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Environmental impacts of structural materials for multi-floor buildings: life cycle perspective

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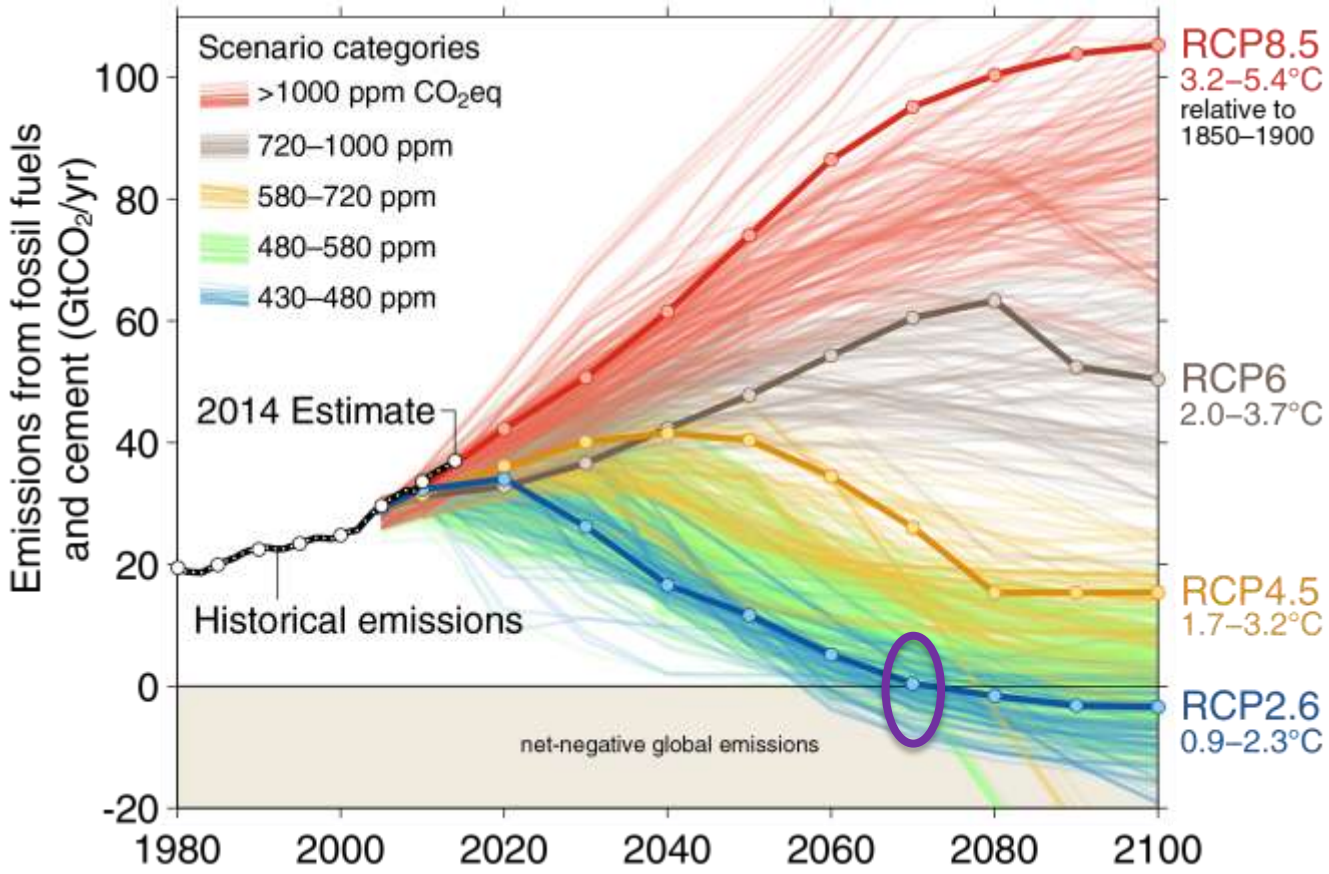
Agenda

- Carbon budget
- Embodied carbon
- Goal and scope
- Results
- Conclusions

Carbon budget 2014

Data: CDIAC/GCP/IPCC/Fuss et al 2014

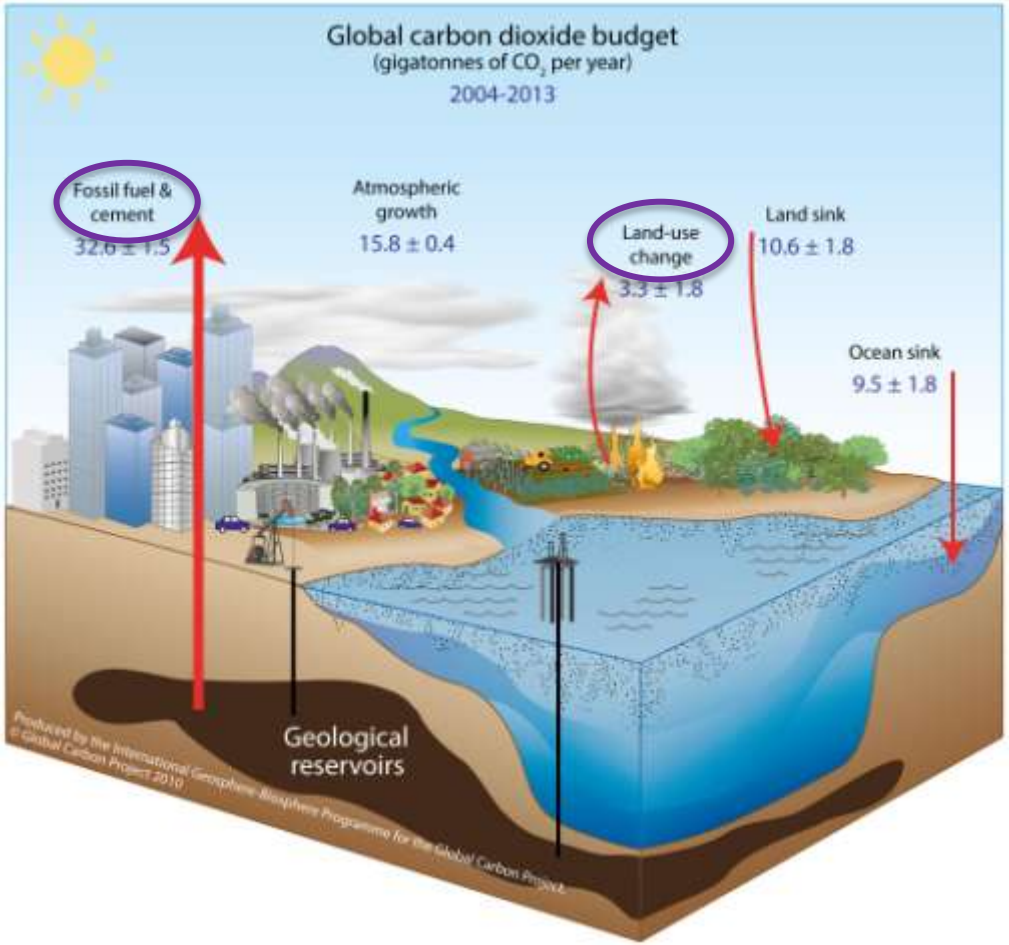


Over 1000 scenarios from the IPCC Fifth Assessment Report are shown

Source: Fuss et al 2014; CDIAC; Global Carbon Budget 2014

Perturbation of the global carbon cycle caused by anthropogenic activities, averaged globally for the decade 2004–2013 ($GtCO_2$/yr)

Data: CDIAC/NOAA-ESRL/GCP

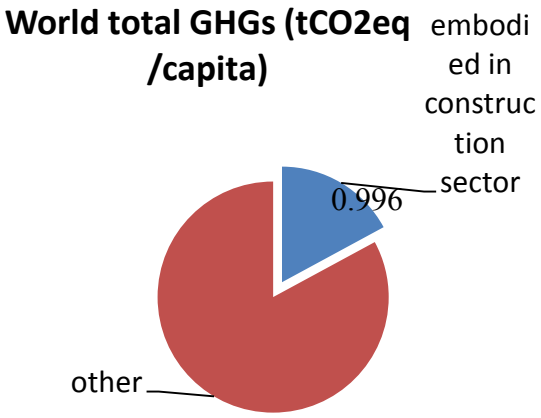


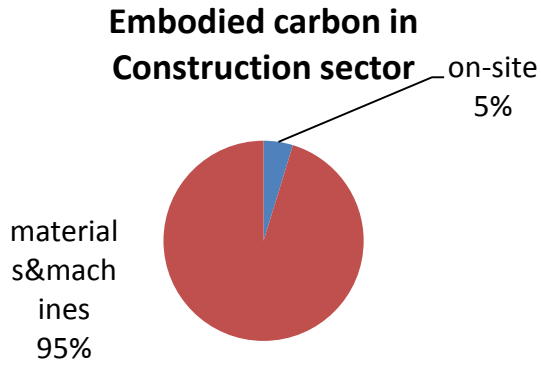
- Source: CDIAC; NOAA-ESRL; Le Quéré et al 2014; Global Carbon Budget 2014

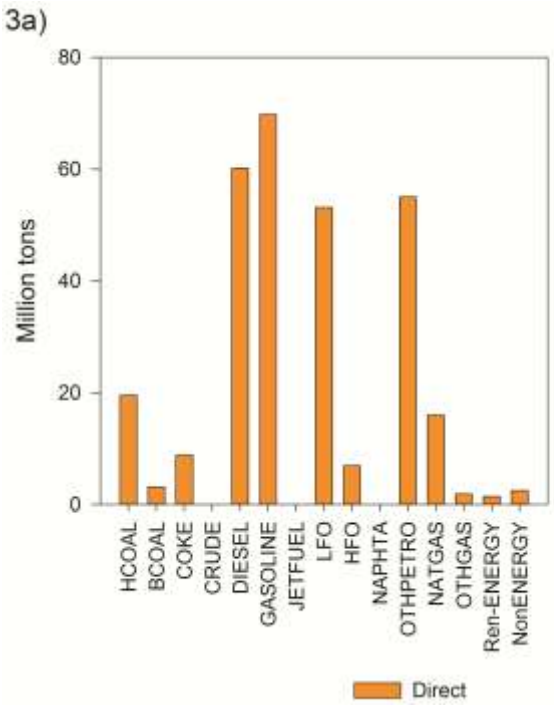
Life cycle carbon emissions of buildings

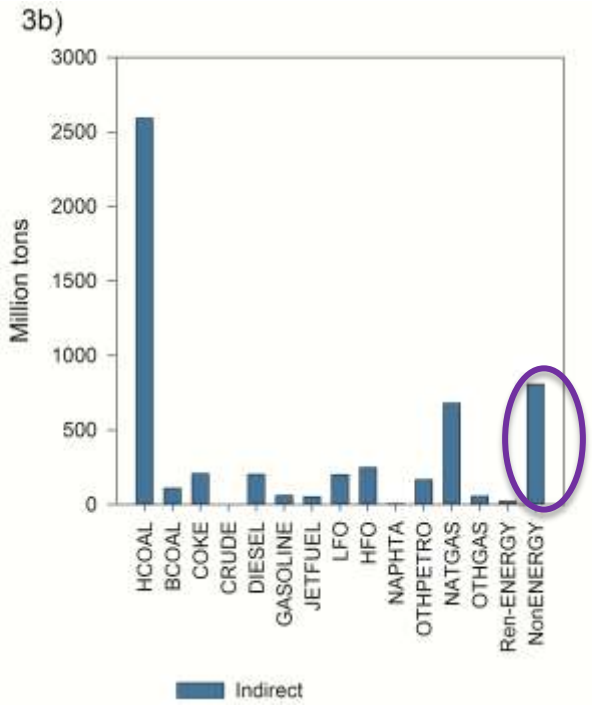
lc= life cycle
e= embodied
u= use stage
eol= end of life

World embodied carbon of construction sector 2009



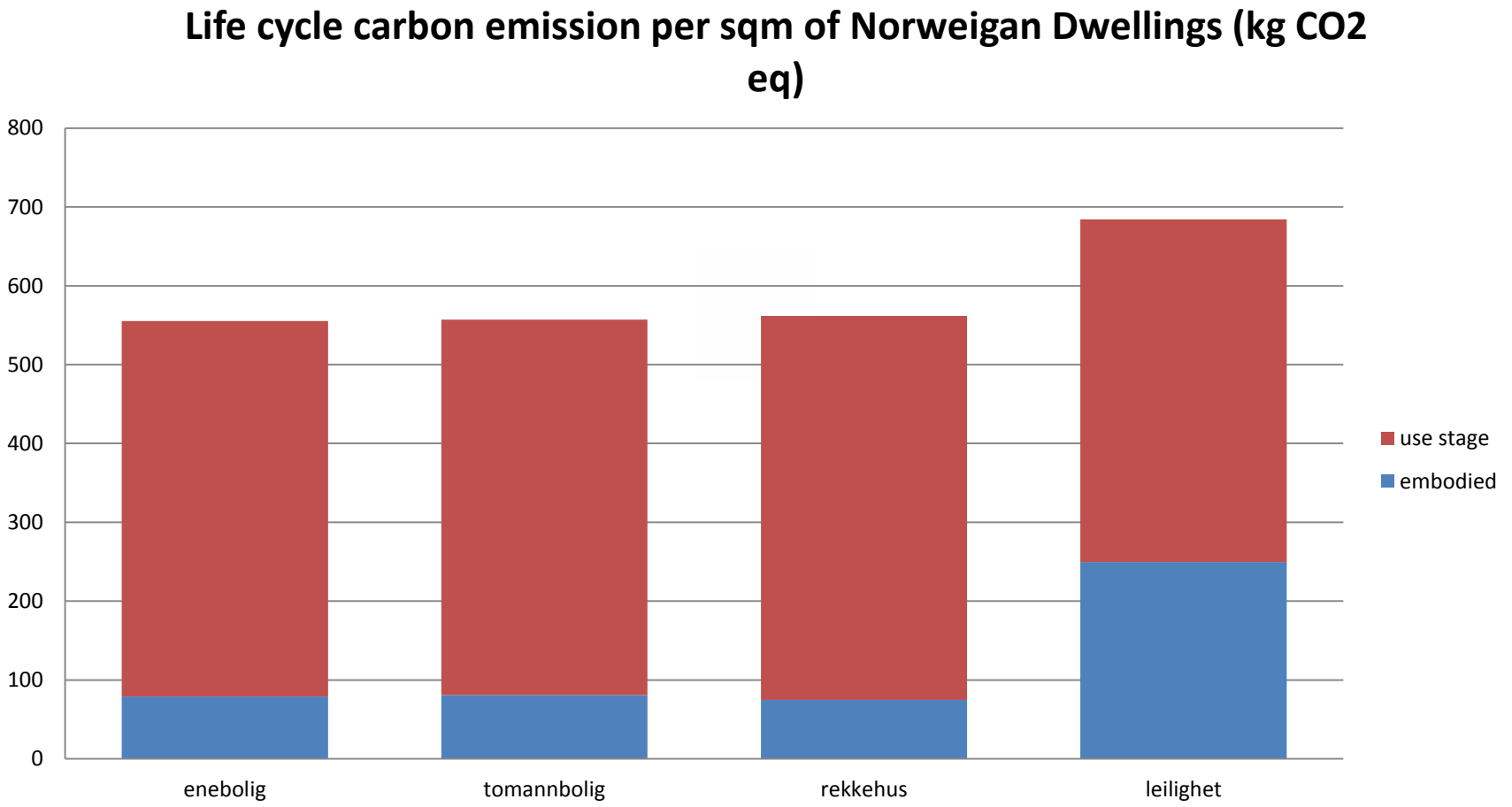






- Source: Huang, Lizhen; Liu, Yongping; Krigsvoll, Guri; Johansen, Fred; Zhang, Xiaoling. Carbon emission of global construction sector. Renewable & Sustainable Energy Reviews 2017

Life cycle carbon emission of buildings in Norway



Source: Bohne, Rolf André; Huang, Lizhen, Life cycle assessment of Dwelling sector in Norway. EcoBalance 2012 "Challenges and Solutions for Sustainable Society"; 2012-11-20 - 2012-11-23, Yokohama, Japan.

Goal and scope

- To assess the influence of materials selection on the life cycle environmental impacts, especially the embodied emissions of buildings according of typical apartment block building system in Norway:
  - Precast concrete inter floor and roof with steel beam and column system, (Option 1)
  - Precast concrete inter floor and roof with precast concrete beam and column system, (Option 1)
  - Cross laminated Timber (CLT) inter floor and roof with Glue Laminated Timber (GLT) beam and column system, (Option 1)
  - Wood frame inter floor element (WFE), and Cross laminated Timber (CLT) roof with Glue Laminated Timber (GLT) beam and column system. (Option 1)

FU: the pre-production, construction and demolition for 4 floor building with 600 m^2 per floor over 50 years

Environmental impacts per FU for the studied four structural systems without consider the end of life scenario

Environmental impacts	Unit	Option 1	Option 2	Option 3	Option 4
Climate change (GWP)	ton CO2 eq	504	457	**47**	177
Ozone depletion (ODP)	kg CFC-11 eq	0.017	0.015	0.015	0.017
Terrestrial acidification (TAP)	ton SO2 eq	1.93	1.65	1.99	2.31
Freshwater eutrophication (FEP)	kg P eq	141	91	99	118
Marine eutrophication (MEP)	kg N eq	84	73	85	96
Human toxicity (HTP)	ton 1,4-DB eq	189	106	114	133
Photochemical oxidant formation (POFP)	ton NMVOC	2.20	1.94	2.03	2.21
Particulate matter formation (PMFP)	ton PM10 eq	1.16	0.90	0.95	1.09

Environmental impacts of the studied four structural systems with 100% main materials recycling

Environmental impacts	Unit	Option 1	Option 2	Option 3	Option 4
Climate change (GWP)	ton CO2 eq	306	334	35	148
Ozone depletion (ODP)	kg CFC-11 eq	0.011	0.011	0.015	0.016
Terrestrial acidification (TAP)	ton SO2 eq	1.198	1.178	2.234	2.427
Freshwater eutrophication (FEP)	kg P eq	84.768	53.715	149.425	152.377
Marine eutrophication (MEP)	kg N eq	57.314	56.591	82.902	91.627
Human toxicity (HTP)	ton 1,4-DB eq	165.986	101.069	148.011	159.246
Photochemical oxidant formation (POFP)	ton NMVOC	1.343	1.439	2.058	2.151
Particulate matter formation (PMFP)	ton PM10 eq	0.607	0.631	1.250	1.288

Conclusions

- Significant differences occur between the amount of greenhouse gas emissions associated with the alternative wood-based and steel-concrete based structure system.
- Storage more carbon in the buildings with wood structures can help the mitigation goal if we can treat wood waste in right way.
- The LCA results on GWP are sensitive when materials recycling is considered.