mitigation strategies for embodied carbon in new constructions

ENV724 – Climate economics for Engineers

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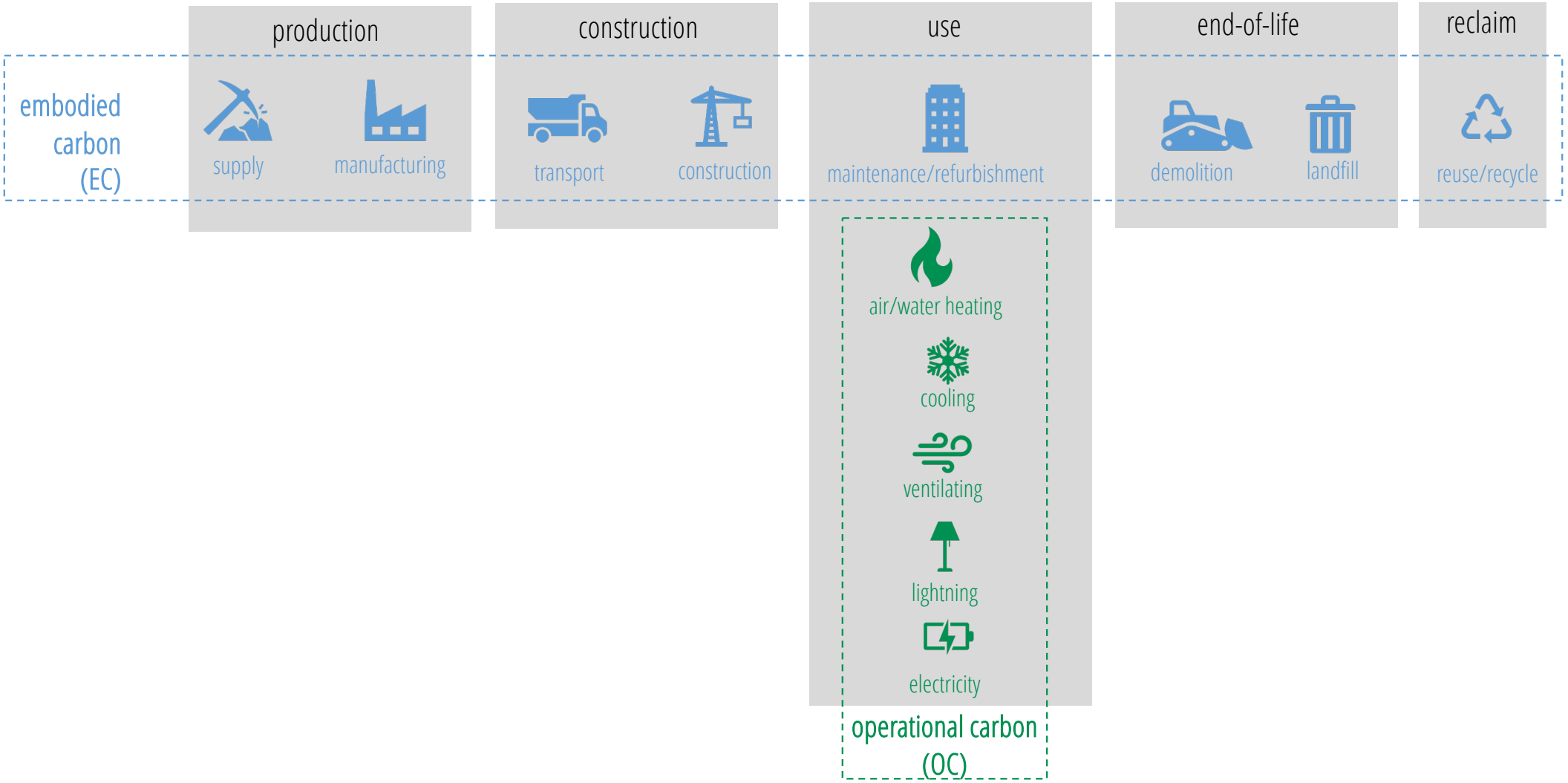
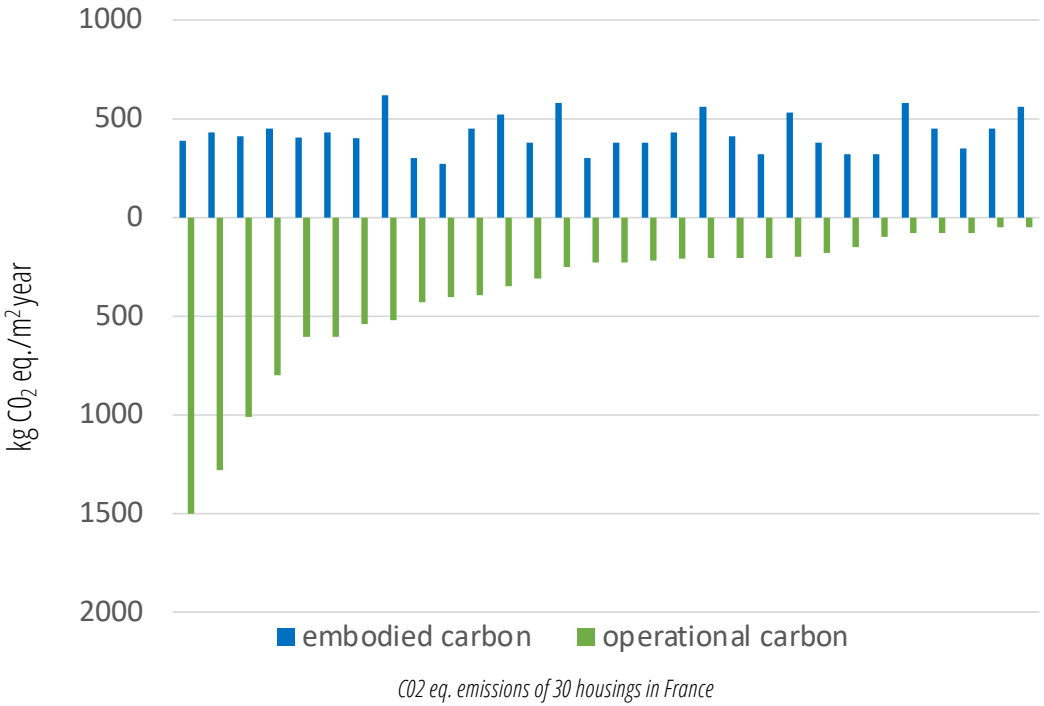
embodied and operational carbon



trends for embodied and operational carbon

Pomponi & Moncaster 2016 (Embodied carbon mitigation and reduction in the built environment – what does the evidence say?)
Crawford 2011 (Life Cycle Assesment in the Built Environment)



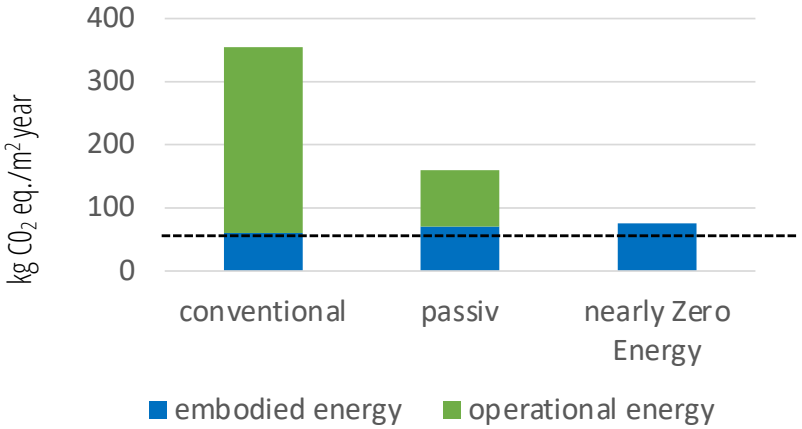
C02 eq. emissions of 30 housings in France

Hoxha et al., 2017 (Influence of construction material uncertainties on residential building LCA reliability)

operational carbon in the swiss climate policies
(C02 tax, "building program", labels, ...)

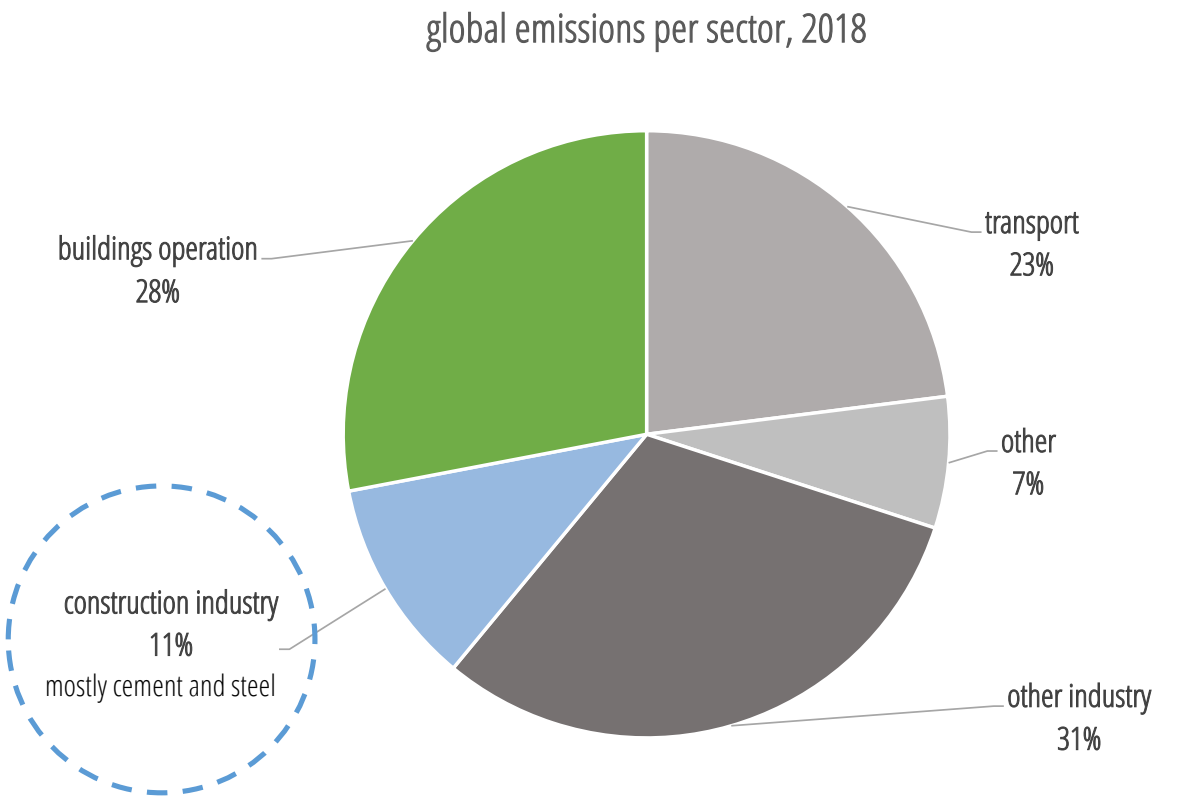
-> OC emissions: lowered by 21% between 1990 and 2018

FOEN, 2020 (Evolution of Switzerland's GHG emissions since 1990)



Sartori & Hestnes, 2006 (Energy use in the life cycle of conventional and low-energy buildings: A review article

construction industry in global emissions

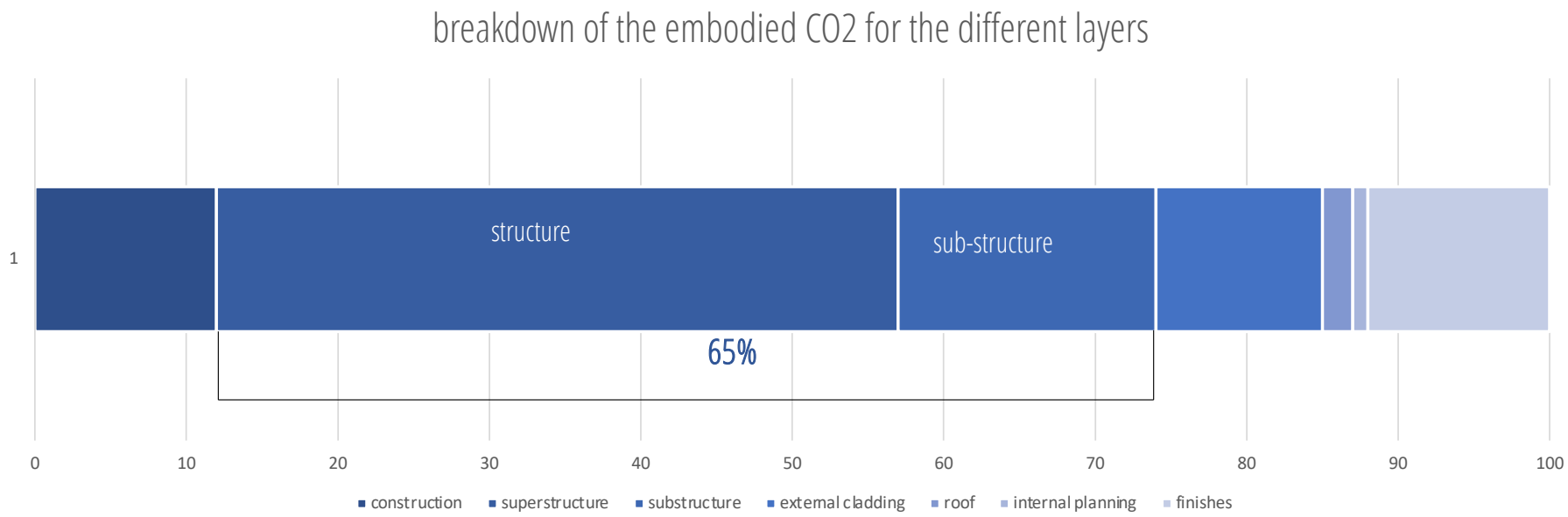


IEA, 2019 (2019 Global Status Report for Buildings and Construction, Towards a zero-emissions, efficient and resilient buildings and construction sector)

1) where is the embodied carbon of buildings hidden?

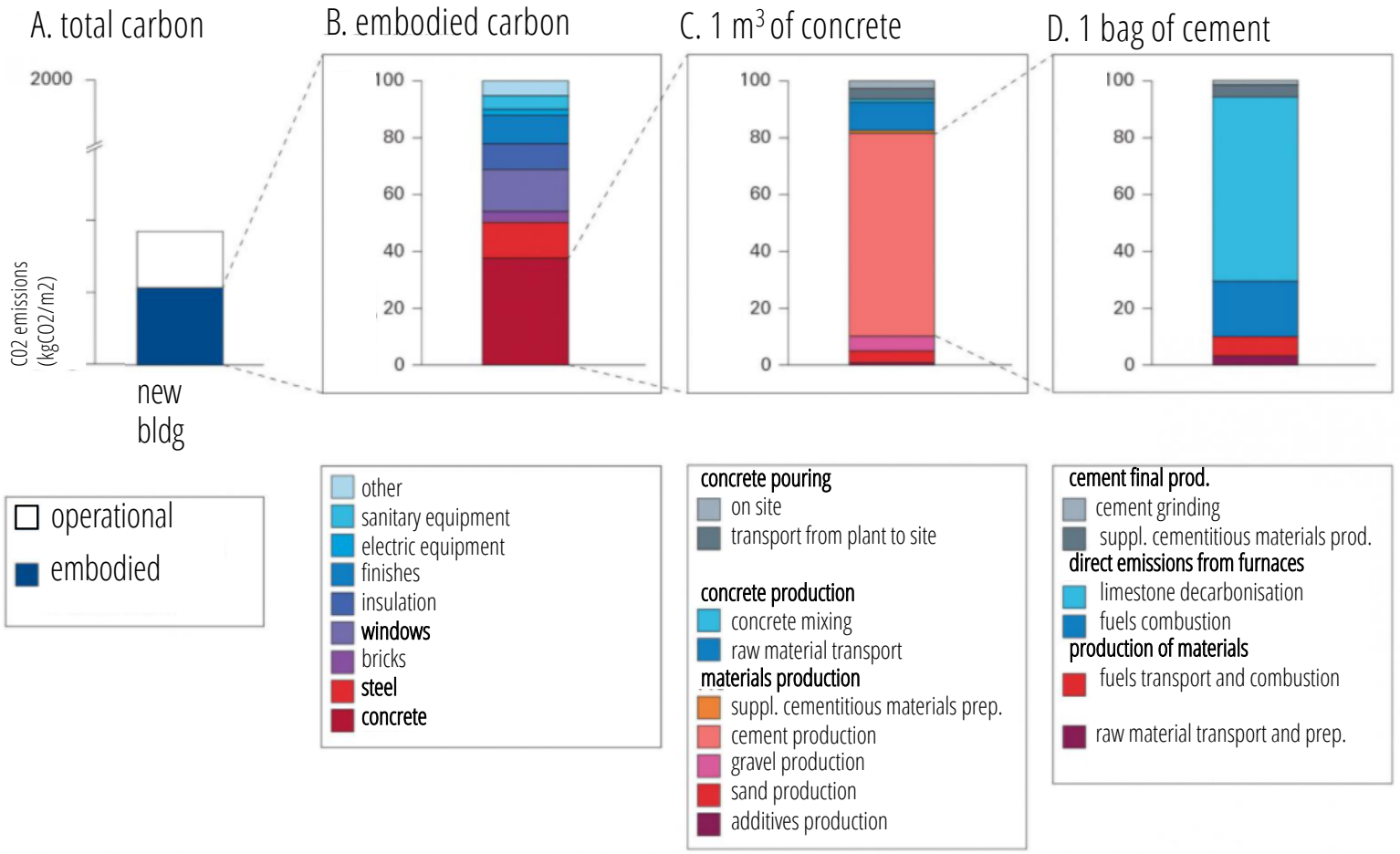
2) what mitigation strategies are recommended to lower it?

where is the embodied carbon?



Kaethner & Burridge, 2012 (Embodied CO2 of structural frames)

where is the embodied carbon?



sample: 320 buildings
(75% in Europe and 35% in Asia)

sample: 35 masonry houses built between 2010 and 2015 in Switzerland

figures for standard concrete with 25% ciment in Australia and Switzerland

French standards figures

Habert et al. 2020 («Environnemental impacts and decaronization strategies in the cement and concrete industries»)

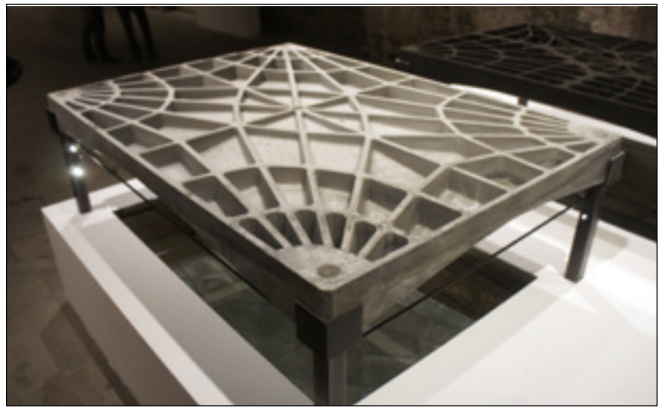
using less material

Better design (e.g. optimized structure)
EC saving: up to **20%** (Acquaye and Duffy, 2010; Chau et al., 2012)

Design for less waste on site (e.g. through prefabrication)
EC saving: up to **3.2%** (Mao et al., 2013)

Design for reuse and deconstruction

Pomponi & Moncaster, 2016
(Embodied carbon mitigation and reduction in the built environment – what does the evidence say?)



Optimized floor system. ETH Block research group. Photo credit: Nick Krouwel

Actors
designers (engineers + architects), producers, constructors, organizations for standardisation, ...

Limitations
- design habits and structural risk mitigation
- **savings on material < additional design costs**
- little incentives
- uncertainties concerning end-of-life and next life-cycles

Instruments
- public invetsment: R&D
- voluntary approach: labels (structural optimization, reusability, ...)
  -> uncertain results
- command and control instrument: standards (e.g. maximum amount of material – less «over-design»)

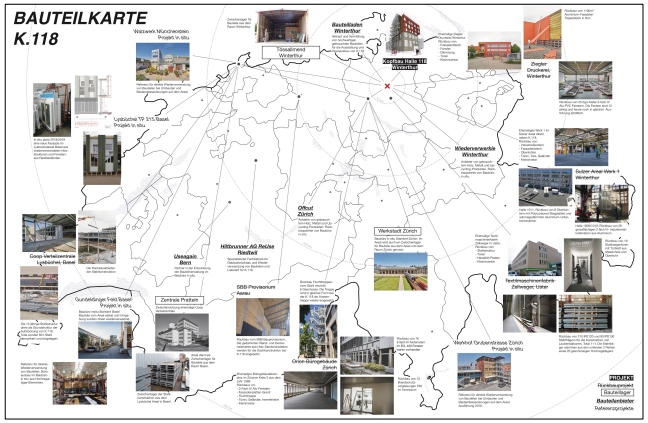
using low-carbon materials

Use recycled content in materials
EC saving: up to **46%** (Intini and Kuehtz, 2011)

Use reused and locally available products and materials
EC saving: up to **40%** per layer (Brütting et al. 2020)

Use bio-based material (e.g. timber-structure, biobased insulation, ...)
EC saving: up to **50%** on materials (Reddy, 2009)

Pomponi & Moncaster, 2016
(Embodied carbon mitigation and reduction in the built environment – what does the evidence say?)



Map of material sources for a new building in Winterthur. Image Baubüro in situ

Actors
designers (engineers + architects), producers, constructors/deconstructors, organizations for standardisation

Limitations
- technical challenges (e.g. direct effect of quality on quantity)
- **costs** (low landfilling cost, ...)
- little incentives
- uncertainties on the end-of-life of bio-based products

Instruments and examples
- public investment: R&D
- voluntary approach: labels (reused components, total EC, ...)
  -> uncertain results
- command and control instrument: codes (e.g. mandatory "resource-diagnosis" - applied by the City of Seattle)
- economic incentives: VAT lowering on repair/reuse activities (European examples) or higher carbon tax ?
  (Sathre, Gustavsson, 2007. Effects of energy and carbon taxes on building material competitiveness)

conclusions

- The building sector is responsible for a large amount of global GHG emissions
- In Switzerland, efforts have been done through policies to lower operational carbon of building and figures are supportive
- However, to reach its net-zero target, Switzerland needs to lower the EC of new buildings as well
- Load-bearing systems (structure) account for nearly half on this EC – focusing on them may be efficient
- Two mitigation strategies were discussed: using less material and using low-carbon material
    - Today, instrument to apply them are mostly based on a voluntary approach (information, labels)
    - In the future, can we imagine a combination of instruments (//operational carbon instruments), using standards and economic incentives? Referring to experiences from other countries may be useful, but **costs (and benefits)** need to be better assessed and **effectiveness** estimated as precisely as uncertainties allow.