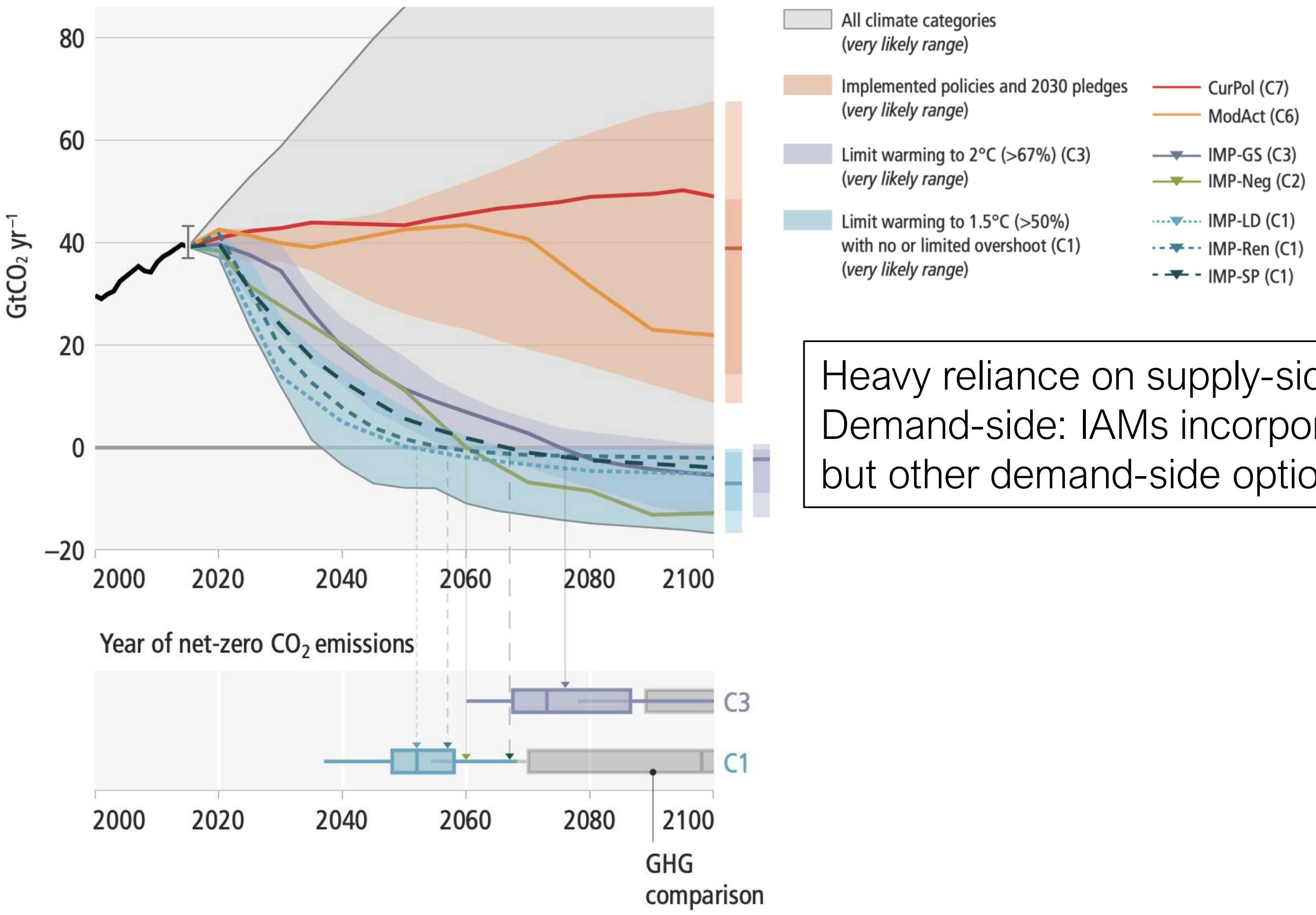
Lightweight reinforced concrete construction

The power of a demand-side GHG mitigation strategy

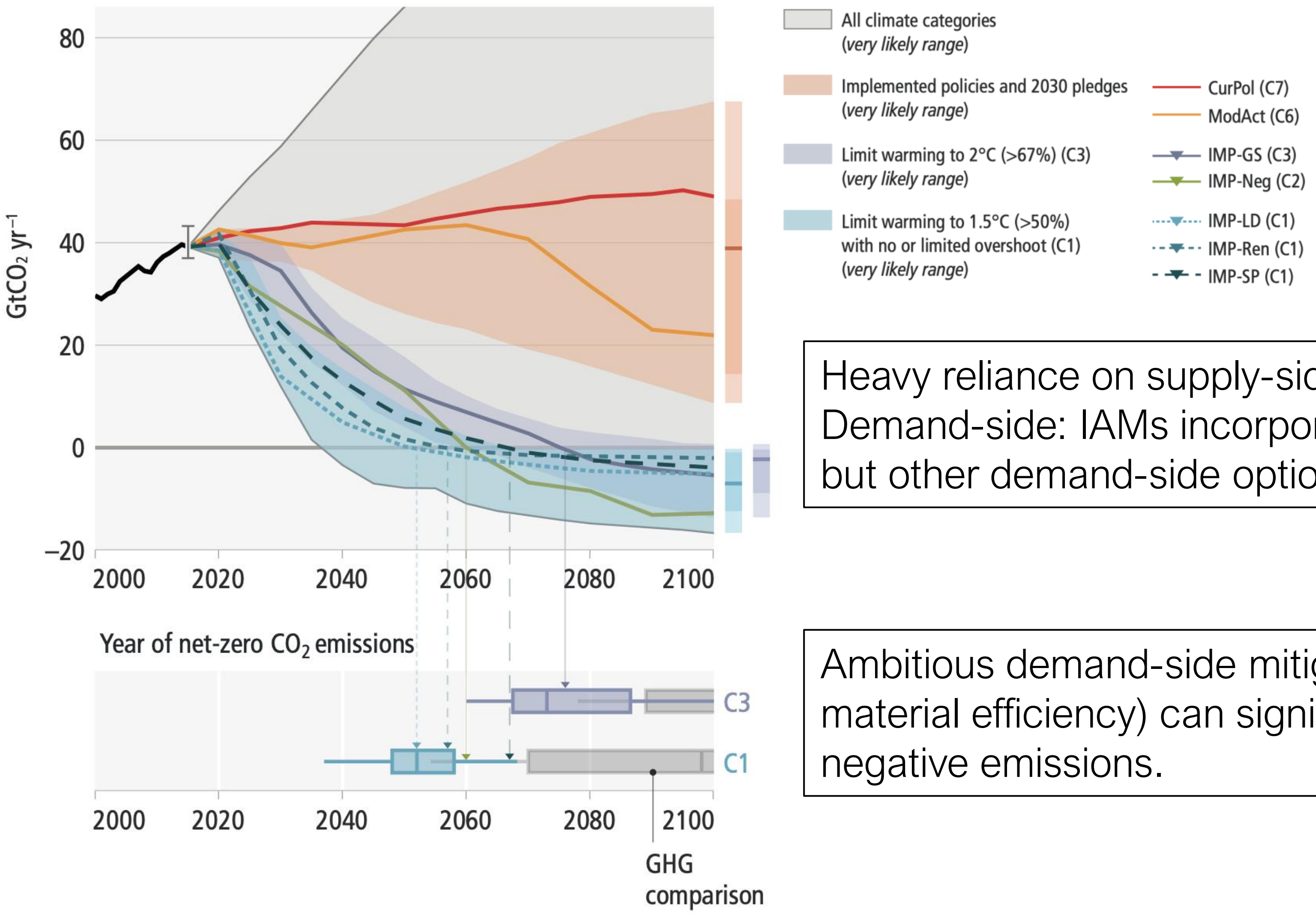
Marcella Saade



Heavy reliance on supply-side mitigation strategies.
Demand-side: IAMs incorporate changes in energy efficiency, but other demand-side options are often excluded.

(van Sluisveld et al. 2015; Creutzig et al. 2016; van den Berg et al. 2019; Wilson et al. 2019)

Illustrative Mitigation Pathways (IMPs) and net zero CO_2 and GHG emissions strategies. Source: IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001



Heavy reliance on supply-side mitigation strategies. Demand-side: IAMs incorporate changes in energy efficiency, but other demand-side options are often excluded.

(van Sluisveld et al. 2015; Creutzig et al. 2016; van den Berg et al. 2019; Wilson et al. 2019)

Ambitious demand-side mitigation options (sufficiency and material efficiency) can significantly reduce the need for negative emissions.

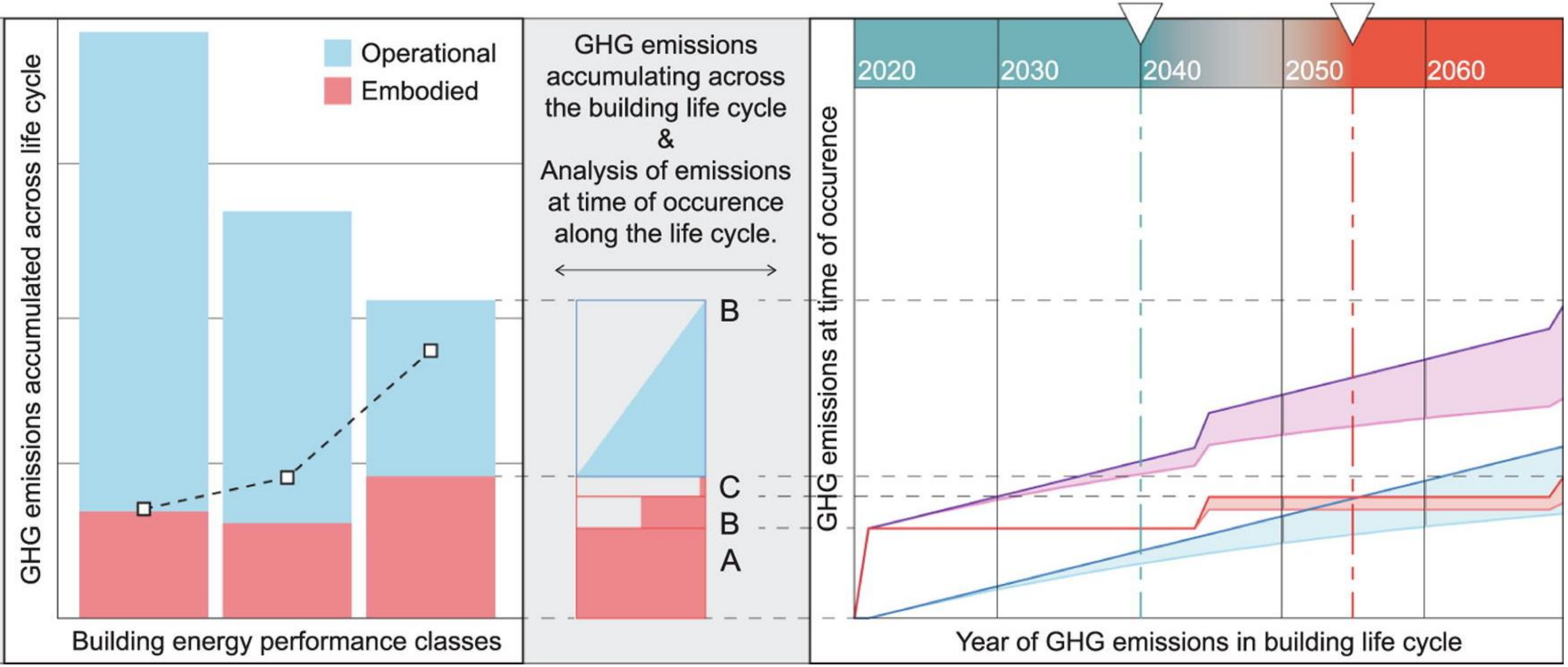
(Wachsmuth and Duscha 2019)

Illustrative Mitigation Pathways (IMPs) and net zero CO_2 and GHG emissions strategies. Source: IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001

Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation

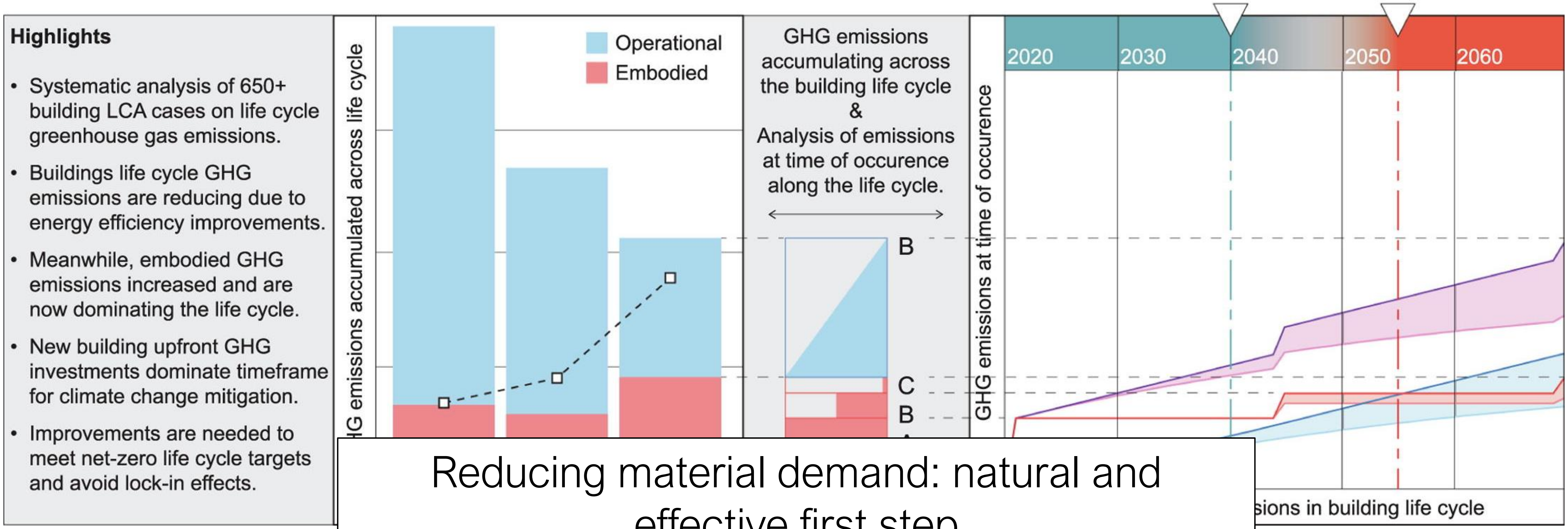
Highlights

- Systematic analysis of 650+ building LCA cases on life cycle greenhouse gas emissions.
- Buildings life cycle GHG emissions are reducing due to energy efficiency improvements.
- Meanwhile, embodied GHG emissions increased and are now dominating the life cycle.
- New building upfront GHG investments dominate timeframe for climate change mitigation.
- Improvements are needed to meet net-zero life cycle targets and avoid lock-in effects.



https://doi.org/10.1016/j.apenergy.2019.114107

Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation



Reducing material demand: natural and effective first step

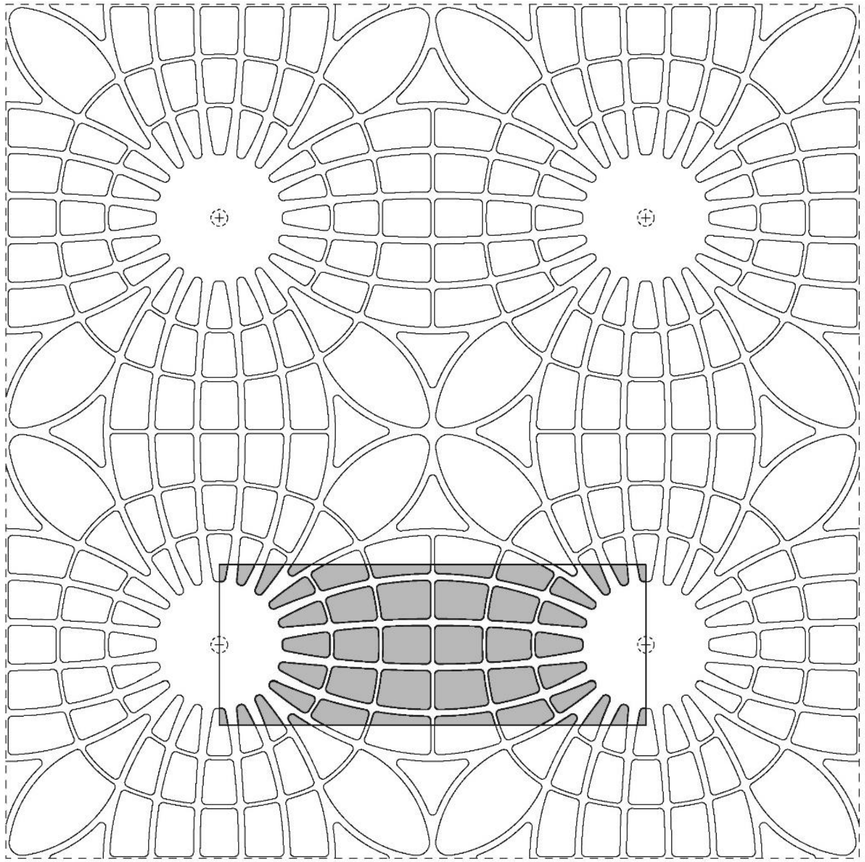
ttps://doi.org/10.1016/j.apenergy.2019.114107

COEBRO – additive fabrication of concrete elements by robots

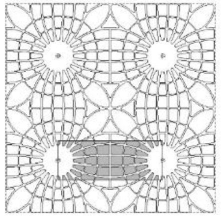

3D printed concrete displacement bodies

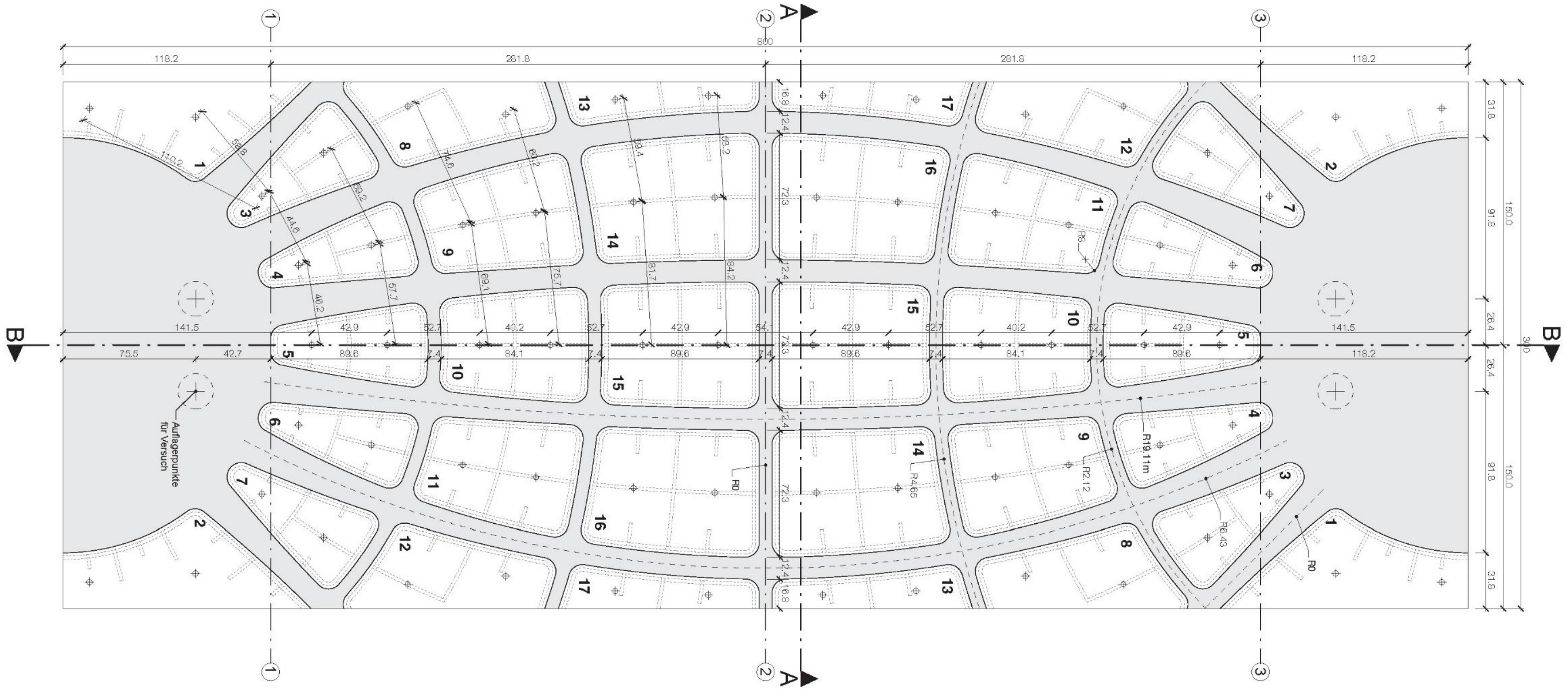
COEBRO – additive fabrication of concrete elements by robots

-40% weight



COEBRO – additive fabrication of concrete elements by robots

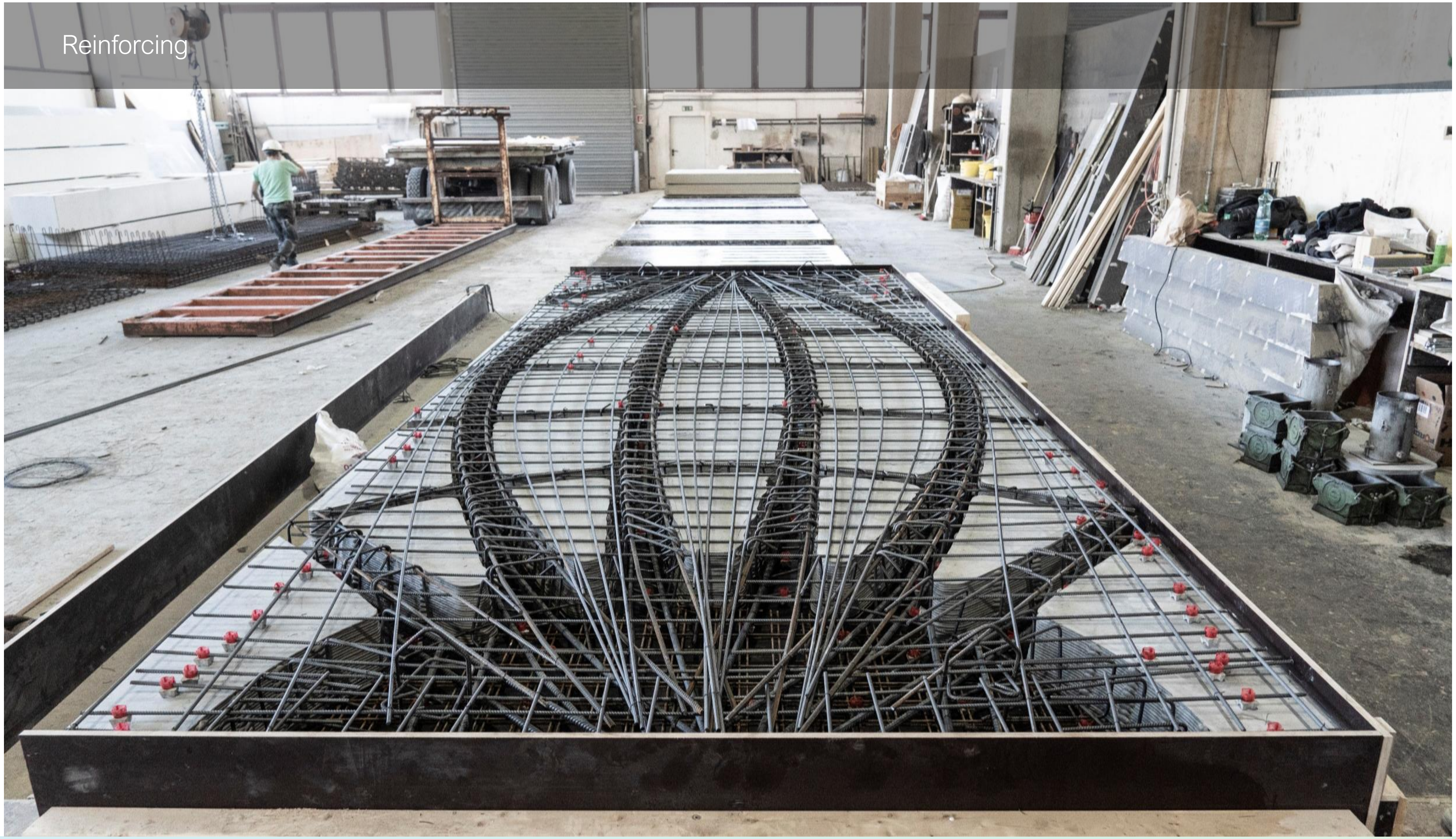




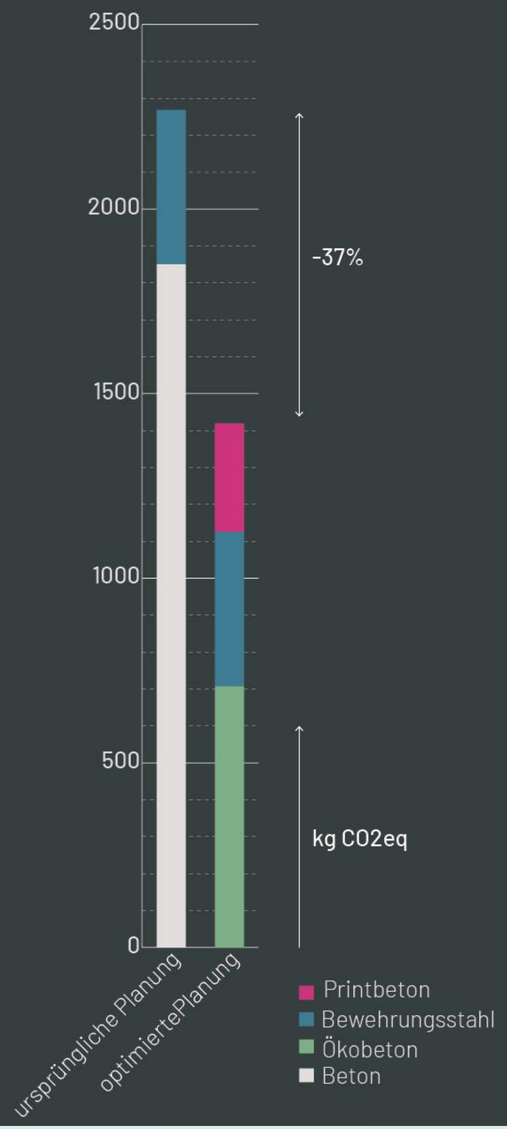
COEBRO – additive fabrication of concrete elements by robots

Positioning of displacement bodies

COEBRO – additive fabrication of concrete elements by robots



COEBRO – additive fabrication of concrete elements by robots

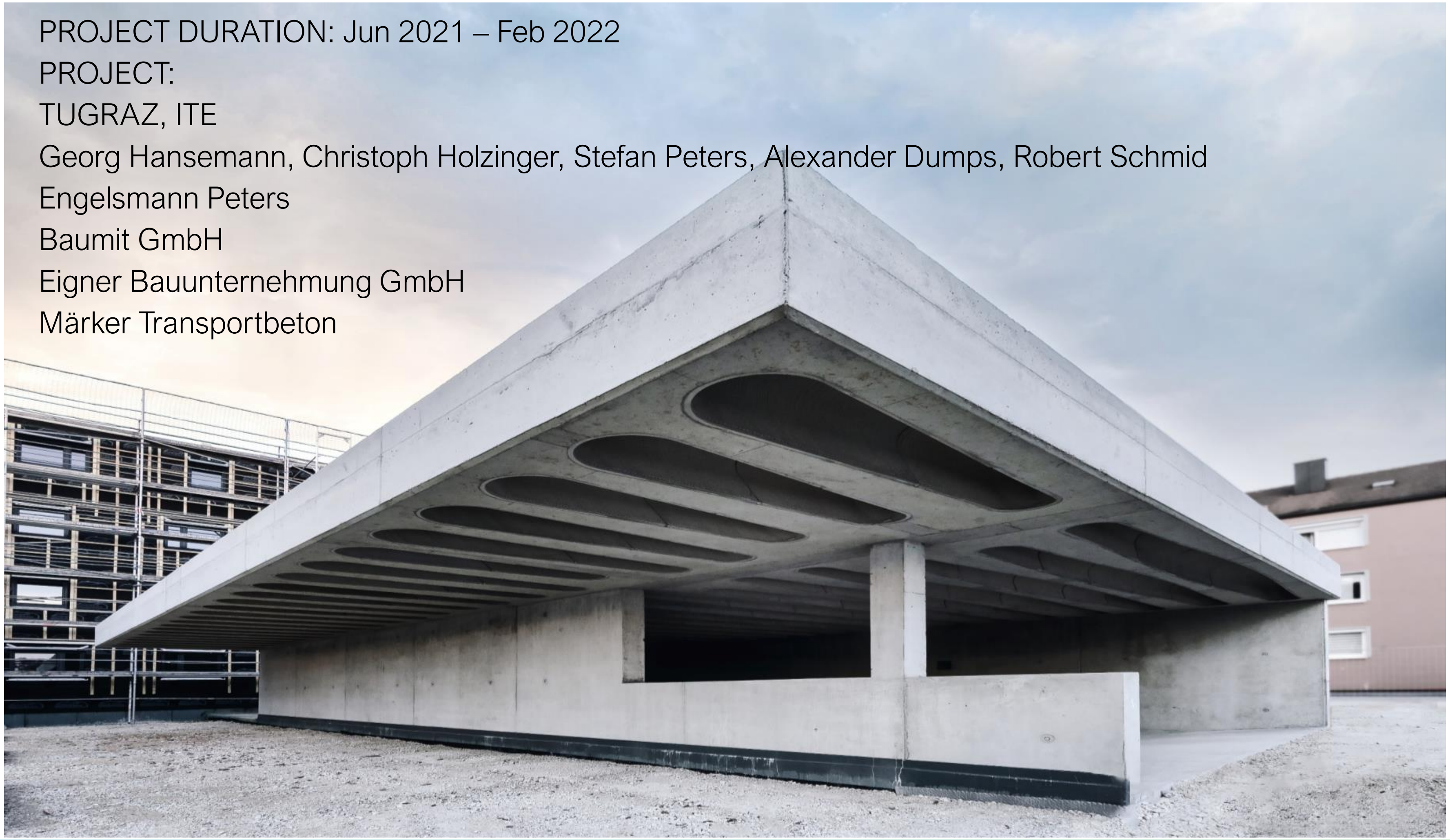


COEBRO:

im Rahmen des Forschungsprojektes wurde zum ersten mal die Bauweise einer materialreduzierten Flachdecke, durch 3D gedruckte Aussparungskörper aus Beton, überprüft. Die Ergebnisse während der Prüfung des Prototypen bestätigen die Gebrauchstauglichkeit und ermöglichen somit den Einsatz im Bauwesen. Im ausgewählte Bereich eines Deckenausschnittes konnten 37 % CO_2 im Vergleich zu einer herkömmlichen Flachdecke gespart werden

Underground parking lot ceiling - NÖRDLINGEN

PROJECT DURATION: Jun 2021 – Feb 2022
PROJECT:
TUGRAZ, ITE
Georg Hansemann, Christoph Holzinger, Stefan Peters, Alexander Dumps, Robert Schmid
Engelsmann Peters
Baumit GmbH
Eigner Bauunternehmung GmbH
Märker Transportbeton



Winner of
Architekturpreis Beton
2023

Underground parking lot ceiling - NÖRDLINGEN

PROJECT DATA:

17m x 10m

160m² roof area

Single-axis clamping

168 printed concrete segments

48 elongated displacement bodies (DB)

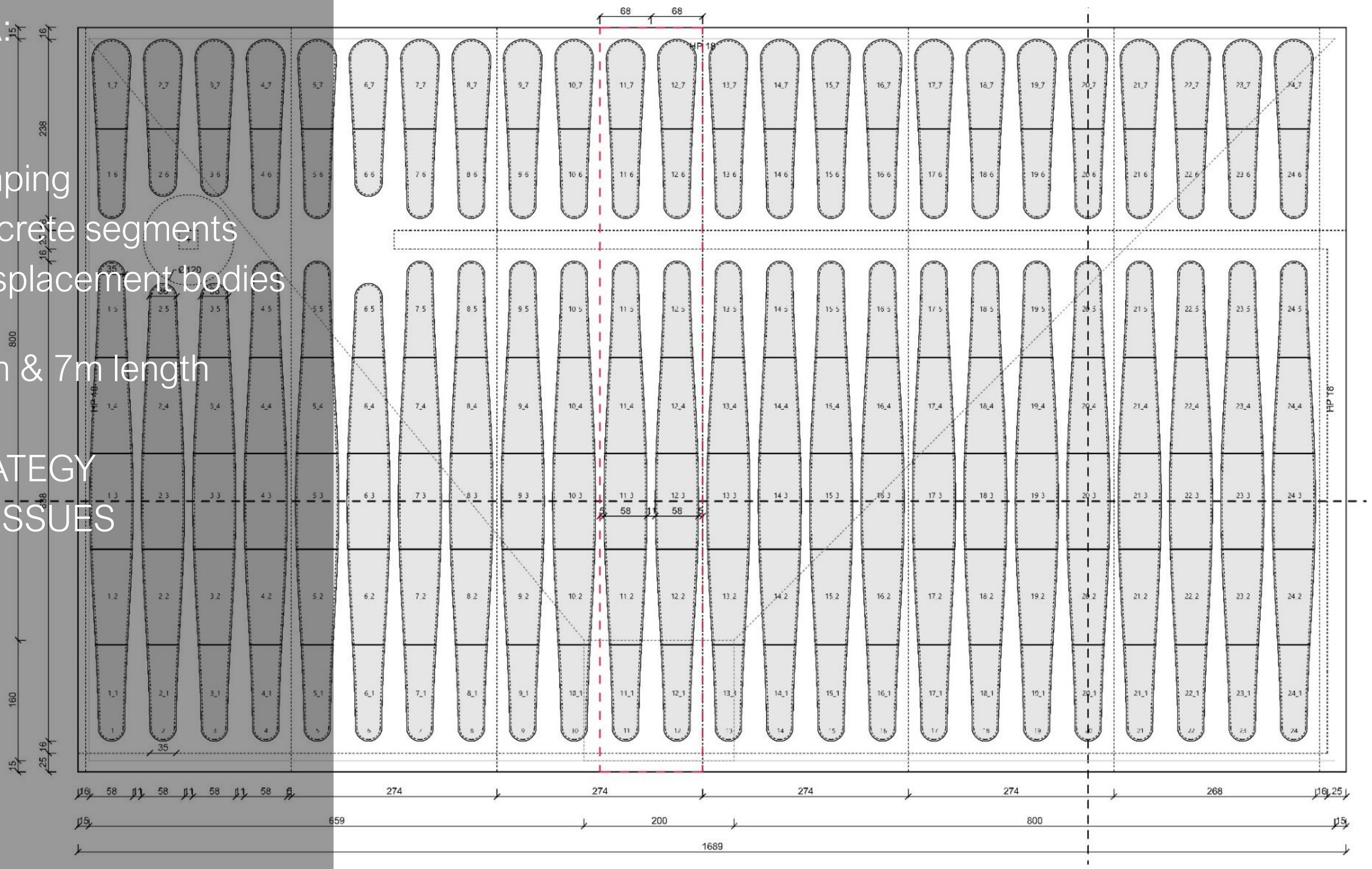
DB. between 2m & 7m length

PRINTING STRATEGY

CONNECTION ISSUES

LOGISTICS

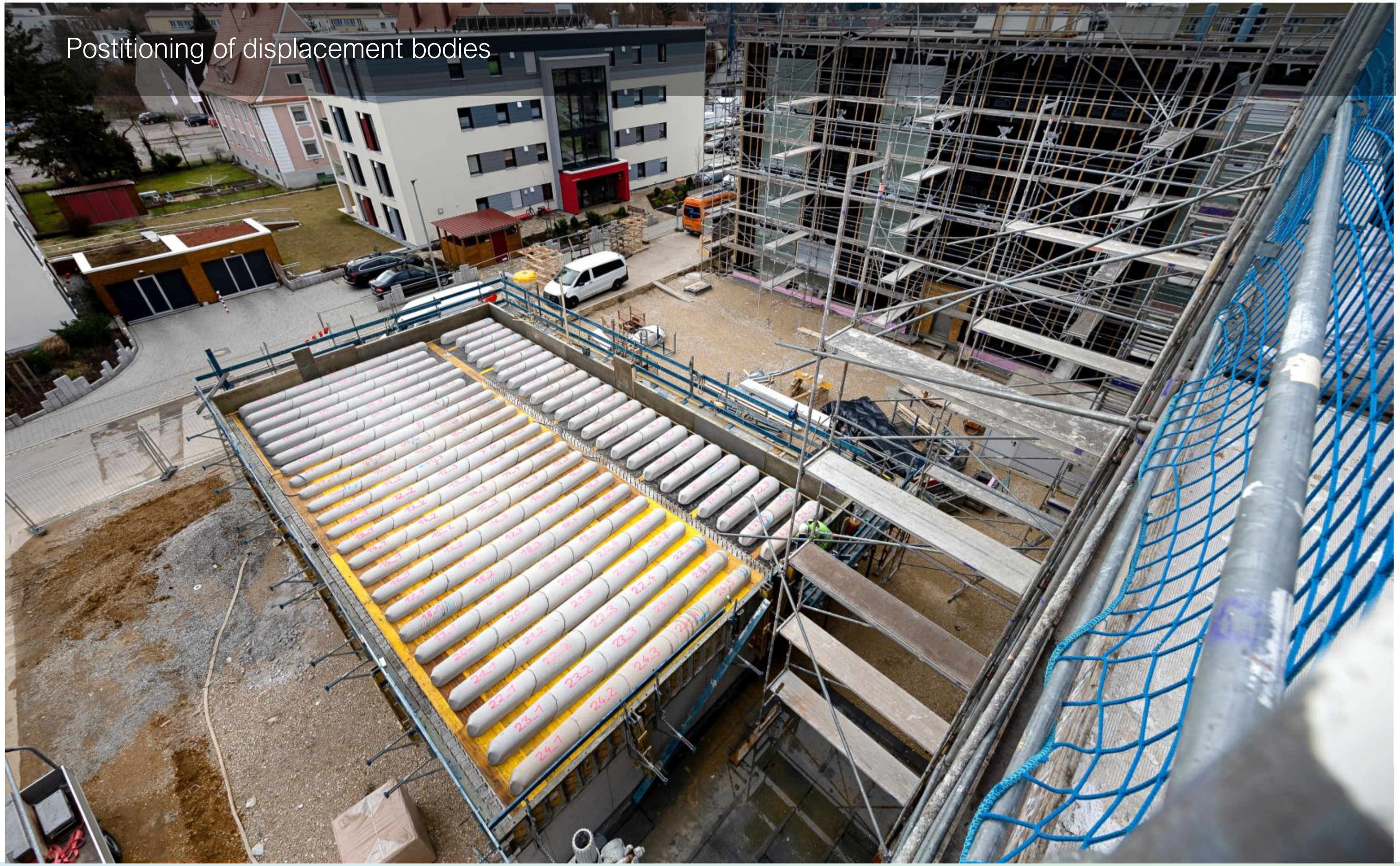
POSITIONING



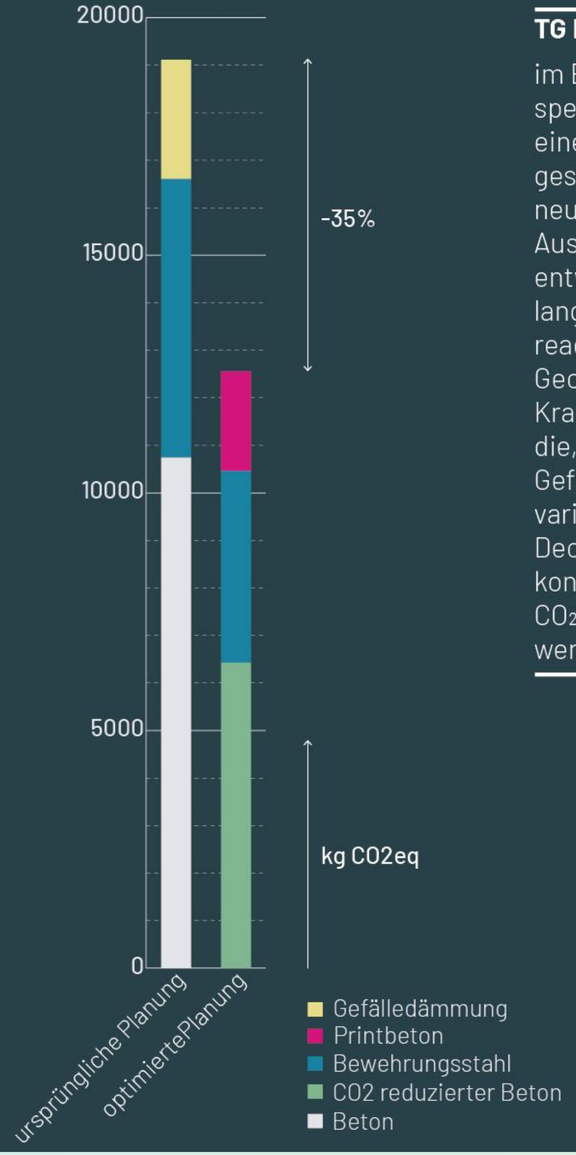
Underground parking lot ceiling - NÖRDLINGEN

Underground parking lot ceiling - NÖRDLINGEN

Underground parking lot ceiling - NÖRDLINGEN



Underground parking lot ceiling - NÖRDLINGEN



TG Decke Nördlingen:

im Bauprojekt wurde speziell für das Design einer einachsig gespannten Decke eine neue Form von Aussparungskörpern entwickelt. Die langgezogenen Körper reagieren mit ihrer Geometrie auf den Kraftfluss sowie auf die, durch den Gefällebeton, variierende Höhe der Decke. Im Projekt konnten somit 35 % CO_2eq eingespart werden.

WERIT WERKSTOFFHOF – Vorarlberg, Bludenz

PROJECT DURATION: Feb 2022 – Mar 2023

PROJECT:

TUGRAZ, ITE

Atelier Ender

gbd ZT

concrete3D

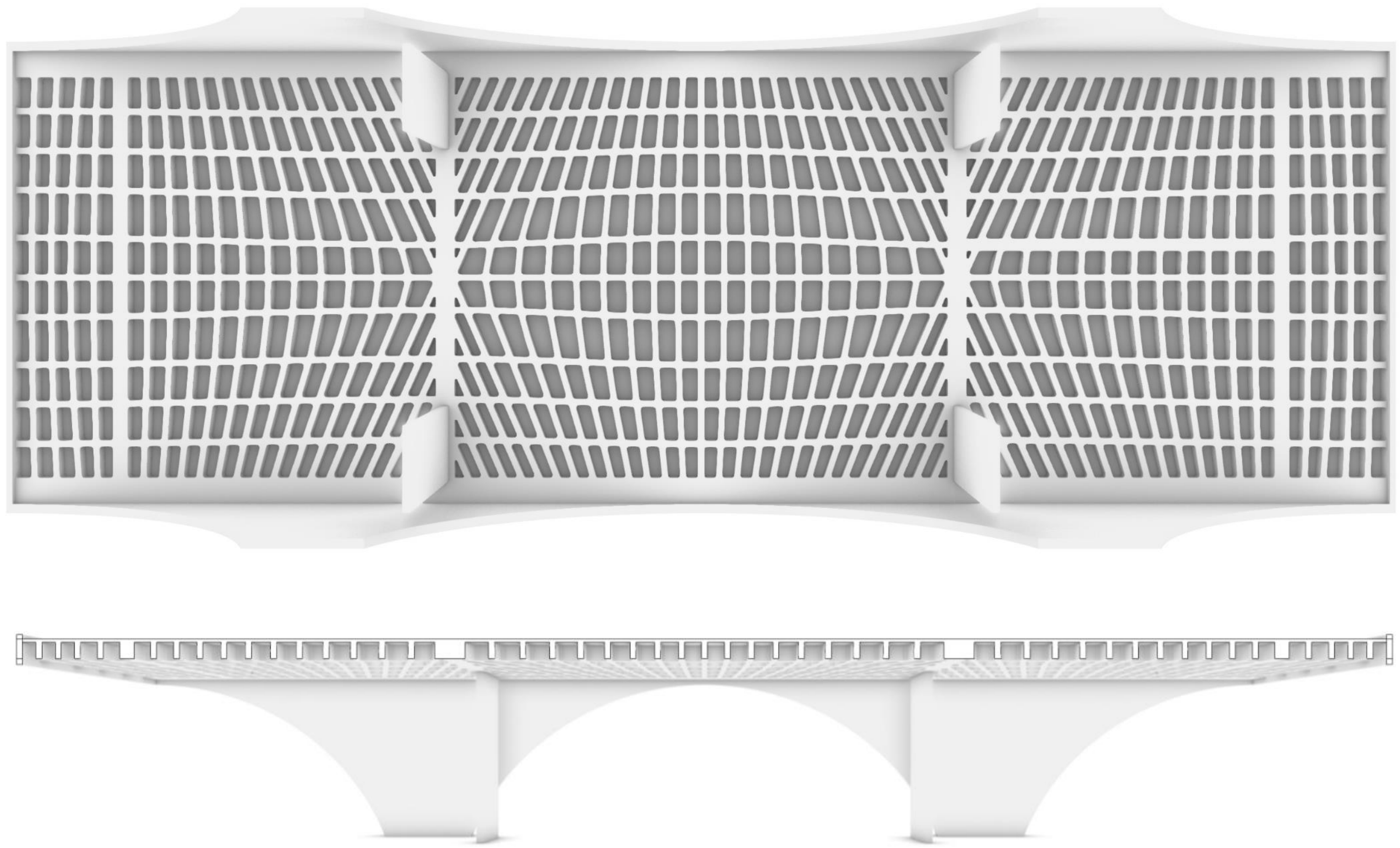
Baumit

Tomaselli Gabriel Bau

WERIT WERKSTOFFHOF – Vorarlberg, Bludenz

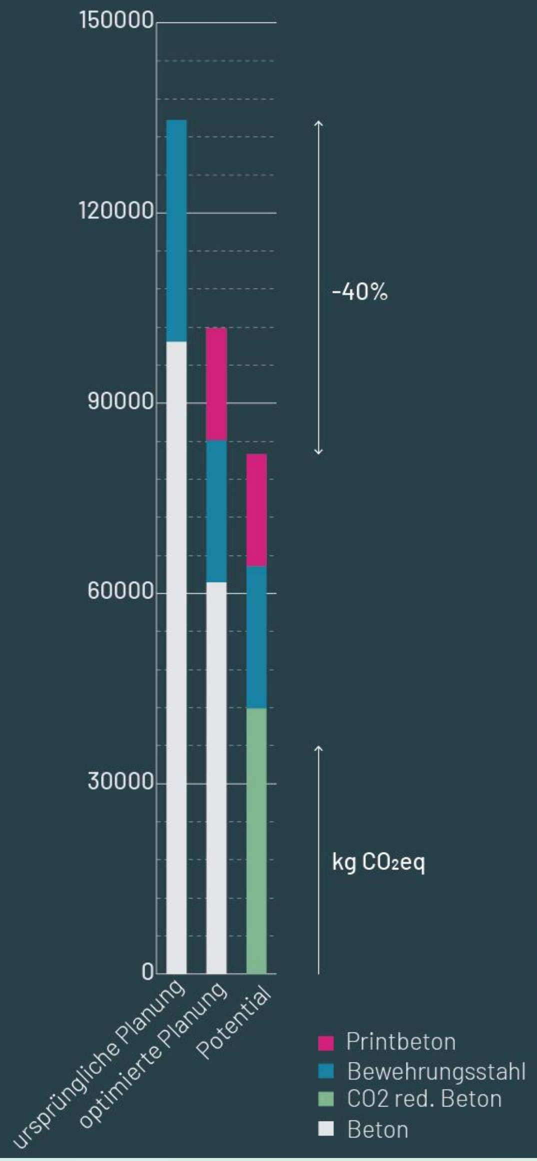
717 m²

792. Displacement bodies („voids“)



WERIT WERKSTOFFHOF – Vorarlberg, Bludenz

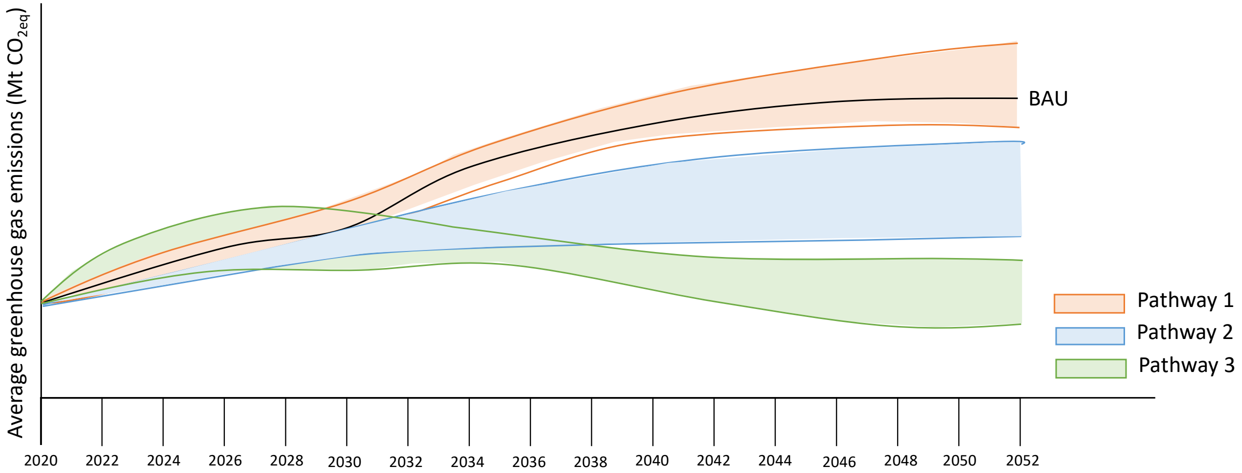
WERIT WERKSTOFFHOF – Vorarlberg, Bludenz



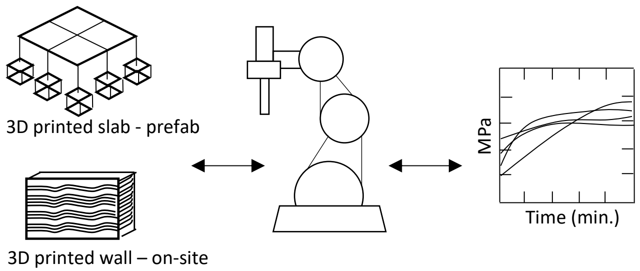
Werkhof Bludenz:

im Bauprojekt konnten durch den Einsatz der 3D Drucktechnologie an die 24% CO_2eq eingespart werden. Das Einsparungspotential wird voll ausgeschöpft wenn der Vergussbeton durch einen Klinker reduzierten Beton ersetzt wird. In diesem Fall erhöht man die Ersparnis im Projekt auf 40 %. Neben dem Beton der durch die Aussparungskörper eingespart wurde konnte durch die Reduktion des Eigengewichtes der Struktur auf einen Anteil des Bewehrungsstahls verzichtet werden.

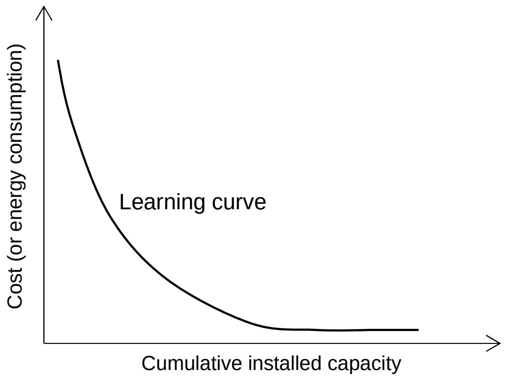
In Summe verursachte die ursprüngliche Planung 135 toCO_2eq, wobei die optimierte Planung mit 102 toCO_2eq auskommt. Somit konnten allein durch das Deckentragwerk 33 toCO_2eq substituiert werden



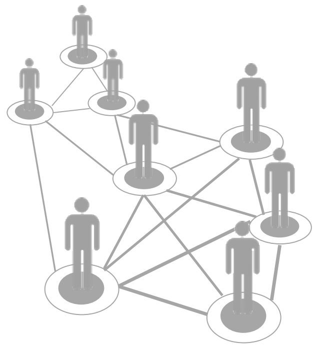
(v) Prospective Life Cycle Assessment



(i) Material testing and selection, structural calculations and printing design



(ii) Upscaling methods – proxy learning curves for future implementation predictions



(iii) Expert interviews for stakeholder perspective + Agent based modelling for client acceptance

	Scenario 1	Scenario 2	Scenario 3	...
Robot efficiency low	x			
Robot efficiency high		x	x	
Electricity 100% renewable		x	x	
Electricity 50% renewable	x			
Clinker content high	x	x		
Clinker content low			x	
...				
[Parameter n] high		x		
[Parameter n] low	x		x	

(iv) Scenario definitions

Source: Saade, Passer, Trummer and Peters (2021) – starting grant proposal – TU Graz


“Efficiency first” in the
embodied emissions realm:
low risk, low cost, low impact

TU Graz

INSTITUTE
OF
STRUCTURAL
DESIGN

www.ite.tugraz.at

tragwerksentwurf@tugraz.at

Phone: +43(0)316/873-6211