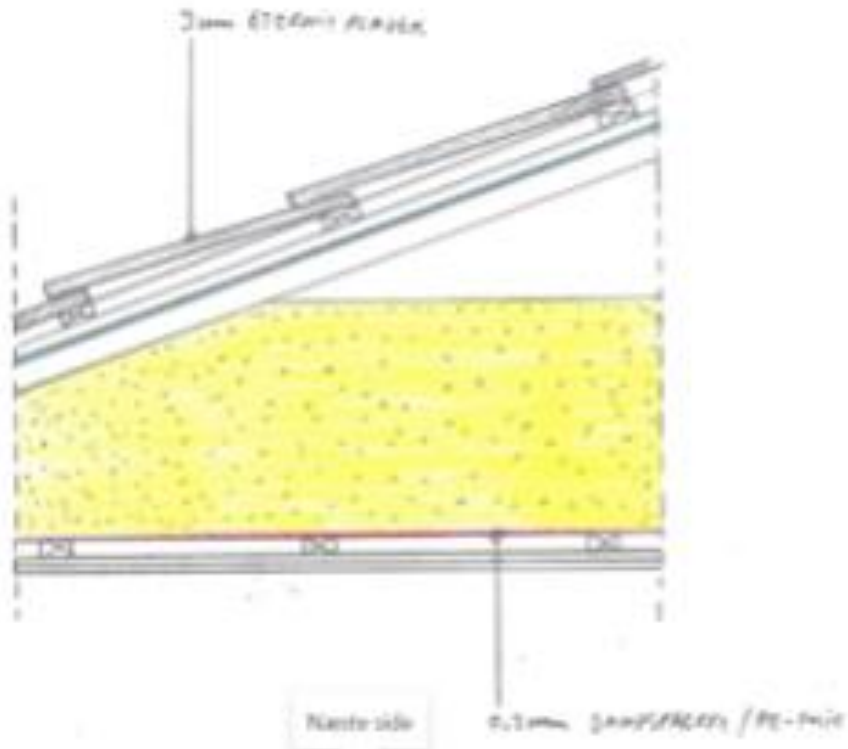


Fase 4 – Fundament G - materialeniveau

G



Fase 5 - Tagkonstruktion



Opbygning af tagkonstruktion

Materialer der undersøges:

Tagbelægning

Stål

Eternitplader

Betontagsten

Tagpap

Skifer

Isoleringsmateriale

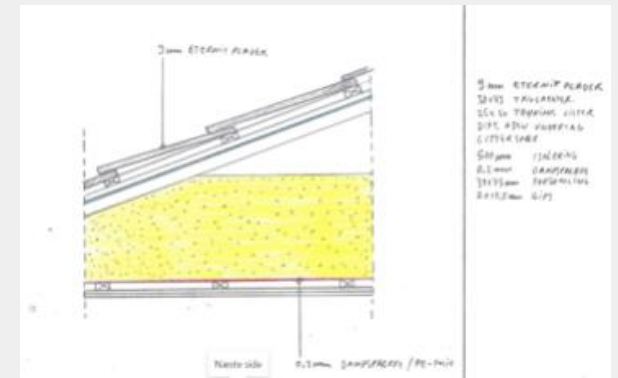
Mineraluld

Træfiber

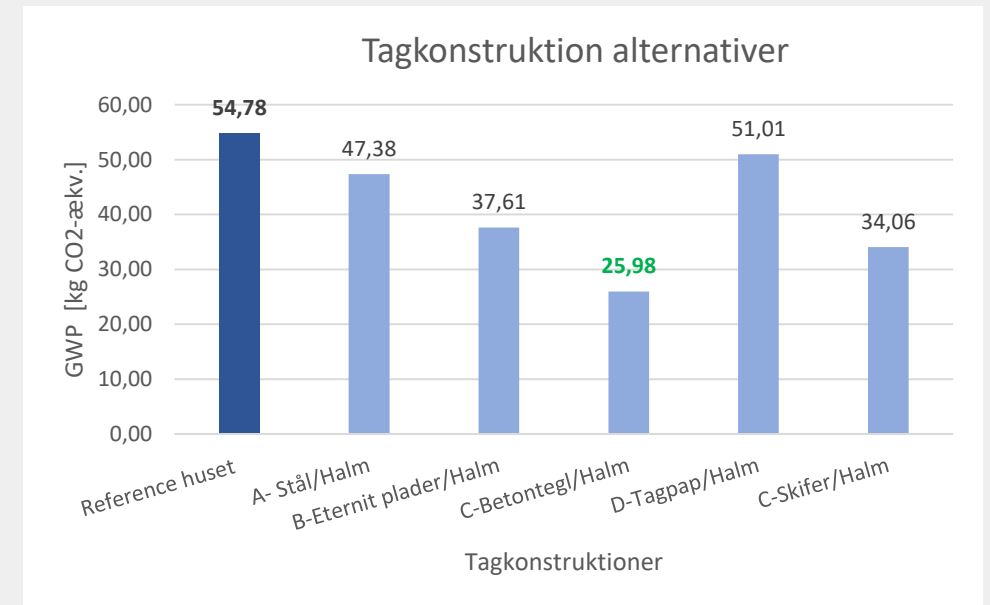
Papir

Halm

Fase 5 - Tagkonstruktion

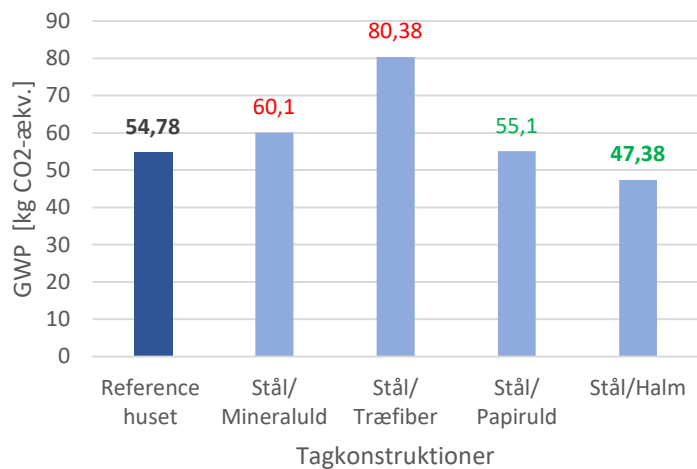


Tag/loft	Fugt problemer	Tagbelægning	Mineraluld [mm] GWP [CO2eq/m2]	Træfiber [mm] GWP [CO2eq/m2]	Papir [mm] GWP [CO2eq/m2]	Halm [mm] GWP [CO2eq/m2]
Reference huset	Nej	Tegl	495 54,78			
A	Nej	Stål	395 60,10	445 80,38	445 55,10	550 47,38
B	Nej	Eternit plader	395 50,34	445 70,62	445 45,33	545 37,61
C	Nej	Betontegl	395 38,70	445 58,99	445 33,70	545 25,98
D	Nej	Tagpap	395 63,73	445 84,02	445 58,73	545 51,01
E	Nej	Skifer	395 46,78	445 67,06	445 41,77	545 34,06

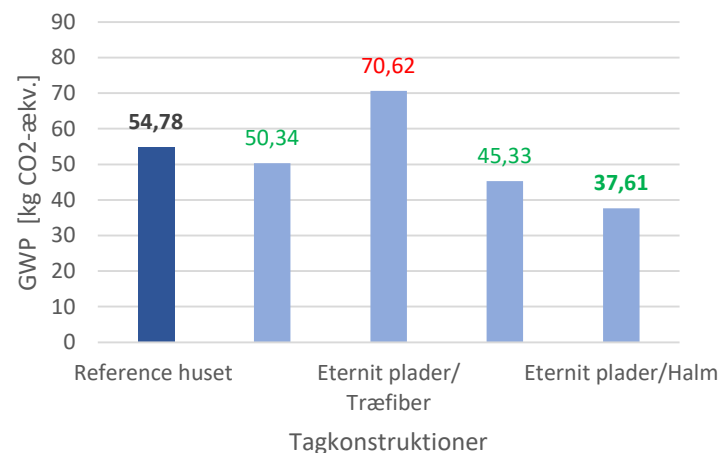


Fase 5 - Tagkonstruktion

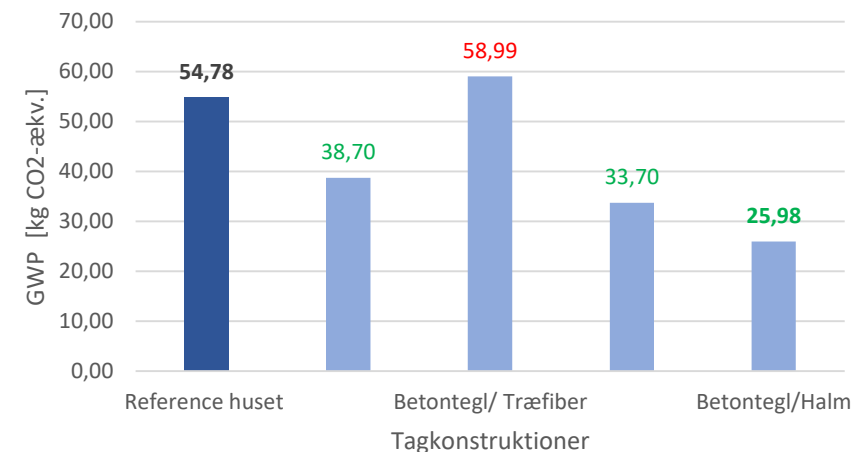
Tagkonstruktion A- Stål



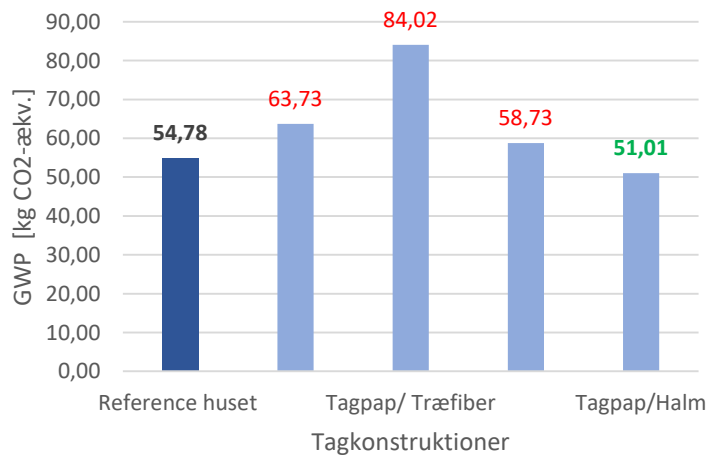
Tagkonstruktion B- Eternit plader



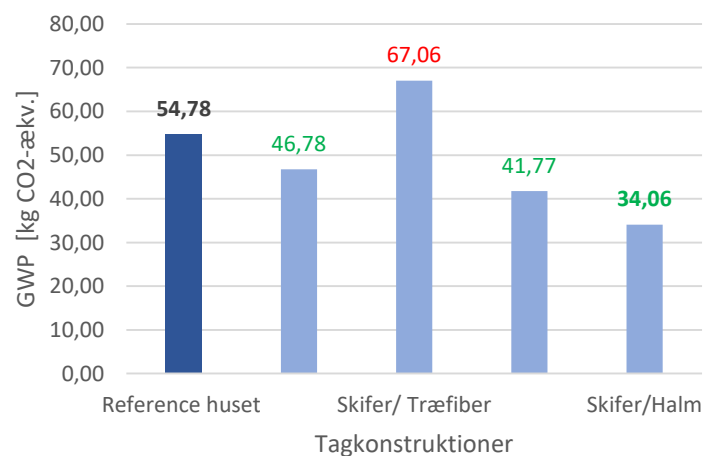
Tagkonstruktion C- Betontegl



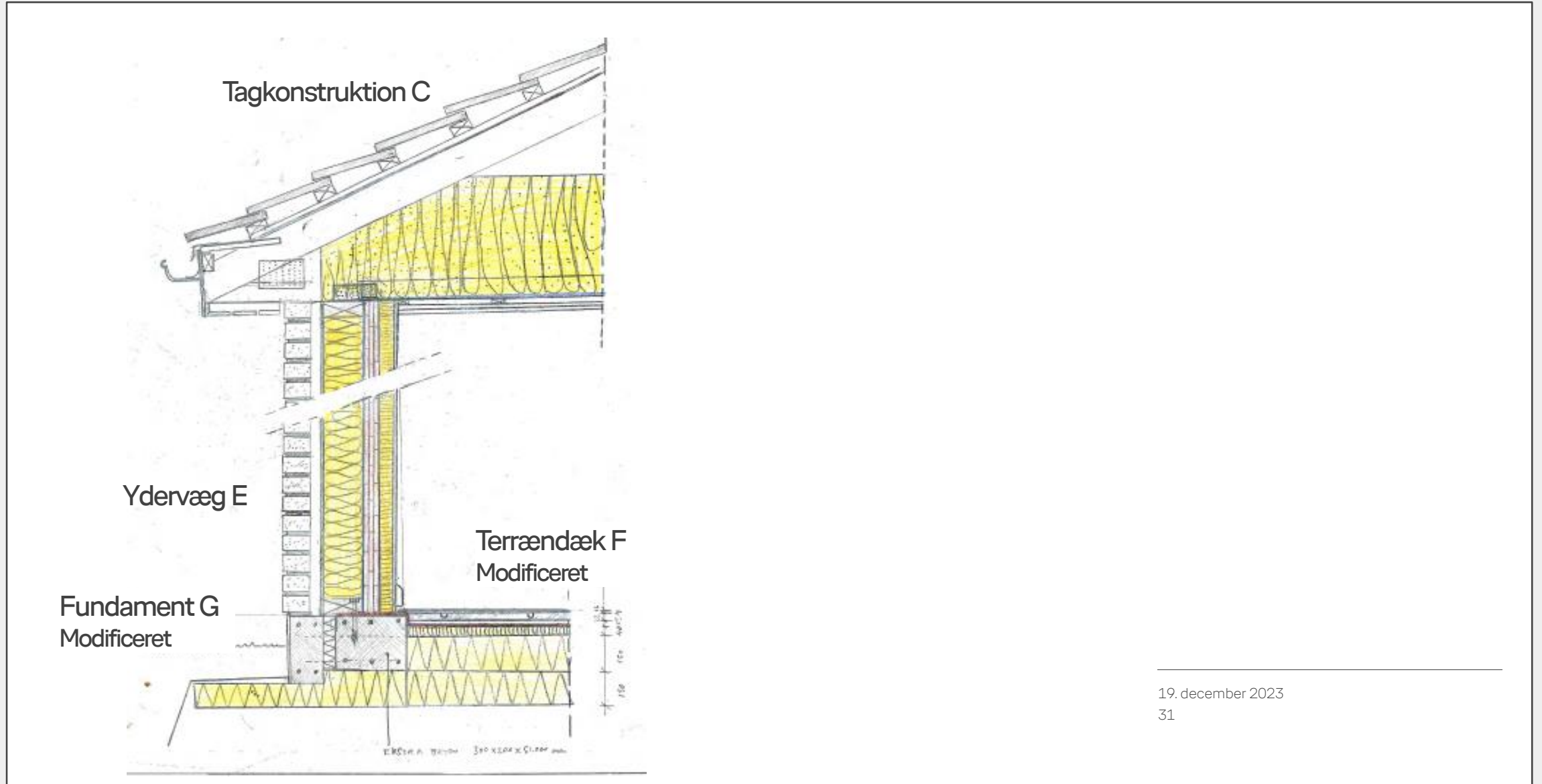
Tagkonstruktion D- Tagpap



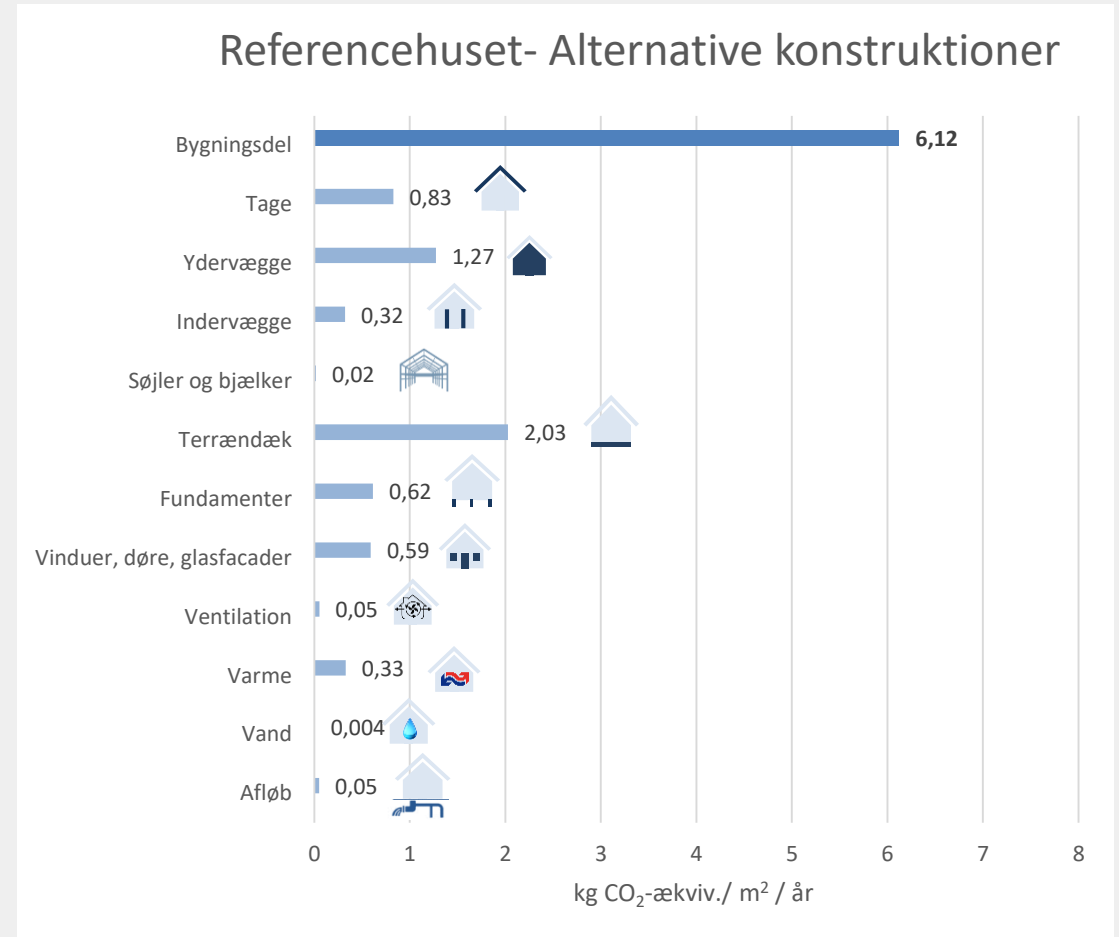
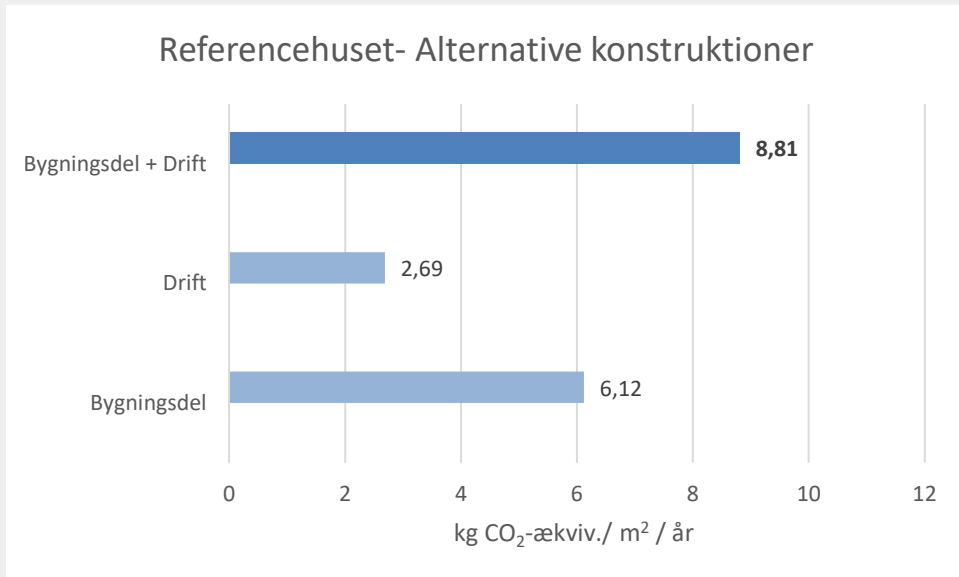
Tagkonstruktion E- Skifer



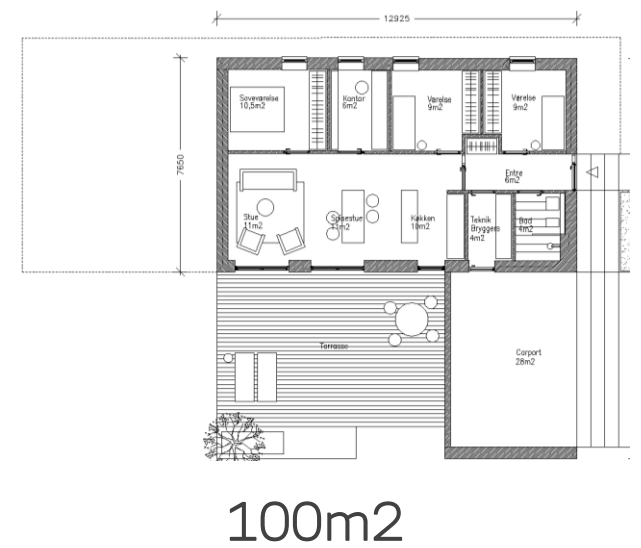
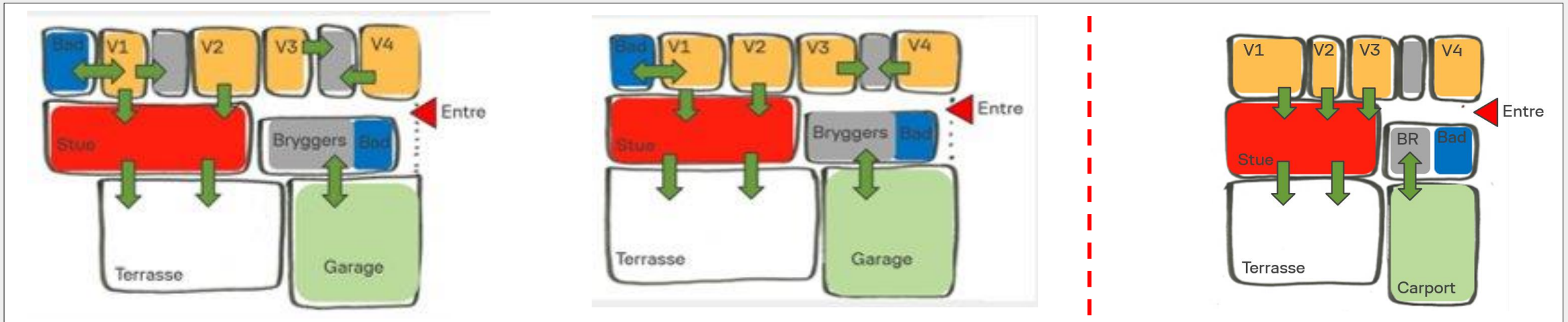
Fase 6 – Hus alternative konstruktioner



Fase 6 – Hus alternative konstruktioner LCA



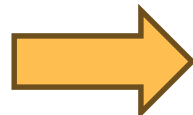
Fase 7 - Arealoptimering



Fase 7 - Arealoptimering



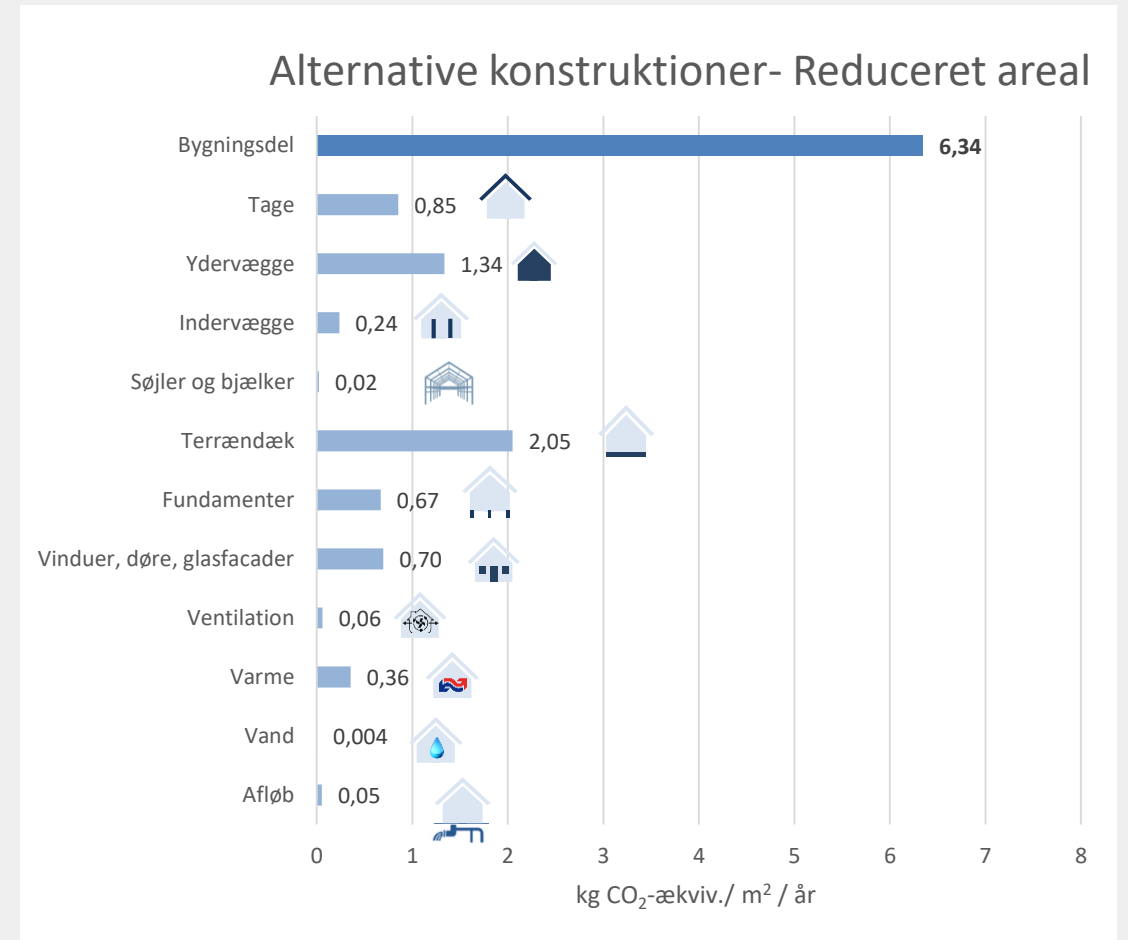
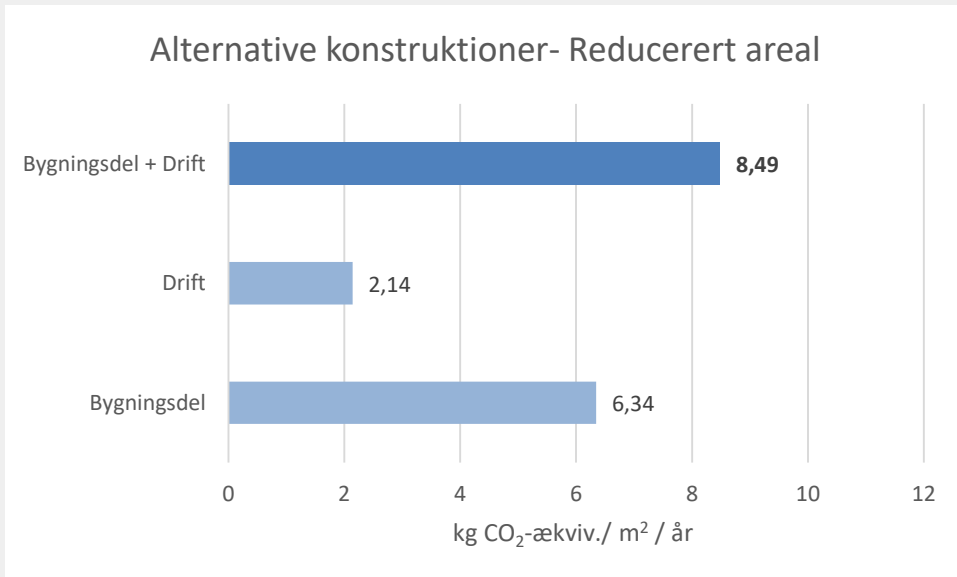
174m²



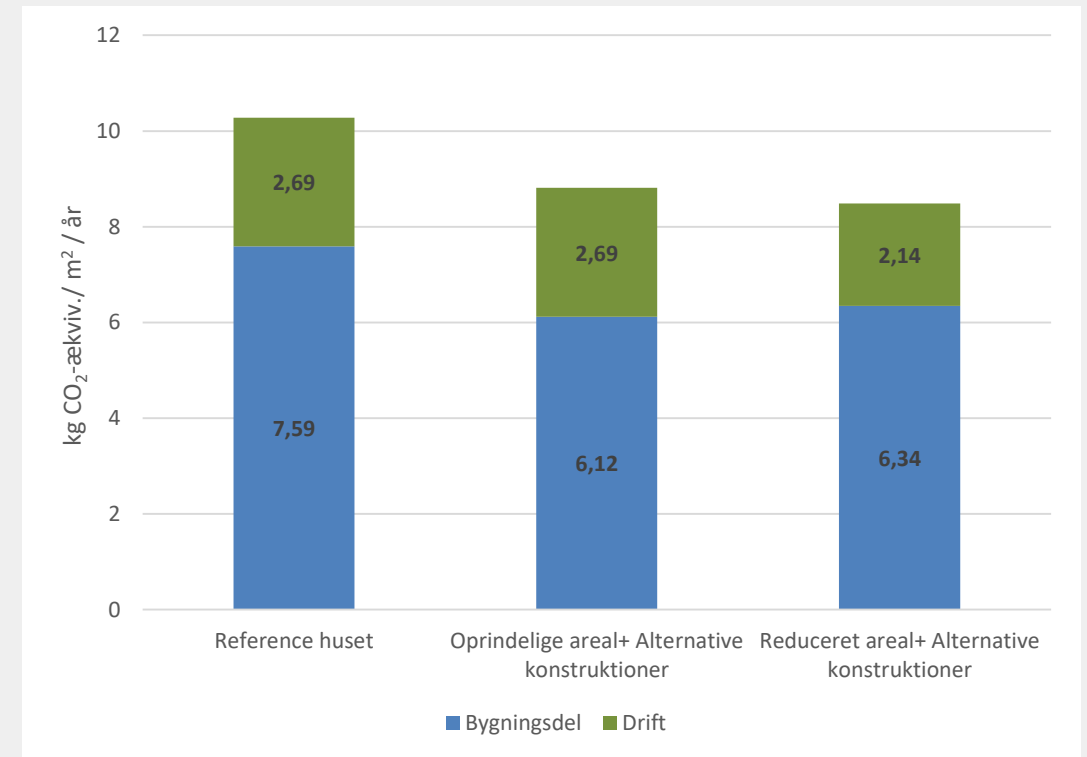
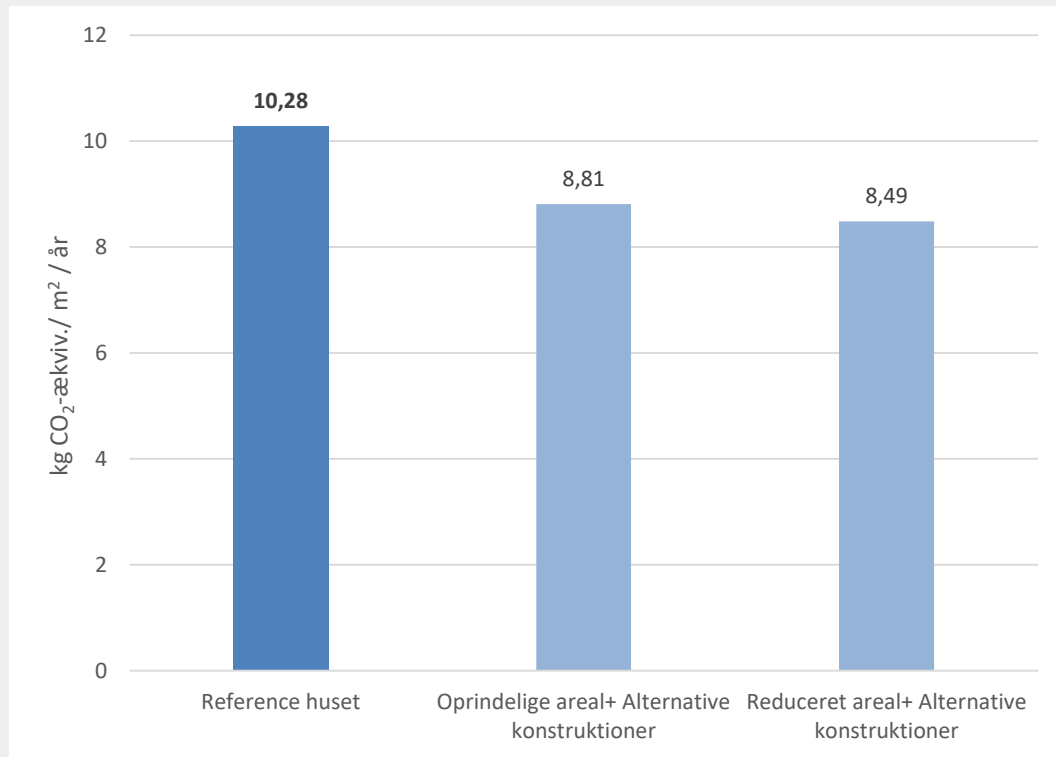
144m²

144m²

Fase 6 – Alternative konstruktioner- Reduceret areal LCA

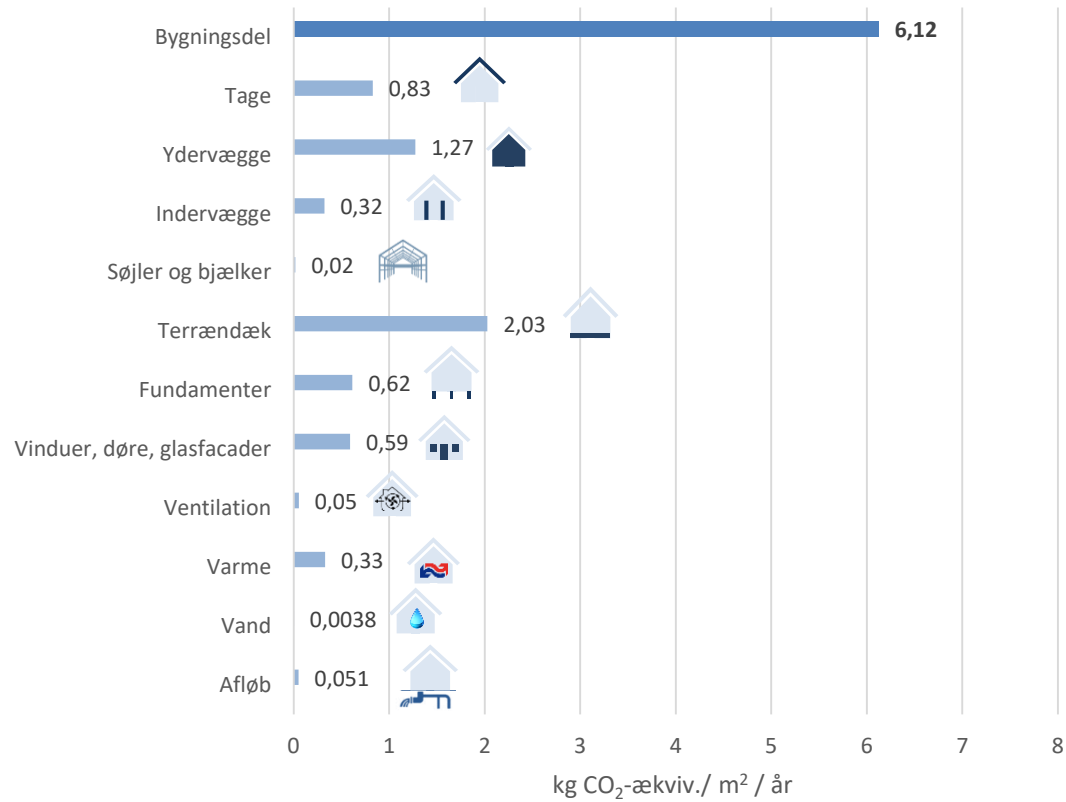


Fase 7 – Sammenligning af resultater

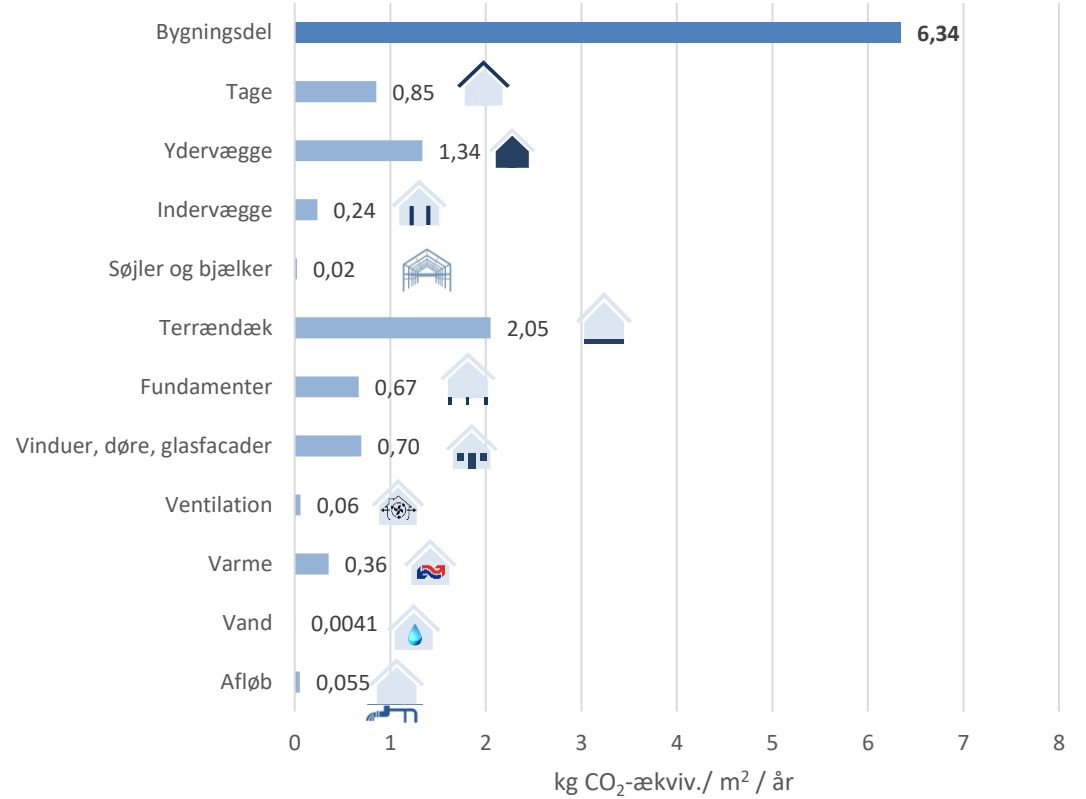


Fase 7 – Sammenligning af resultater

Referencehuset- Alternative konstruktioner

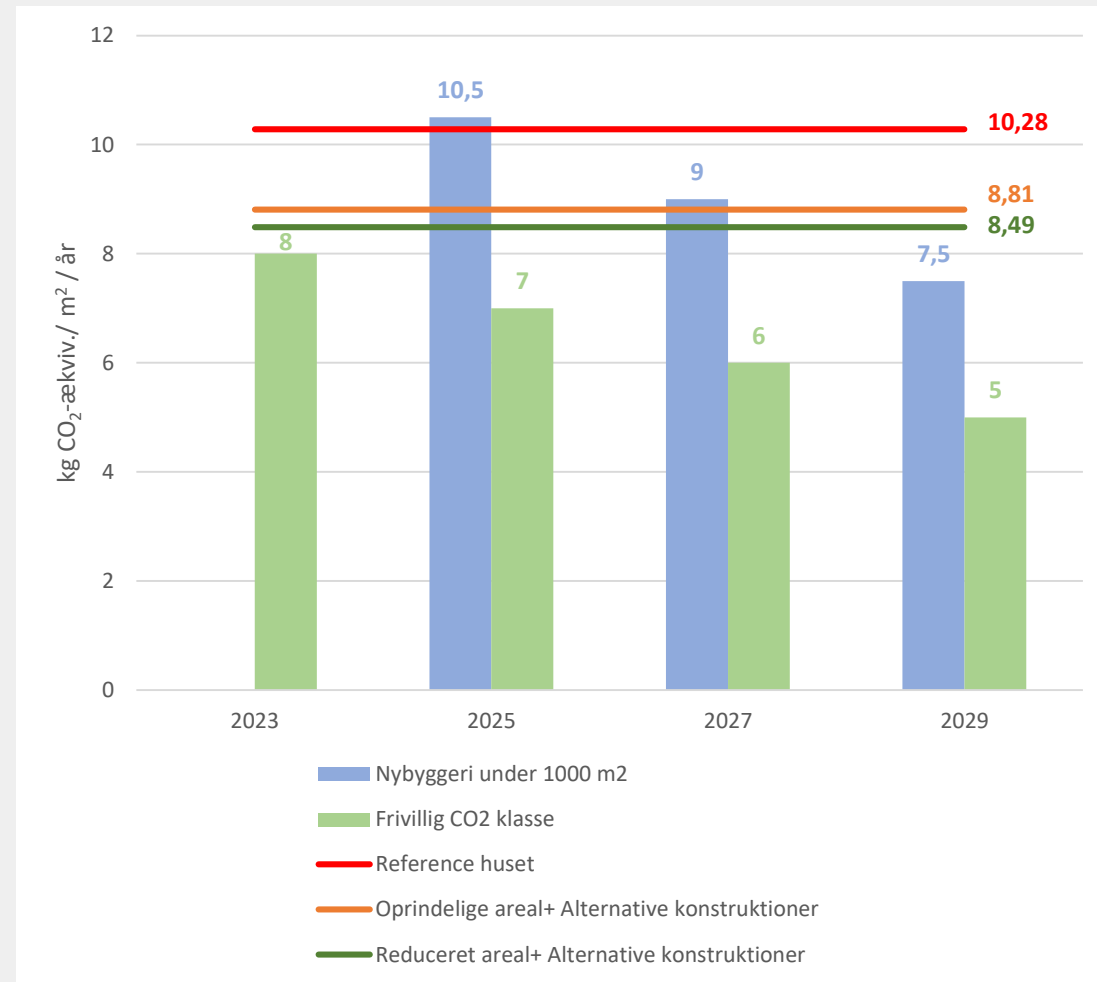


Alternative konstruktioner- Reduceret areal



Konklusion – Parcelhuset lever?

Kan den danske parcelhusarkitektur bevares med de nye og kommende krav til grænseværdier for CO₂?



Konklusion – Parcelhuset lever?

Hvordan optimeres konstruktionsopbygningen i forhold til klimabelastning?

- Materialevalg - materialesammensætning
- Bygningen som helhed – hvordan bliver konstruktionerne sat sammen
- Se på geometrien af huset

Konklusion – Parcelhuset lever?

Hvilken betydning har bygningsarealet for klimaftrykket

- Konstruktionerne har en højere klimaaftryk ved et lavere areal
- Driften bliver lavere ved mindre areal så samlet set bliver det en fordel
- Matematisk regel:

Når volumen bliver mindre, bliver overfladearealet proportional større

- Konstruktioner vil få en højere klimabelastning jo mindre areal pga. de matematiske grundregler
- Hvordan skal lovgivningskravet for klimaaftrykket dokumenteres?

Spørgsmål - diskussion

