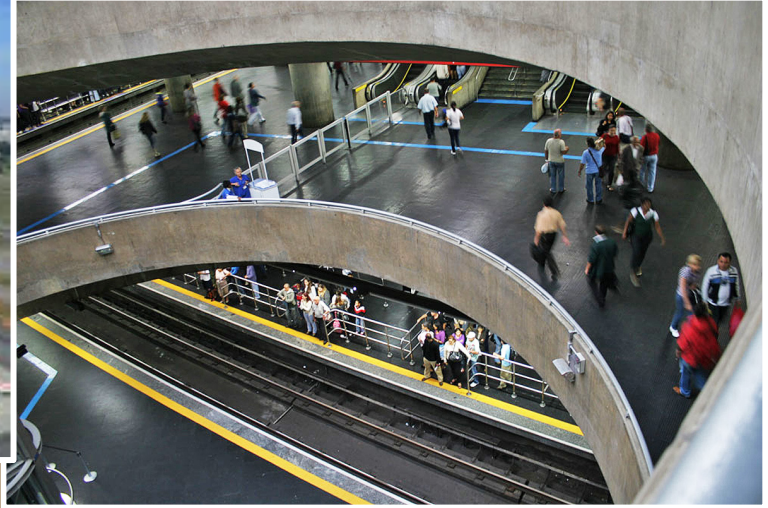


Variability of the environmental impact of ready-mix concrete: a case study for Brazil

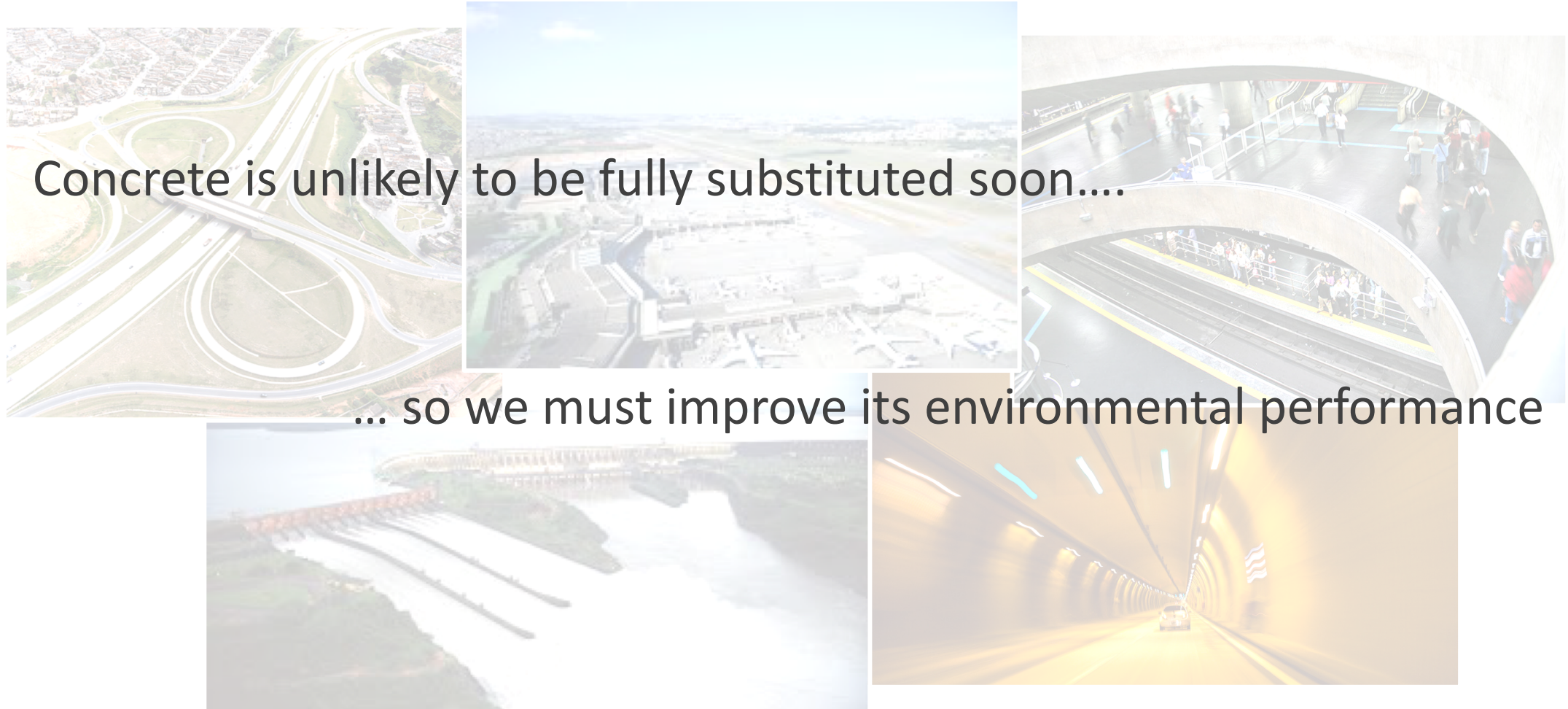
Fernanda Silva, Luciana Oliveira, Olga Yoshida, Vanderley John



Motivation



Motivation

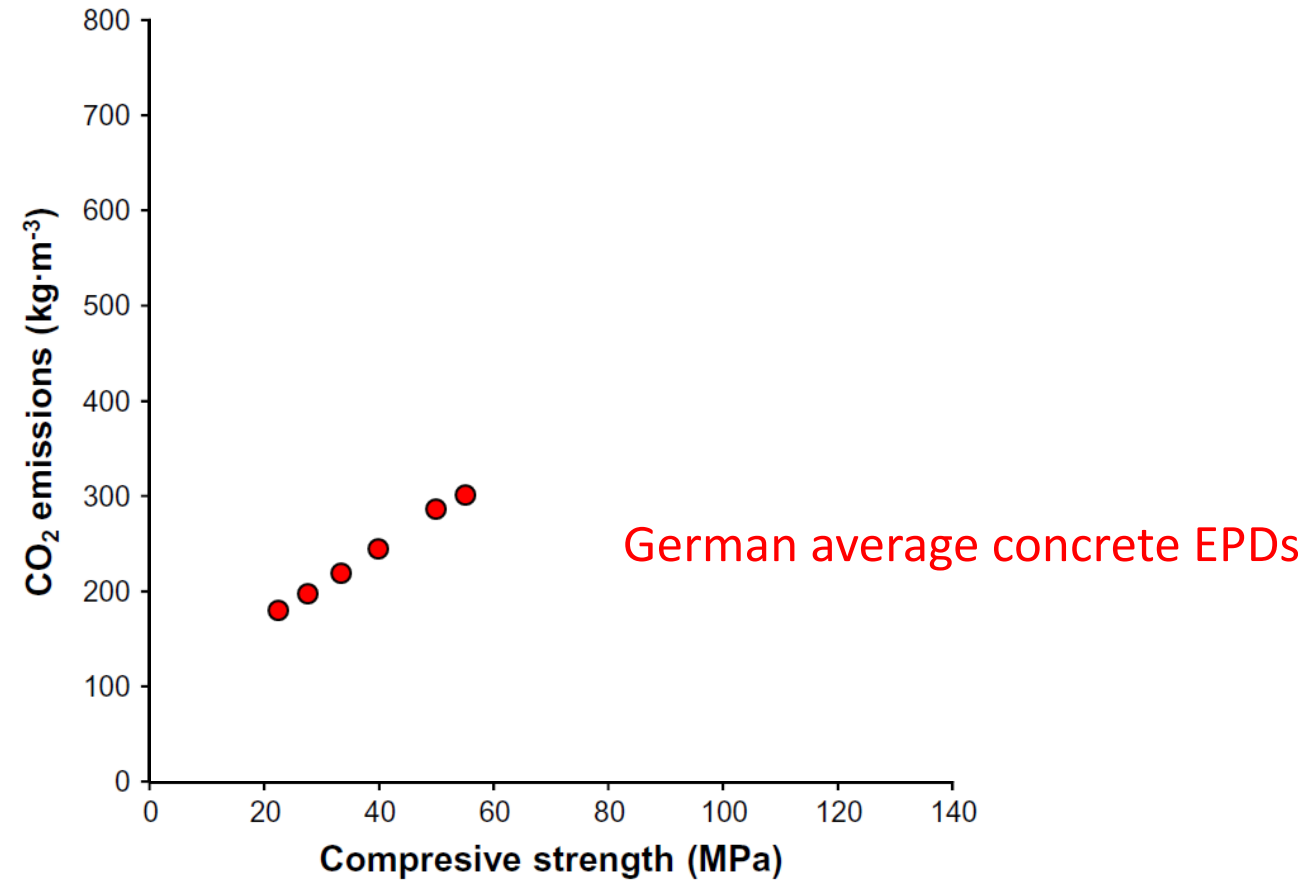


Concrete is unlikely to be fully substituted soon....

... so we must improve its environmental performance

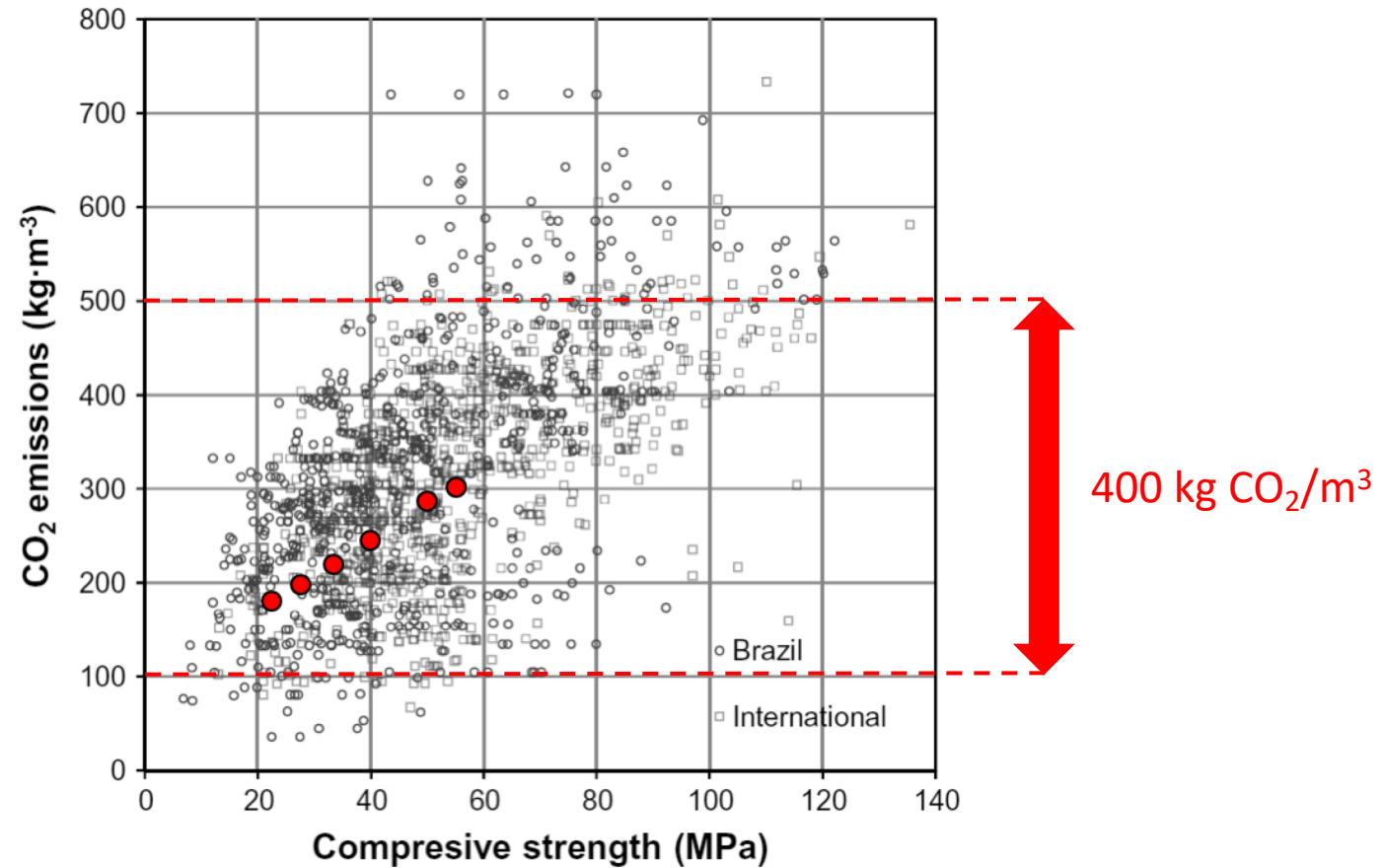
Motivation

Today in LCA:
Average values



Motivation

How it really looks like...



Aim

To analyse the variability of cradle-to-gate LCA results for ready-mix concrete in Brazil, considering:

- Differences among concrete plants
- Variations in upstream processes – production of raw materials

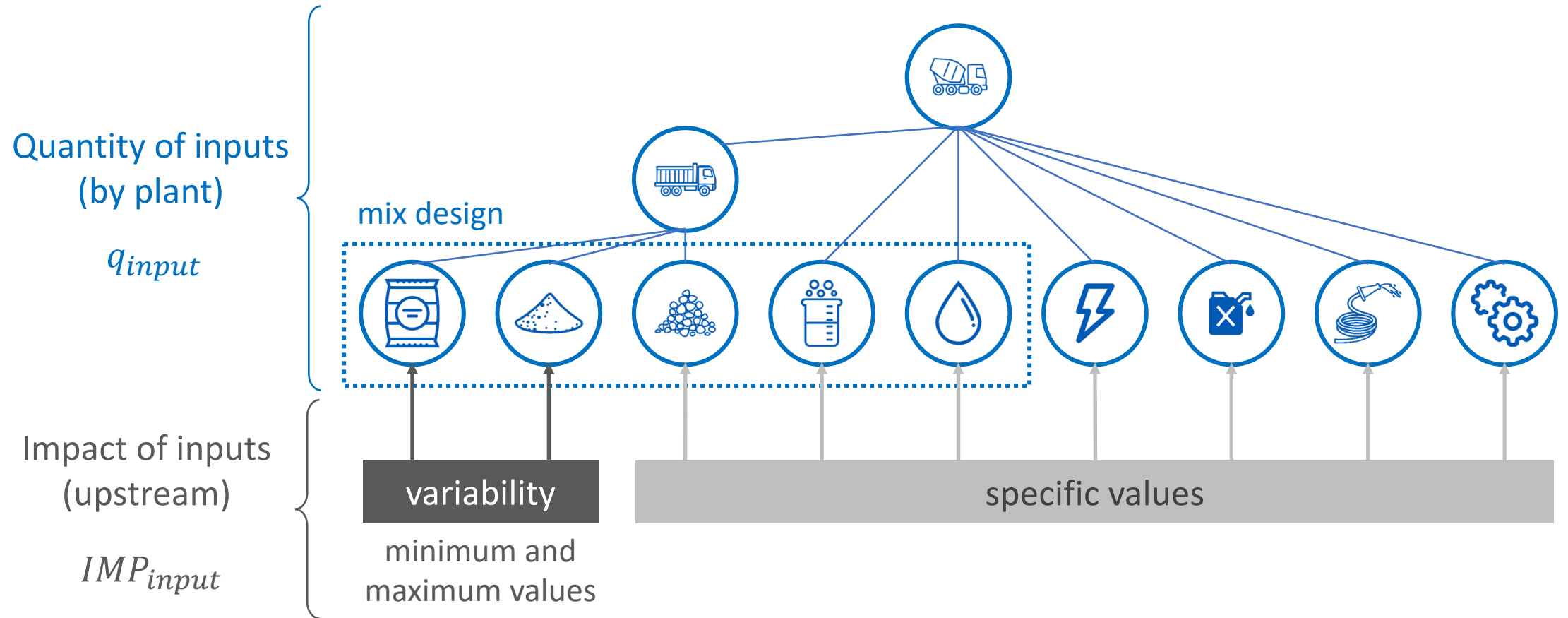
Method

- 4 concrete strength classes (fck): 25, 30, 35 and 40 MPa
- Slump value: 100 mm
- Impact assessment: EN 15084 - CML Baseline
- Background database: ecoinvent 3.4, Allocation cut-off

Data collection

- Concrete:
 - 34 plants in Brazil (3-10% of national production)
 - Mix design declared by strength class (fck)
 - Inputs for the operation of concrete plant
 - Raw materials supply: average BR transportation distance
- Upstream processes:
 - Cement: BR data (70% of national production), all cement types
 - Sand: BR data, 2 processes (extraction from open pit and riverbed)
 - Gravel: BR data, single value

Variability sources



Variability assessment



1st step: only variability among concrete plants
(example: GWP)

For each concrete plant "i" and each fck

$$GWP_{fck,i} = \sum (q_{input,i} \cdot GWP_{input}) \quad \text{cement and sand: average impact values}$$

For each fck (all plants)

$$GWP_{fck,min} = \min(GWP_{fck,i}) \quad GWP_{fck,avg} = \text{avg}(GWP_{fck,i}) \quad GWP_{fck,max} = \max(GWP_{fck,i})$$

Variability assessment



2nd step: variability among concrete plants + variability of upstream processes
(example: GWP)

For each concrete plant "i" and each fck

$$GWP_{fck,i,min} = \sum (q_{input,i} \cdot GWP_{input}) + q_{cem,i} \cdot GWP_{cem,min} + q_{sand,i} \cdot GWP_{sand,min}$$

$$GWP_{fck,i,max} = \sum (q_{input,i} \cdot GWP_{input}) + q_{cem,i} \cdot GWP_{cem,max} + q_{sand,i} \cdot GWP_{sand,max}$$

For each fck (all plants)

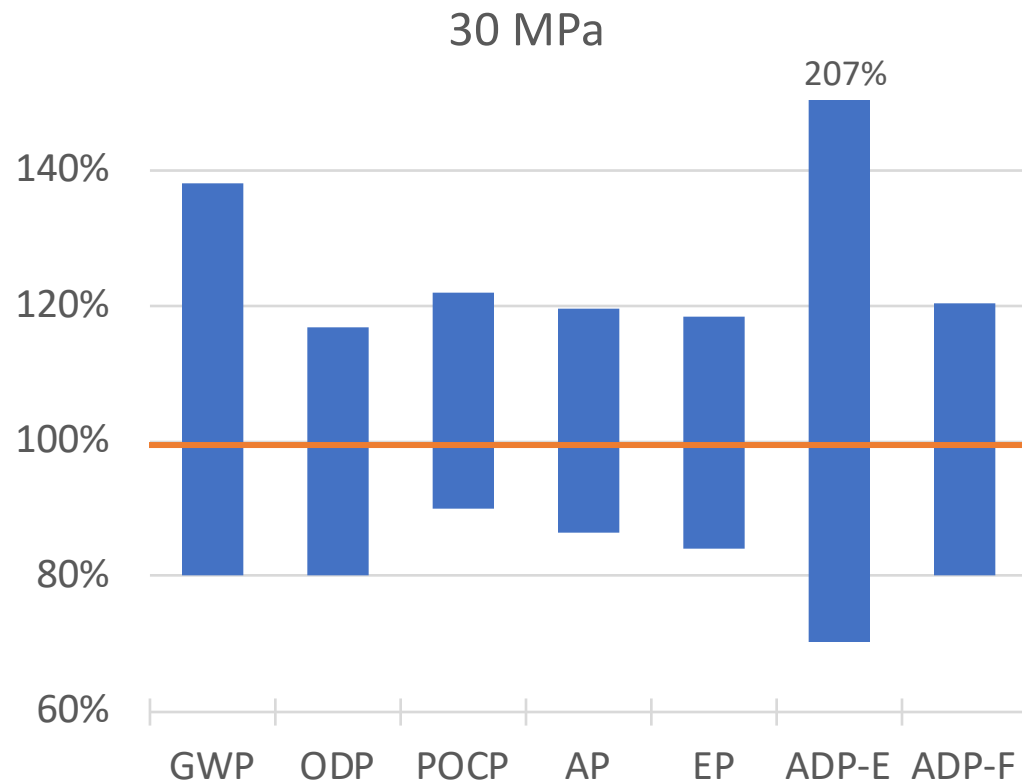
$$GWP_{fck,min} = \min(GWP_{fck,i,min})$$

$$GWP_{fck,max} = \max(GWP_{fck,i,max})$$

Results



Variability among concrete plants

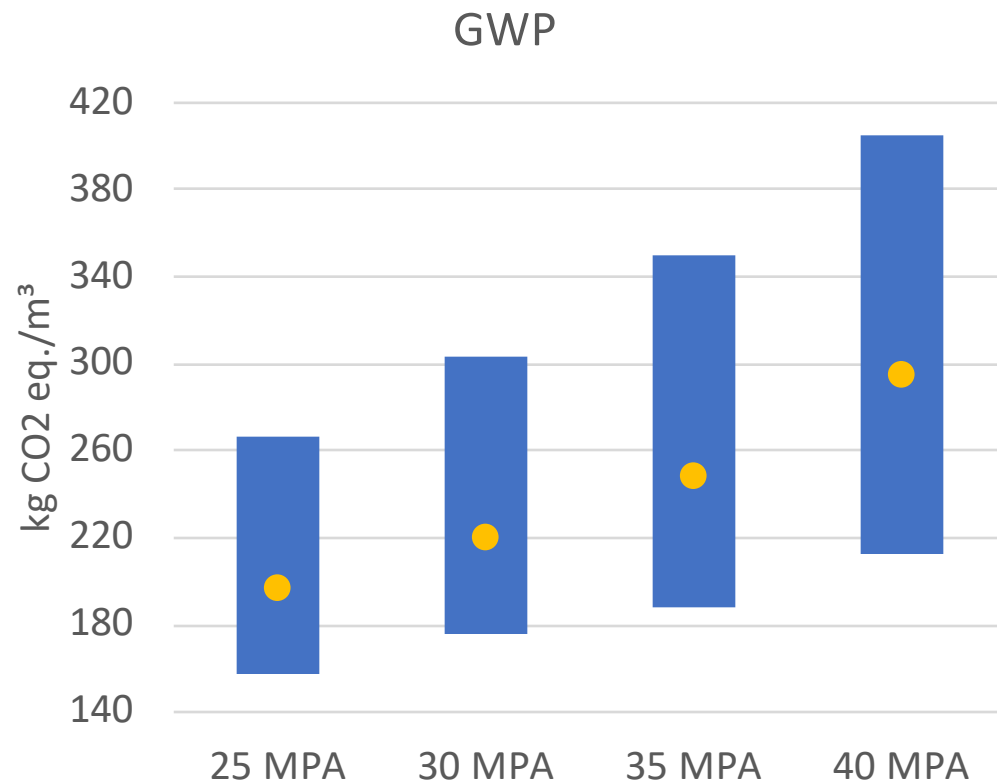


- ODP, POCP, AP, EP, ADP-F:
 - $\pm 20\%$ relative to the average
 - maximum = 1,5 x minimum
- GWP:
 - -20% to +40% relative to the average
 - maximum = 1,7 x minimum
- ADP-E:
 - -70% to +214% rel. to the average
 - Driven by steel parts for maintenance

Results



Variability among concrete plants

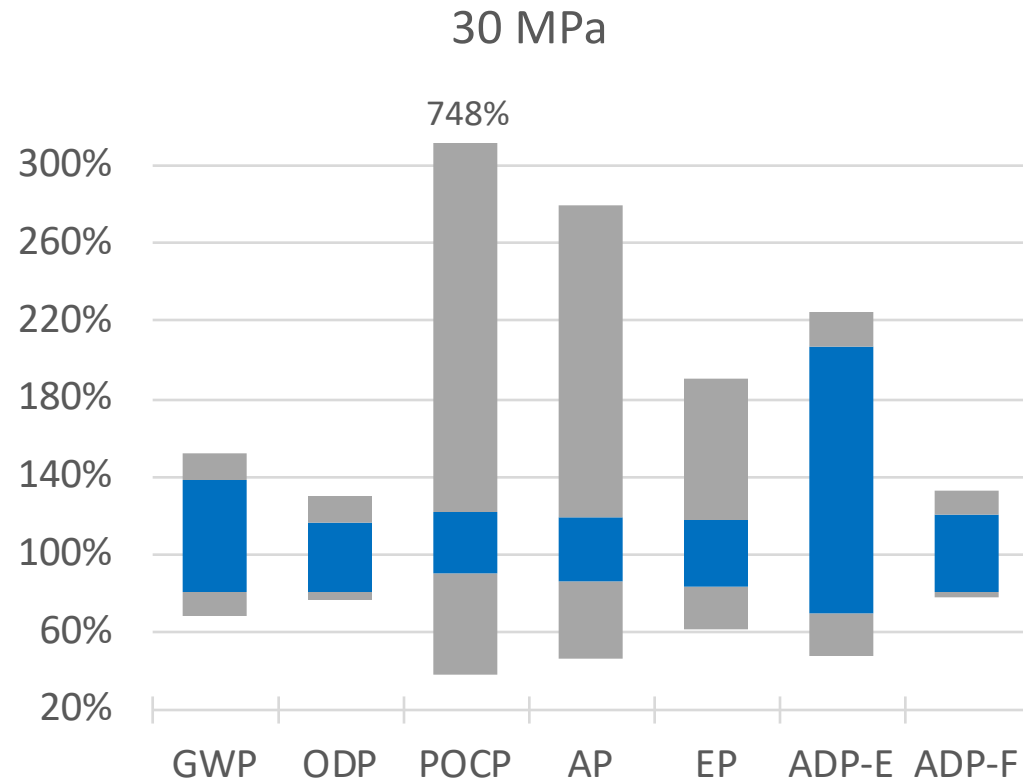


Fck	Average GWP (kg CO2eq./m ³)	GWP range (kg CO2eq./m ³)
25 MPa	196	110
30 MPa	220	128
35 MPa	248	162
40 MPa	295	192

Results



Variability among concrete plants + upstream variability



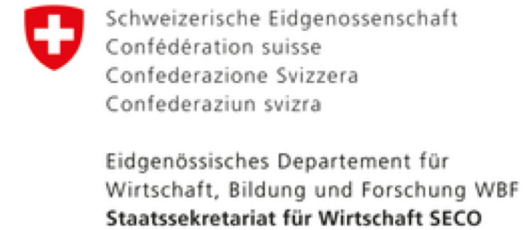
- GWP, ODP, ADP-F: small increase
- EP: almost 4x more variable
 - Variability in NO_x emissions in cement production (C.V. 65%)
- AP: 7x more variable
 - Variability in NO_x and SO₂ emissions in cement production (C.V. 128%)
- POCP: charcoal use in cement production

Take home messages

1. Choosing the concrete supplier of a building matters
2. Choosing the cement supplier of concrete matters
3. If you do not know your supplier, you should consider the variability (not only the average)

We need supplier-specific LCA results

Acknowledgments



Thank you

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