Evolving the well-established

Decarbonisation and preservation of natural resources along the cement and concrete value chain

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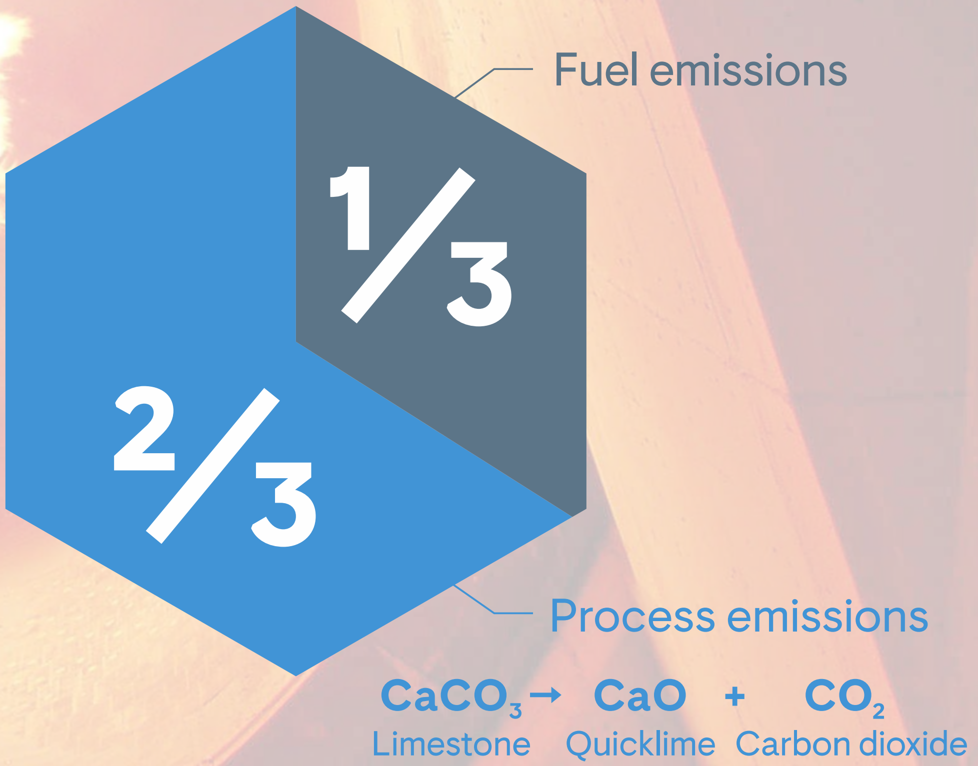
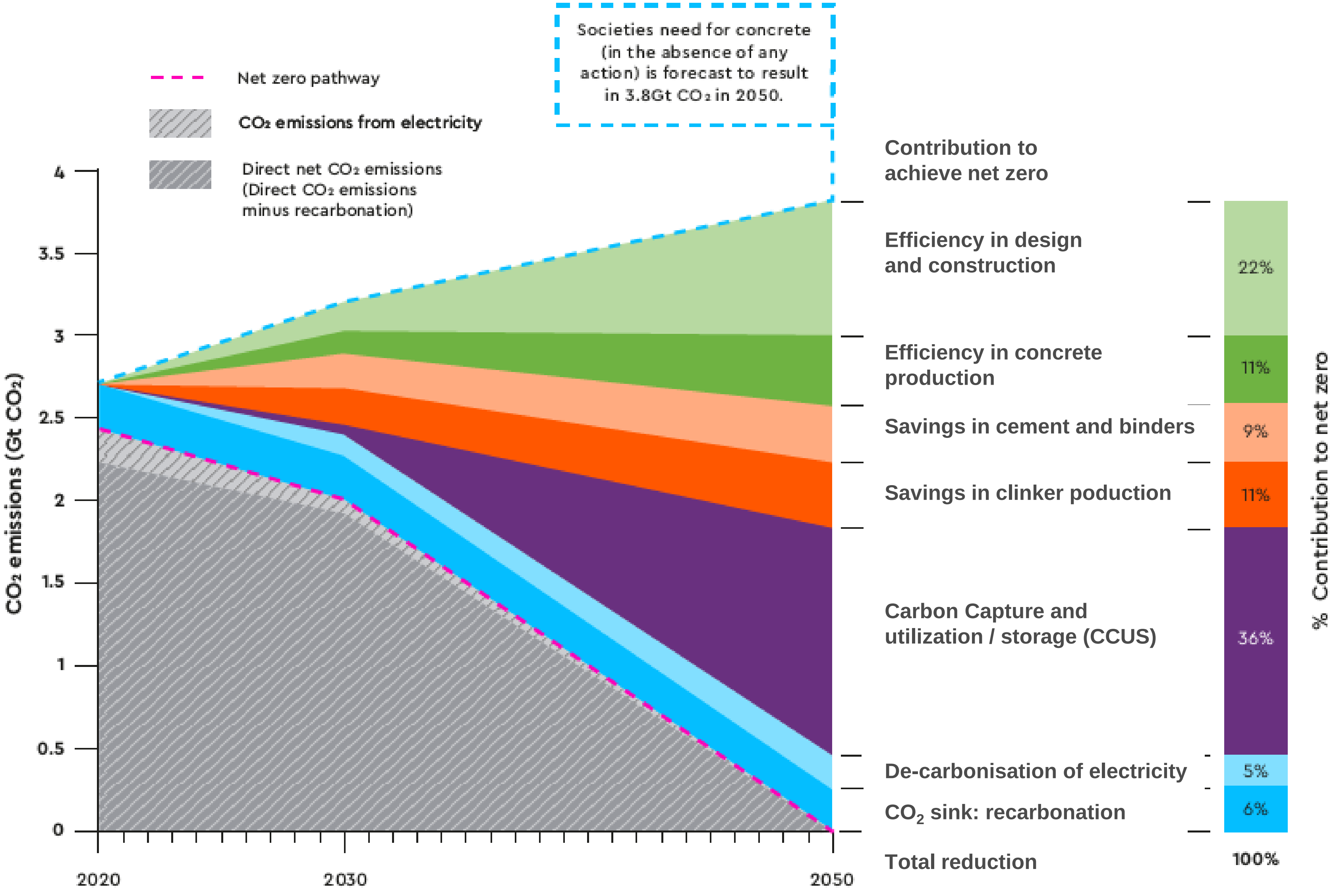
C2 Congress: Green Cement & Concrete 2050
May 6 – 9 2024, Guatemala (virtual presentation)

Portland cement clinker

- Main constituent of cement
- Burned limestone
- Temperature up to 1450 °C



GCCA-Roadmap for Net Zero Concrete



- Net Zero Concrete requires a broad mix of measures along the value chain
- The use of low carbon cement, concrete and structures are main levers
- Carbon capture to be used to achieve net zero cement and concrete

Source: GCCA/VDZ

Clinker/cement-ratio

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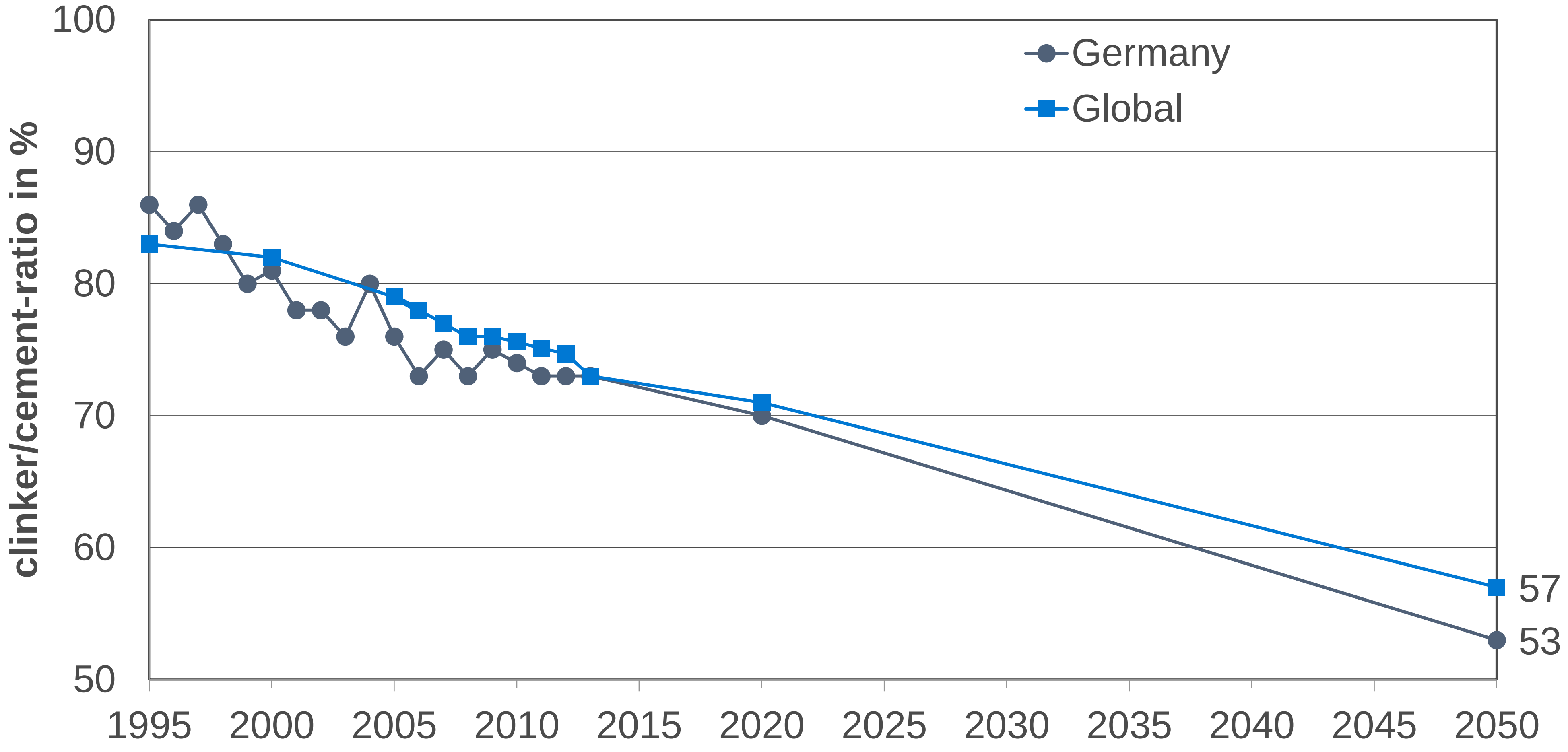

Estimation of possible SCM‘s for cement - worldwide

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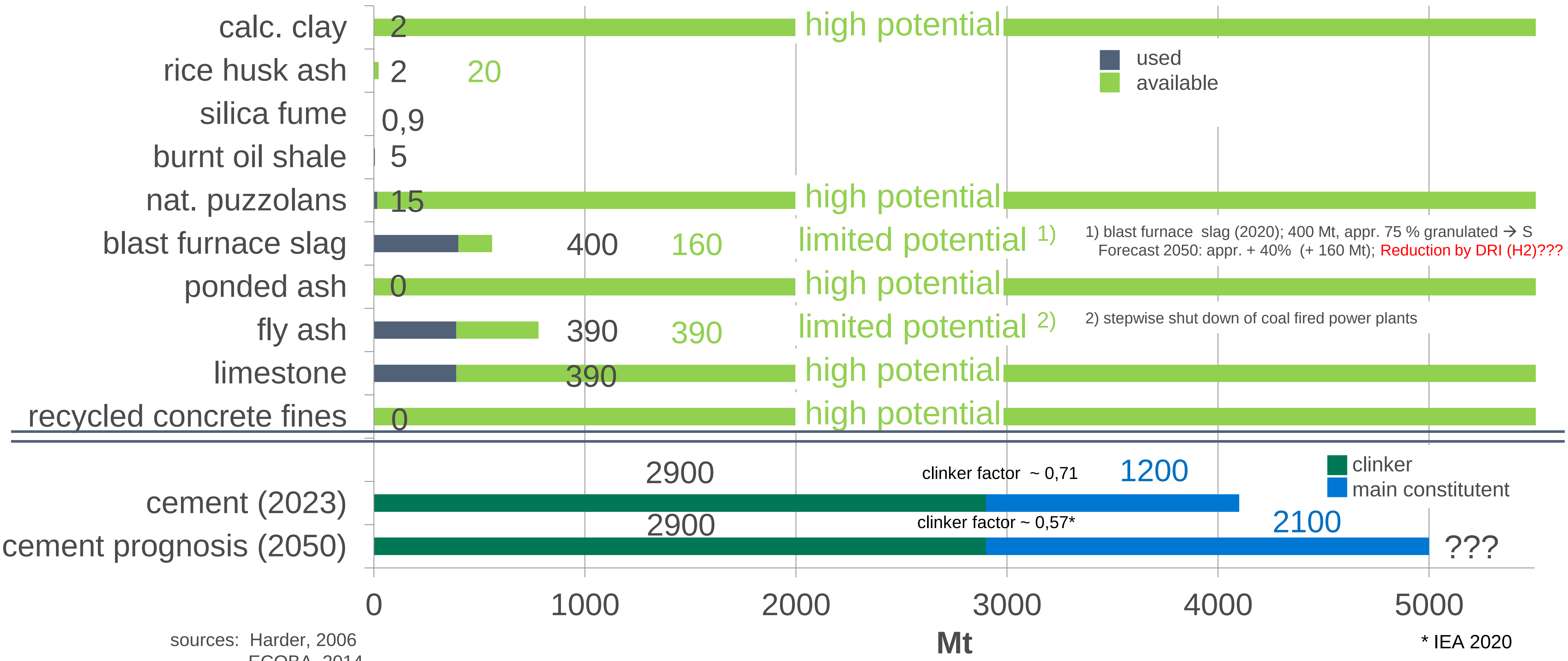


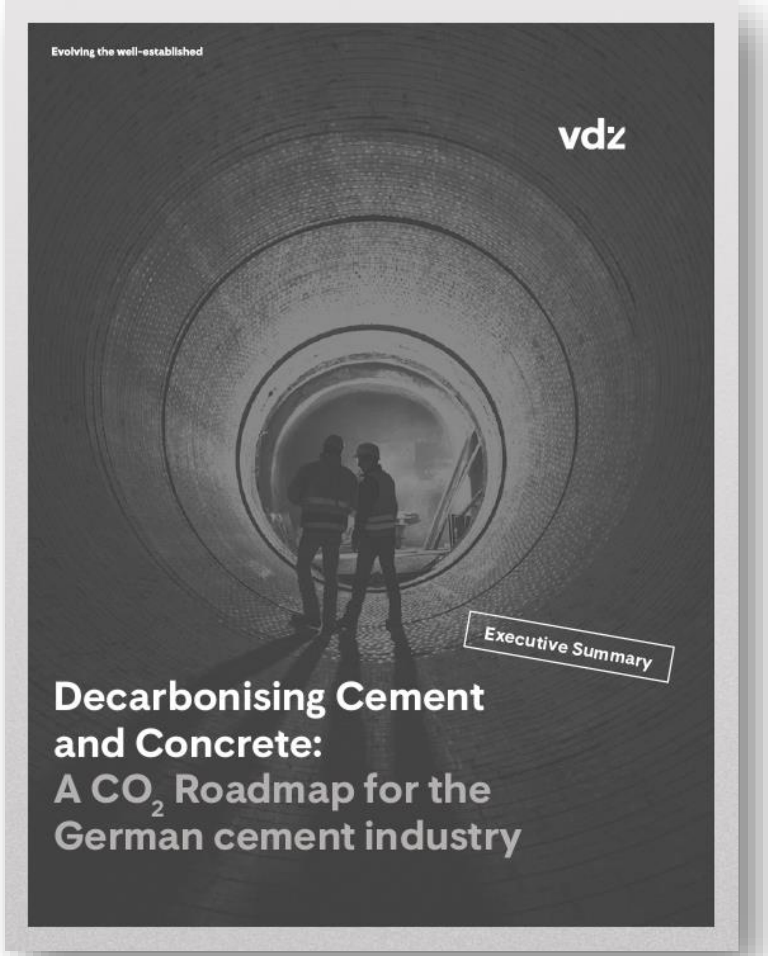
sources: Harder, 2006
ECOBA, 2014
Heidrich;Feuerborn;Weir, 2013
Schulze, Diss. 2014
FEhS, 2020

Decarbonising Cement and Concrete

Key questions of the CO_2-Roadmap

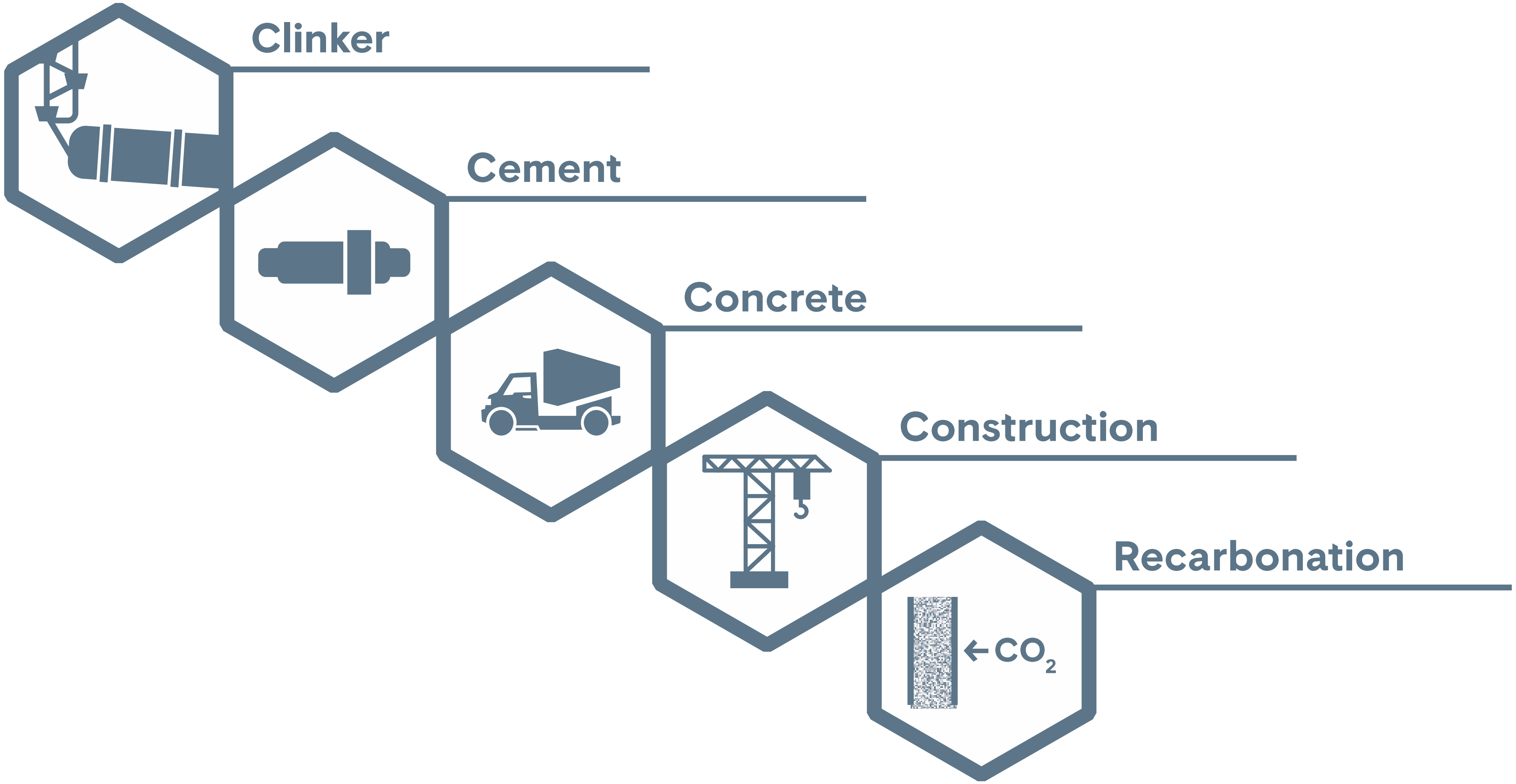
- Is a climate-neutral cement & concrete value chain possible?
- What challenges does the industry face regarding decarbonisation?
- Which technologies and innovations are necessary?
- What are the (external) prerequisites for climate-neutral concrete construction?

https://www.vdz-online.de/en/knowledge-base/publications/decarbonising-cement-and-concrete-a-co2-roadmap-for-the-german-cement-industry



Holistic approach for climate neutrality

CO_2 reduction along the value chain



Source: VDZ, based on CEMBUREAU's 5C approach

CO_2 reduction in the climate neutrality scenario until 2045

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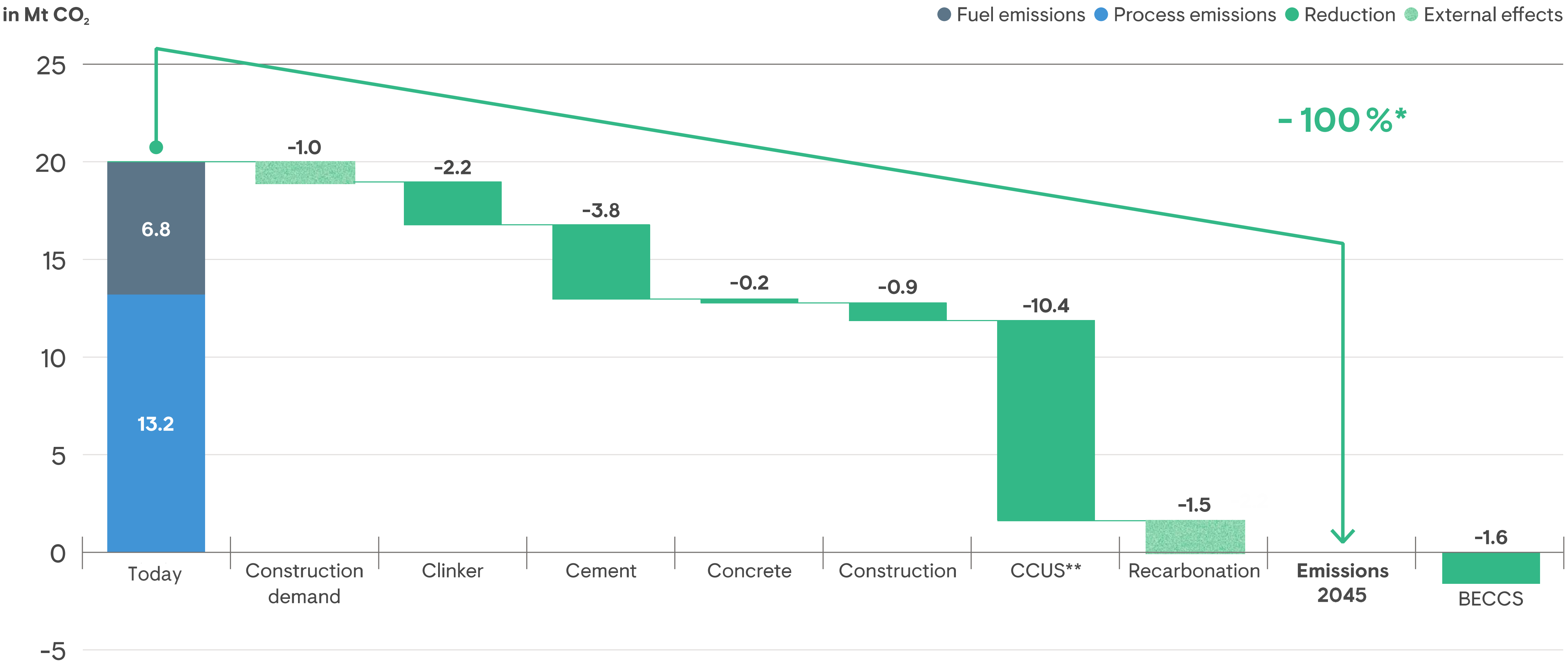
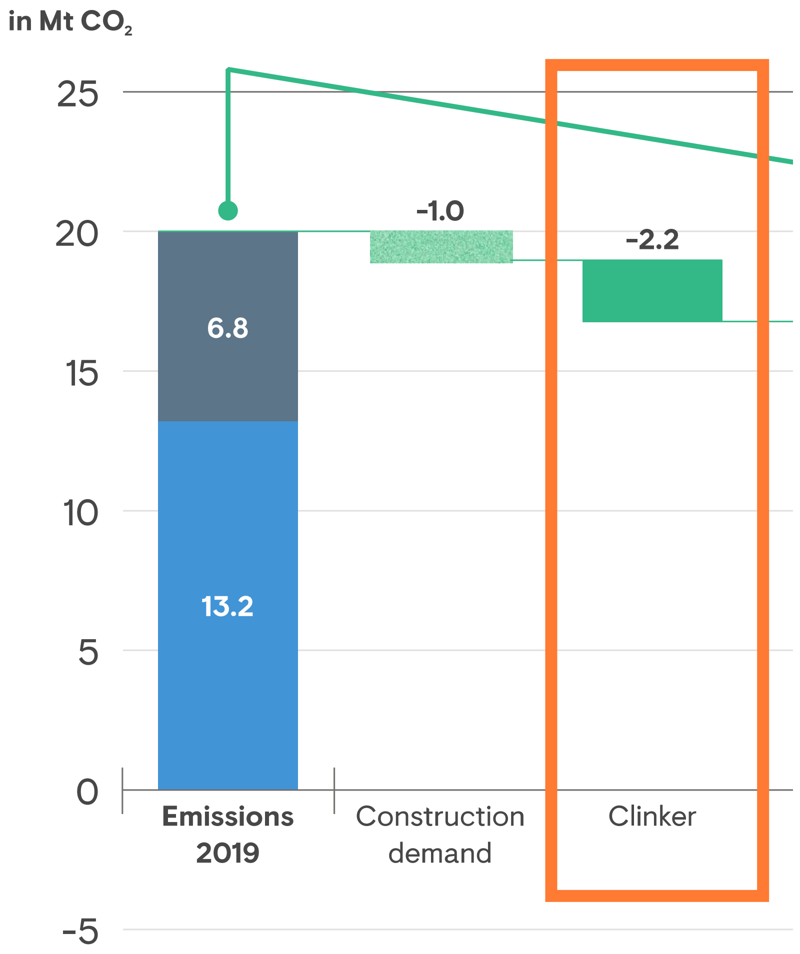


Source: VDZ / Notes: *Thereof about 88 % reduction through measures along the value chain. Remaining emissions are reduced by a decreasing construction demand as well as the contribution of recarbonation. ** CCUS: Carbon Capture technologies aiming at reducing CO_2 emissions in the atmosphere through CO_2 storage (CCS) and appropriate procedures for CO_2 utilisation (CCU). BECCS: Bioenergy with Carbon Capture and Storage

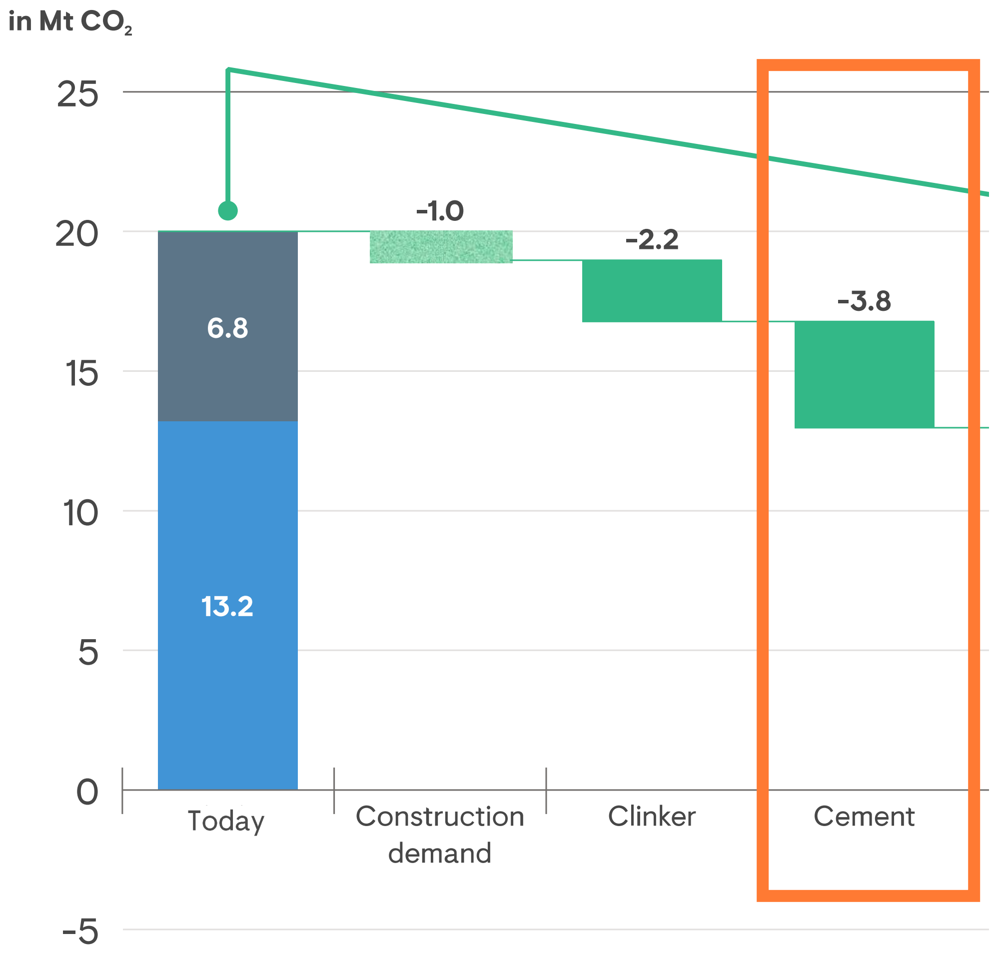
CO_2 reduction in the climate neutrality scenario until 2045



- Thermal efficiency: +13%
- Alternative fuels: 90% (of which 35% biomass)
- 10% hydrogen
- Use of CCUS

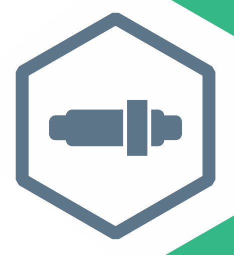
CO_2 reduction in the climate neutrality scenario until 2045

vdz



Fuel emissions · Process emissions · Reduction · External effects

- Thermal efficiency: +13%
- Alternative fuels: 90% (of which 35% biomass)
- 10% hydrogen
- Use of CCUS



- Focus on CEM II/C and CEM VI
- Clinker-cement factor 53%
- 5% market share of new binders

CO_2 reduction in the climate neutrality scenario until 2045

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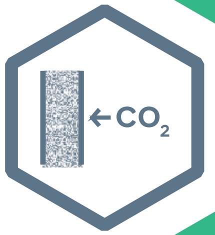
- Differentiated use of cement in concrete depending on requirement profile

- Further material savings, e.g. new concrete construction methods (incl. carbon concrete, additive production)
- Further industrialisation



- Recarbonation of 20% of process emissions

CO_2 reduction of ceiling systems by CO_2 optimized concrete

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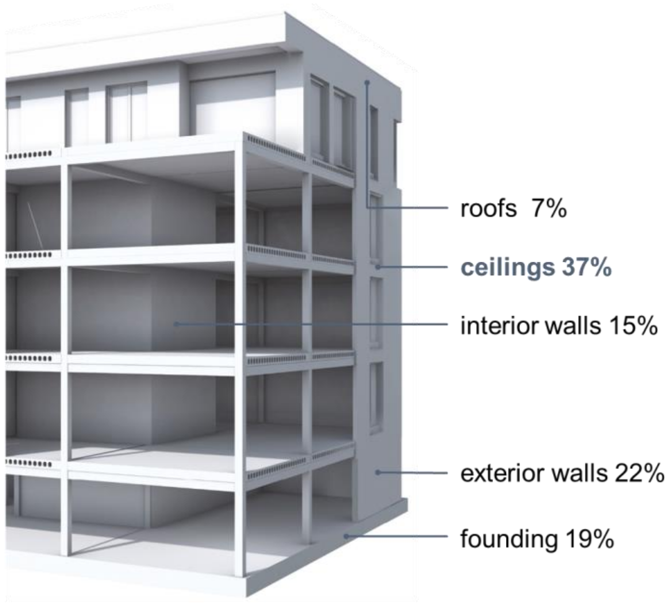
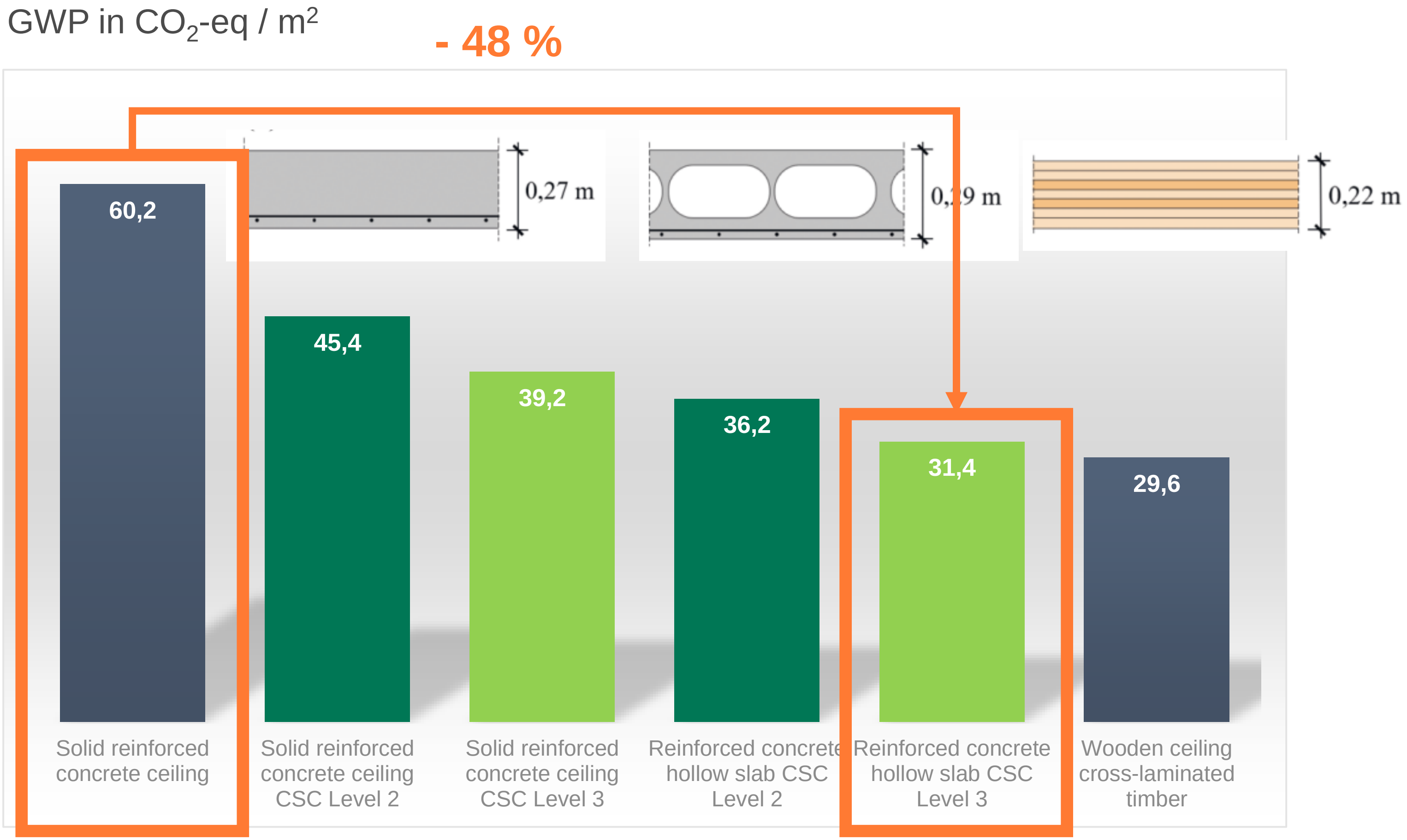


100 % = 7.37 kg CO_2-eq/(m^2 NRA x a)

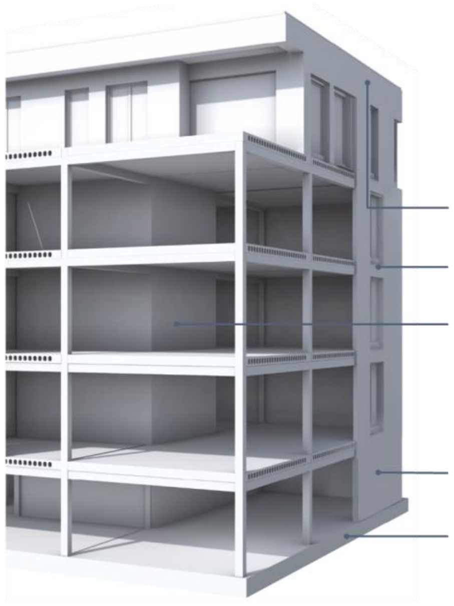
note: NRA = Net Room Area; a = 50 years

Source:
Sustainable building with concrete (in Germany)
www.beton.org



Source: Heidelberg Materials Germany – Customer magazine CONTEXT 01/2024 (modified)

CO_2 reduction of ceiling systems by CO_2 optimized concrete



100 % = 7.37 kg CO_2-eq/(m^2 NRA x a)

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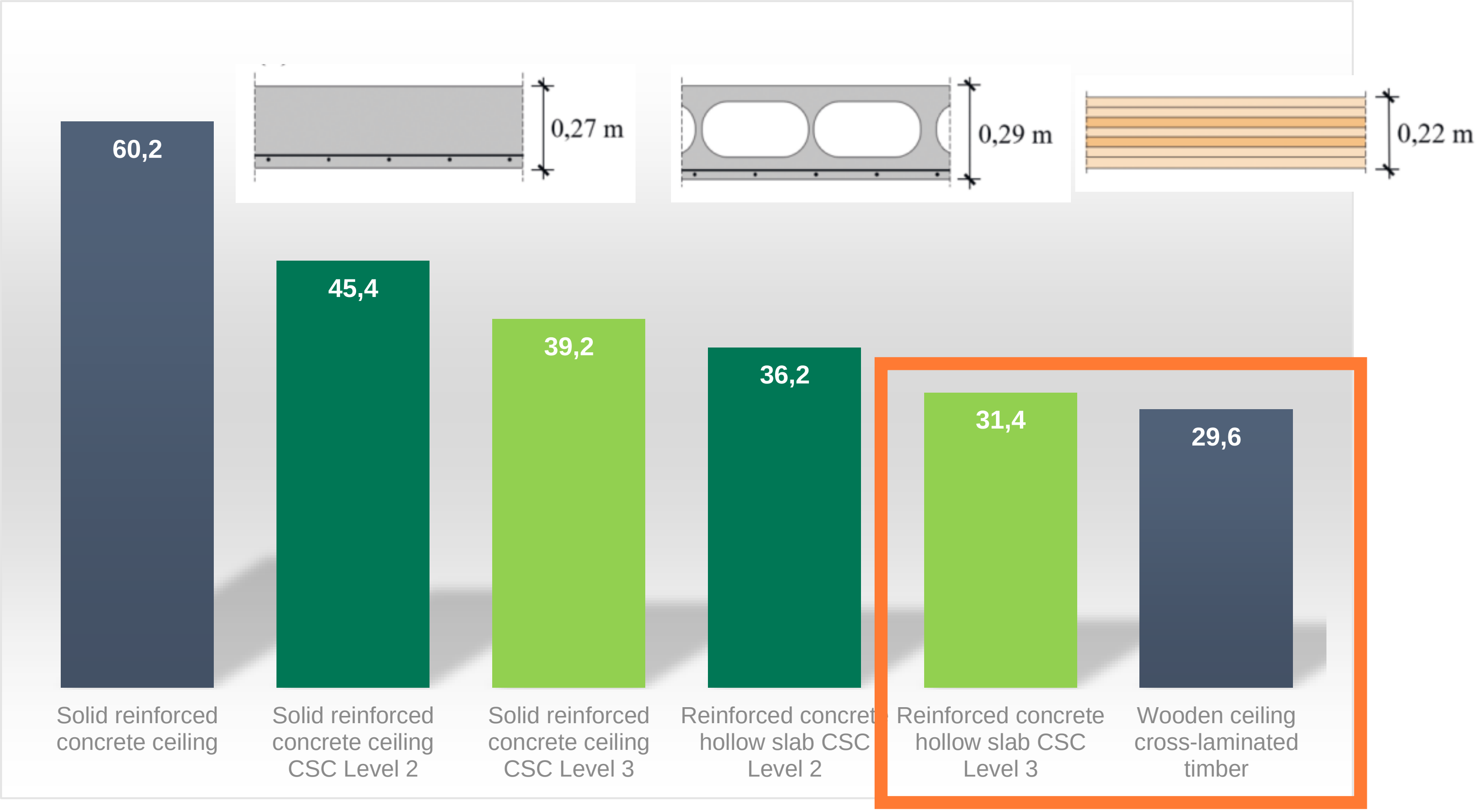
GWP in CO_2-eq / m^2



Source: Heidelberg Materials Germany – Customer magazine CONTEXT 01/2024 (modified)

New clinker efficient cements CEM II/C and CEM VI

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European cement standard EN 197-5

Main types	Notation of the products (types of common cement)		Composition (percentage by mass[a])										
			Main constituents										Minor additional constituents
			Clinker	Blast-furnace slag	Silica fume	Pozzolana		Fly ash		Burnt shale	Limestone		
						natural	natural calcined	siliceous	calca-reous				
	Name	Abbreviation	K	S	D[b]	P	Q	V	W	T	L[c]	LL[c]	
CEM II	Portland-composite	CEM II/C-M	50-64	‹--- 36-50 ---›									0-5
CEM VI	Composite cement	CEM VI (S-P)	35-49	31-59	–	6-20	–	–	–	–	–	–	0-5
		CEM VI (S-V)	35-49	31-59	–	–	–	6-20	–	–	–	–	0-5
		CEM VI (S-L)	35-49	31-59	–	–	–	–	–	–	6-20	–	0-5
		CEM VI (S-LL)	35-49	31-59	–	–	–	–	–	–	–	6-20	0-5

[a] The values in the table refer to the sum of the main and minor additional constituents.

[b] The proportion of silica fume is limited to 10 %.

[c] The proportion of limestone (sum of L, LL) is limited to 6-20 %.

[d] The number of main constituents other than clinker is limited to two and these main constituents shall be declared by designation of the cement.

- CEM II/C-M
- **Min. clinker content: 50 %**
- **Unburned limestone: 20 %**
- Example:

  CEM II/C-M (S-LL)

  CEM II/C-M (V-LL)
- Increasing the range of constituents, that are only available in limited quantities, e.g. blast furnace slag or fly ash

New clinker efficient cements CEM II/F with recycled concrete fines

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European cement standard EN 197-6

Main types	Notation of the products (types of cement)		Composition (percentage by mass) [a]											
			Main constituents											Minor additional constituents
			Clinker	Recycled concrete fines	Blast-furnace slag	Silica fume	Pozzolana natural	Pozzolana natural calcined	Fly ash siliceous	Fly ash calcareous	Burnt shale	Limestone		
	Type name	Type notation	K	F	S	D [b]	P	Q	V	W	T	L [c]	LL [c]	
CEM II	Portland-recycled-fines cement	CEM II/A-F	80–94	6–20	—	—	—	—	—	—	—	—	—	0–5
		CEM II/B-F	65–79	21–35	—	—	—	—	—	—	—	—	—	0–5
	Portland-composite cement [d]	CEM II/A-M	80–88	6–14	‹—— 6–14 ——›									0–5
		CEM II/B-M	65–79	6–29	‹—— 6–29 ——›									0–5
		CEM II/C-M	50–64	6–20	‹—— 16–44 ——›									0–5
CEM VI	Composite cement	CEM VI	35–49	6–20	31–59	—	—	—	—	—	—	—	—	0–5

a The values in the table refer to the sum of the main and minor additional constituents.

b In case of the use of silica fume, the proportion of silica fume is limited to 6 % to 10 % by mass.

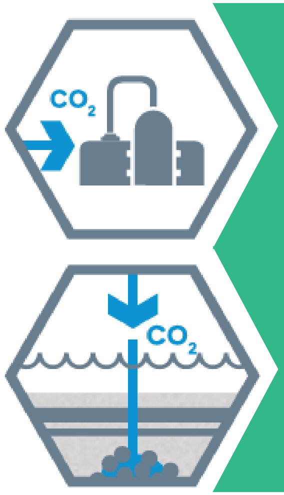
c In case of the use of limestone, the proportion of the sum of limestone and recycled concrete fines (sum of L, LL and F) is limited to 35 % by mass.

d The number of main constituents other than clinker is limited to two and these main constituents shall be declared by designation of the cement (for examples, see Clause 6). In case of the use of both F and (L or LL) in the composition, the number of main constituents other than clinker is limited to three and these main constituents shall be declared by designation of the cement.

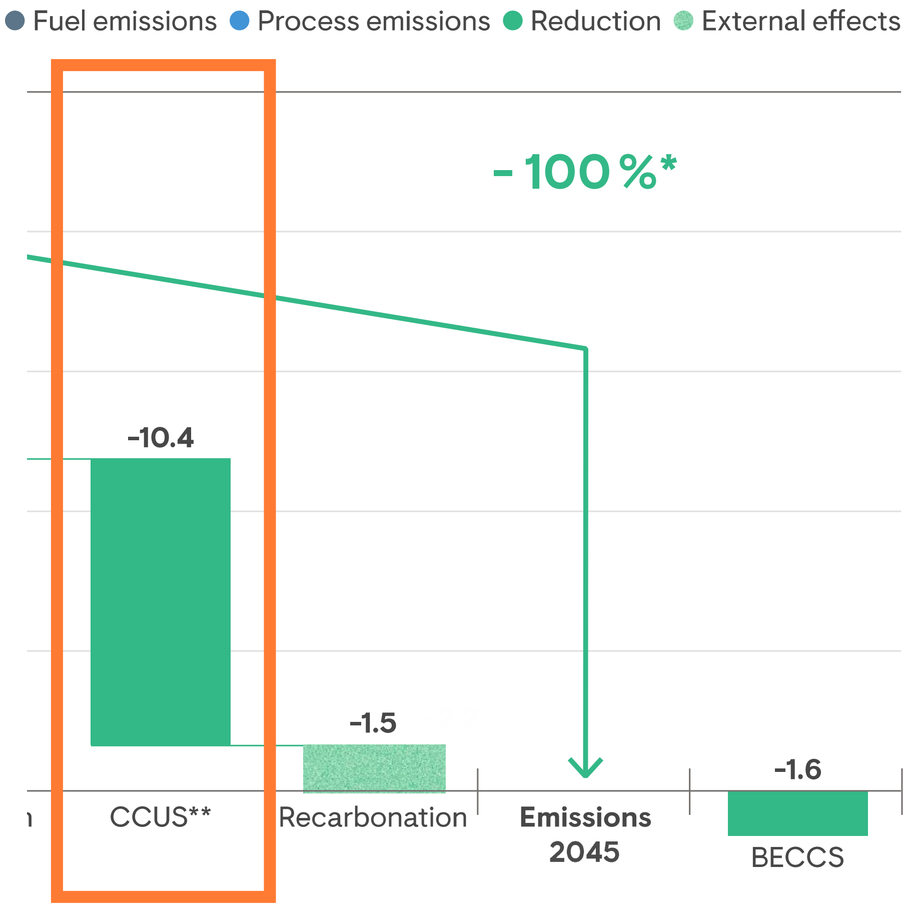
- well-tried and proven constituents combined with recycled concrete fines
- cements can be used in several applications
- application acc. to national rules

CO_2 reduction in the climate neutrality scenario until 2045

in Mt CO_2



- based on the prerequisite that all other potential reduction levers have been exhausted CCUS is essential to decarbonise the sector
- high energy demand, approx. more than double the amount for clinker production



CO_2 reduction in the climate neutrality scenario until 2045

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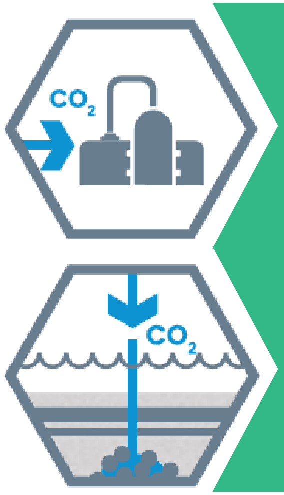
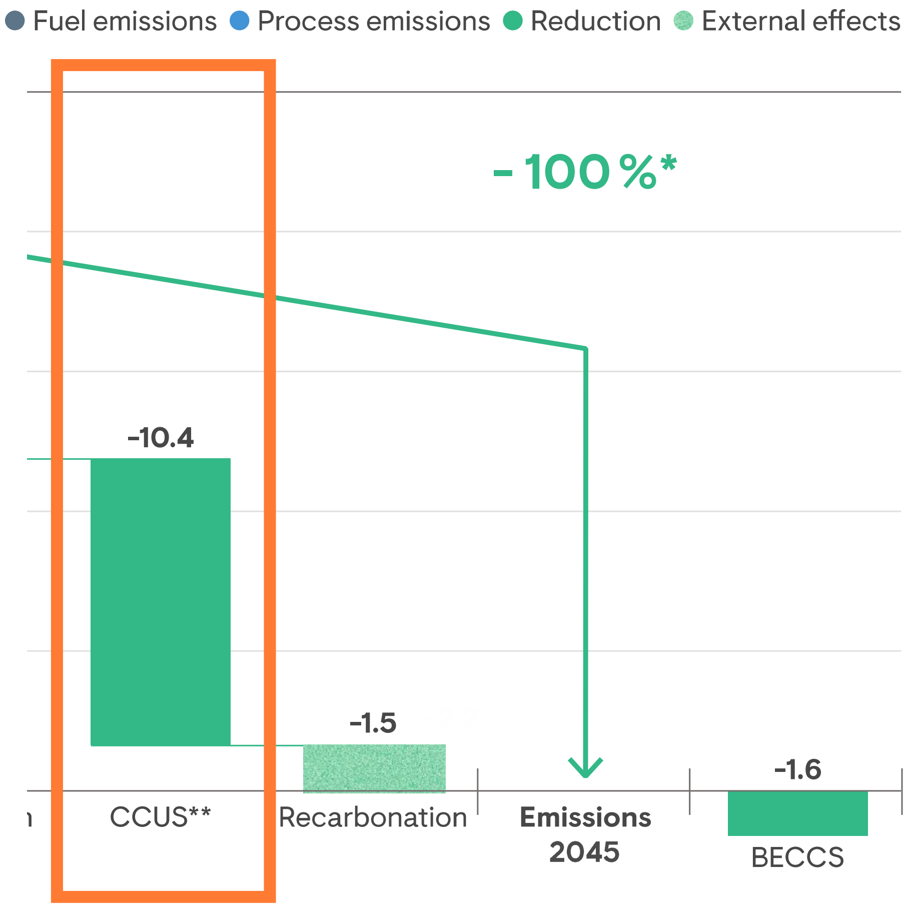
Cost estimations

in Mt CO_2



- Germany: 14bn € for 4800 km pipelines
- CO_2 capture + processing: 80-110 €/t CO_2
- CO_2 transport: 25-60 €/t CO_2
- CCU: 200-400 €/t CO_2
  CCS: 10-50 €/t CO_2



Prerequisites for a climate neutral industry

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Five central fields of activity

- Availability of renewable energy and power grids
- Suitable infrastructure for CO_2 transport
- Policy framework for compe-titiveness and innovation
- Markets for low- and carbon-neutral cement and concrete
- Societal acceptance for industrial transformation

Source: VDZ

Primary materials for cement and concrete production today

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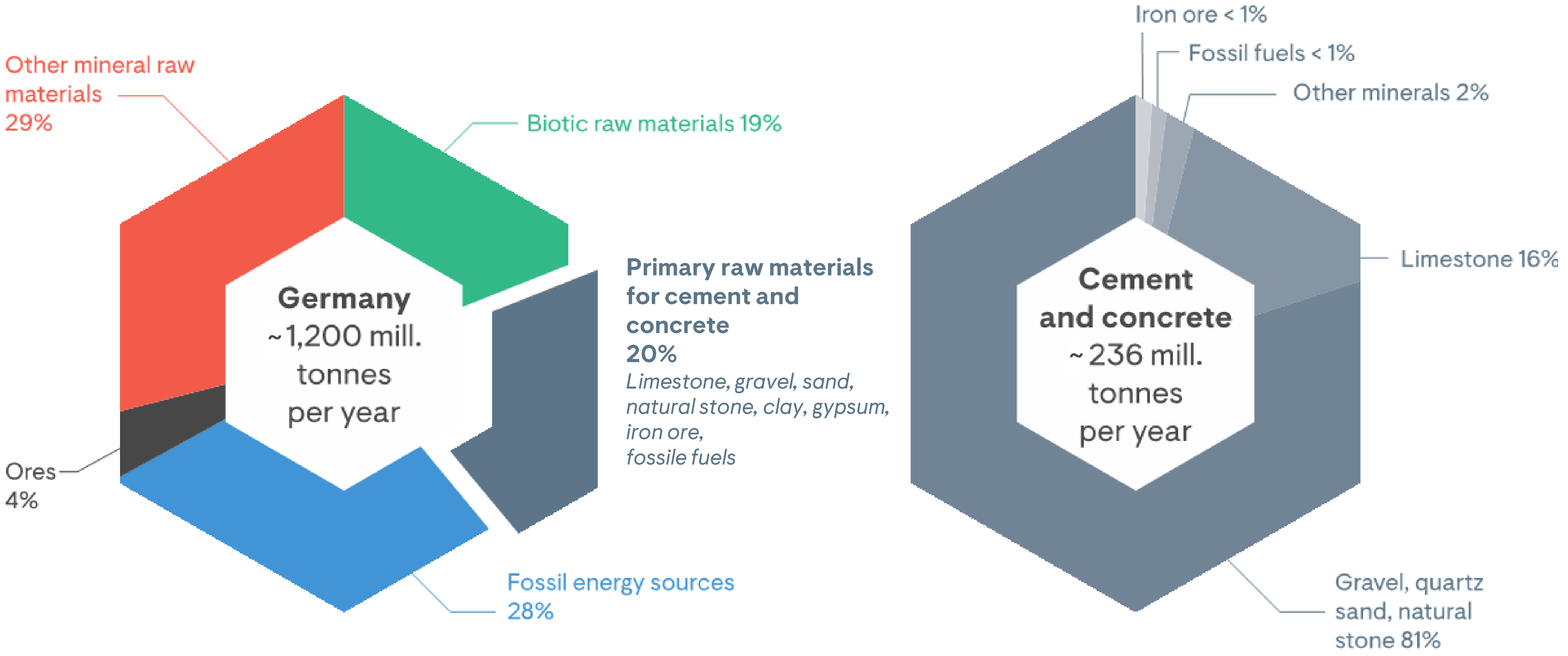
Around 20% of primary raw material are used for cement and concrete

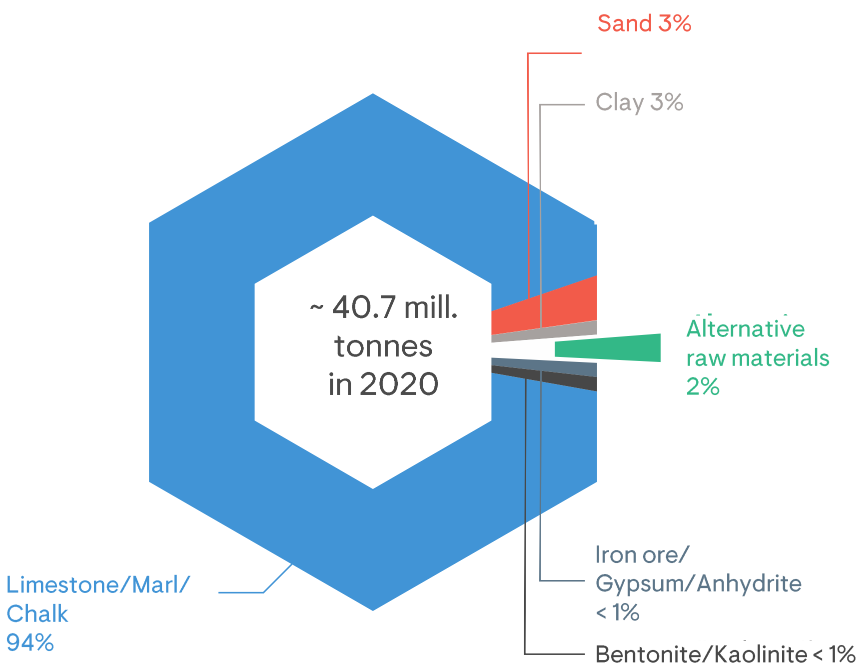


Sources: *German Federal Statistical Office, VDZ, German Association of Mineral Raw Materials e.V.*

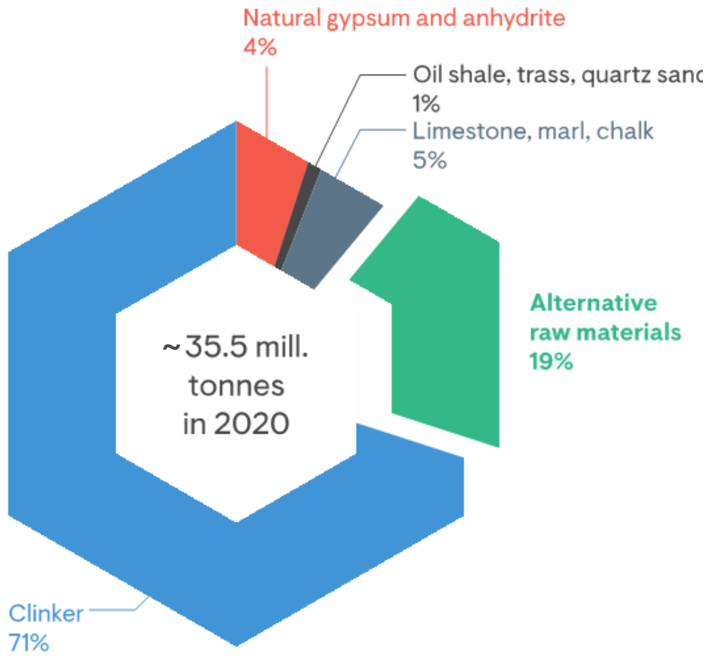
Resource savings – today`s status

More than 10 million tonnes of industrial by-products and recycled products in use

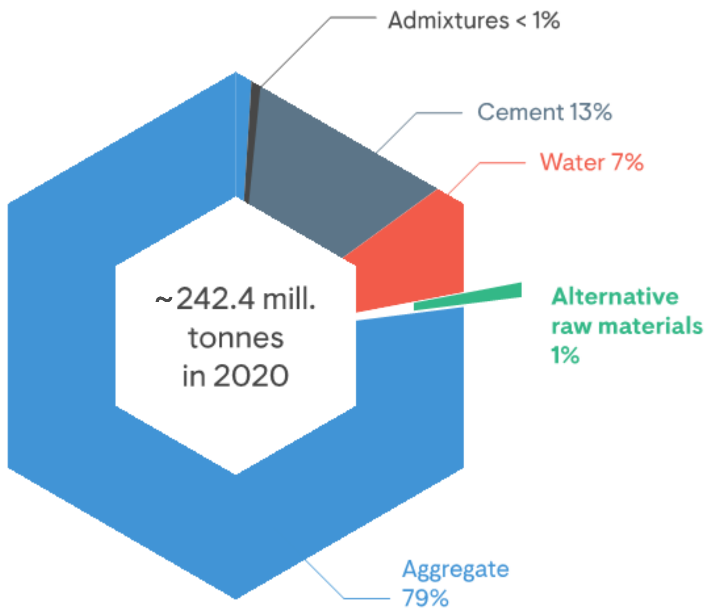
Clinker



Cement



Concrete



source: VDZ

Resources of the future for cement and concrete

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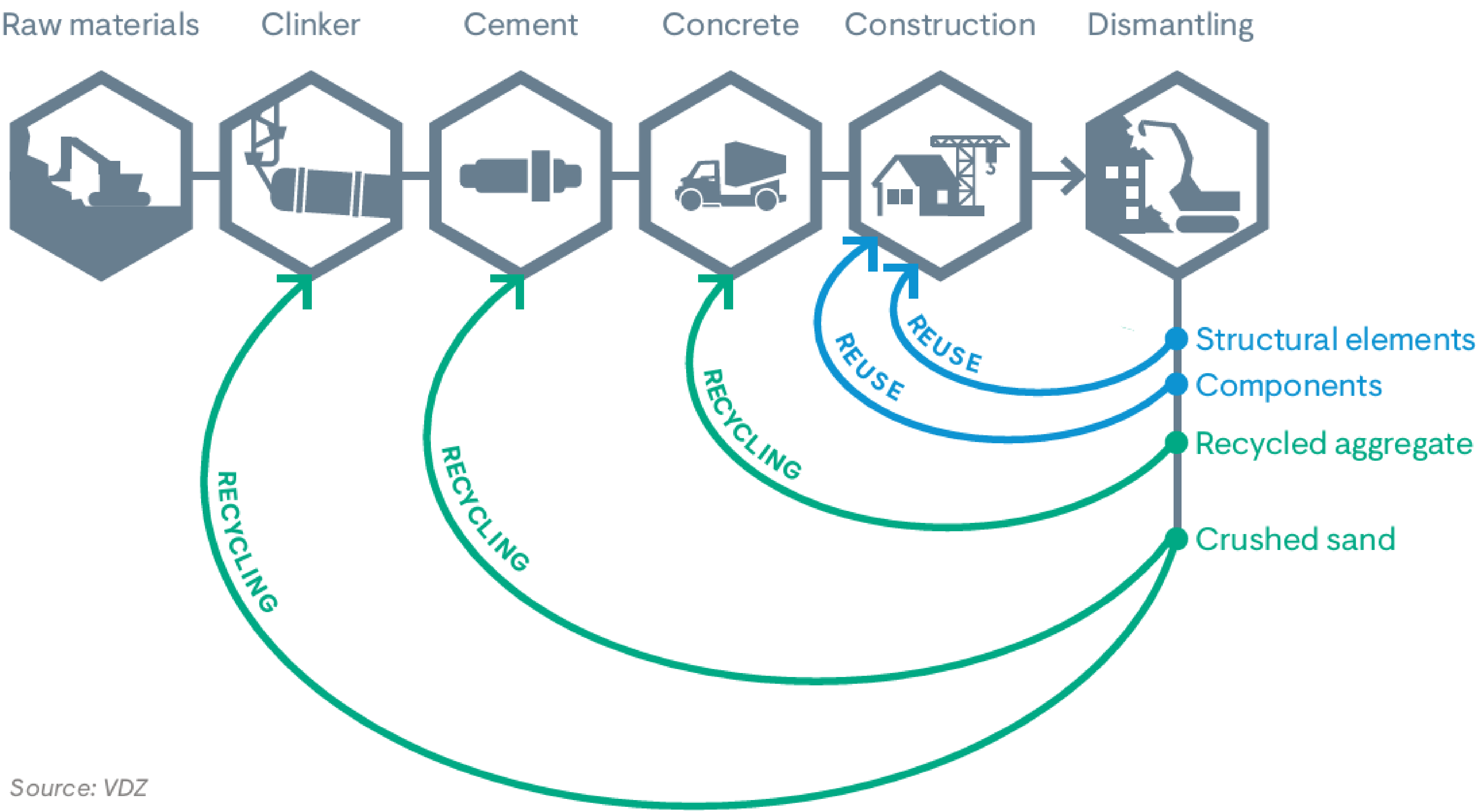
Key questions of the Resource-Roadmap

- To what extent can natural resources or raw materials be saved along the value chain of cement and concrete?
- Which technologies and innovations are required?
- What are the prerequisites for resource-saving concrete construction?
- What challenges does the industry face in reducing its use of raw materials?

https://www.vdz-online.de/en/cement-industry/raw-materials-and-biodiversity

Holistic approach

Resource conservation and circular economy along the value chain



Source: VDZ

Assumptions for savings of primary materials - 2050

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- 5 % drop in demand for concrete

- 3.9 mill. tonnes of recycled fines, 4.3 mill. tonnes of calcined clays and 1.0 mill. tonnes of limestone as substitute for clinker, blast furnace slag and fly ash

- Reduction of the clinker-cement factor to 53 %
- 2.5 mill. tonnes of recycled fines as raw meal component

- 53.3 mill. tonnes of recycled aggregates in concrete
- Cement and rock powder as substitute for fly ash in concrete

- Resource-saving concrete construction methods
- Reuse of components and building structures
- Extended service life of structures

Source: VDZ

Resource savings along the value chain

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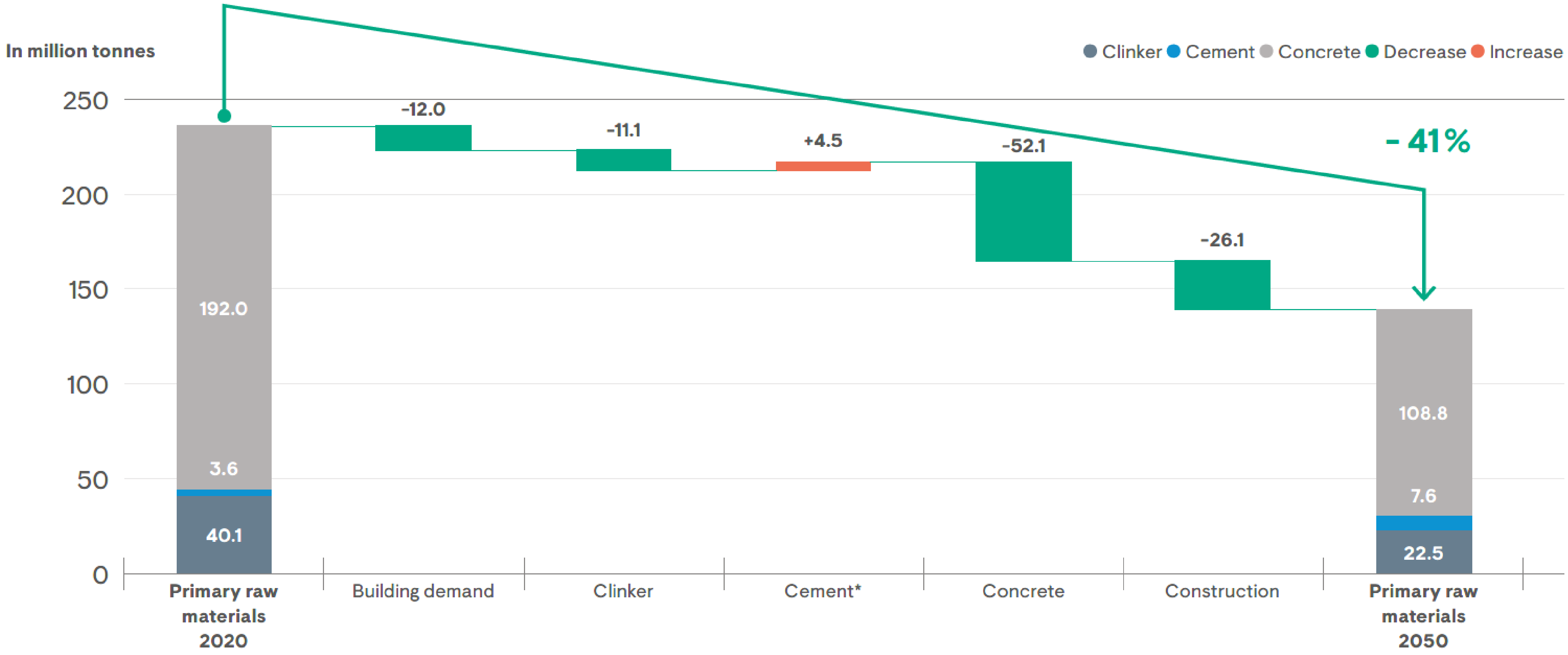
In the 2050 scenario, primary raw material use can be reduced by 97 million t



Source: VDZ

Note:

* *Includes primary main constituents and sulphate agents; clinker is considered separately.*

Resource savings along the value chain

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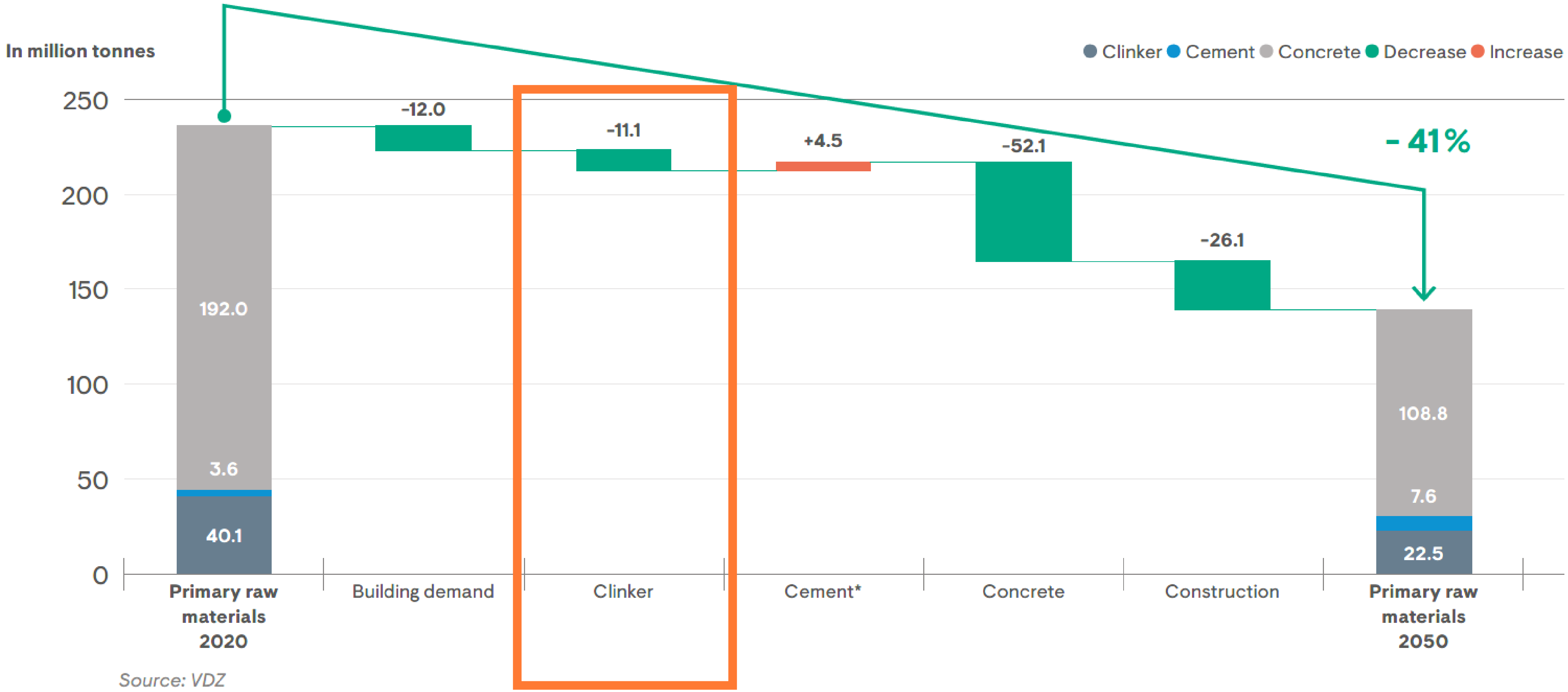

Source: VDZ

Note:

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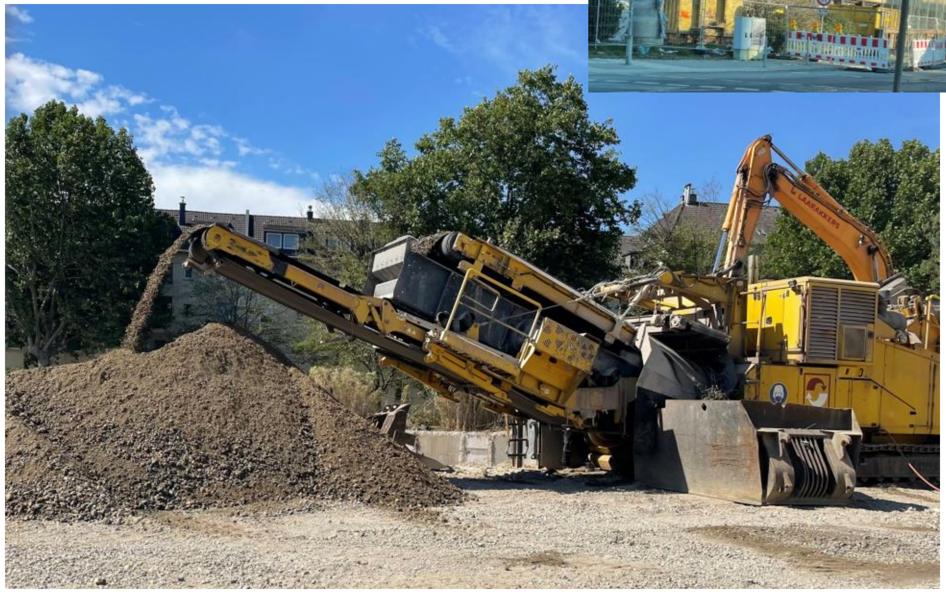
Alternative resources for clinker production

High potential: **2.5 Mio. t / a** recycled concrete fines as low carbon calcium source



- approx. **10 wt.%** (for low sand fractions up to 18 wt.-%) of clinker raw materials can be replaced by recycled concrete fines and stoichiometrically counterbalanced with average limestone qualities
- ~20% of the process CO_2 was taken up by concrete during service life; ~80% of the hardened cement paste in concrete remains uncarbonated and represents a potential CO_2-free source of calcium for clinker production
- savings in CO_2 and primary resources;
- key element to close the loop – circular economy of cement and concrete

Lowering of clinker content

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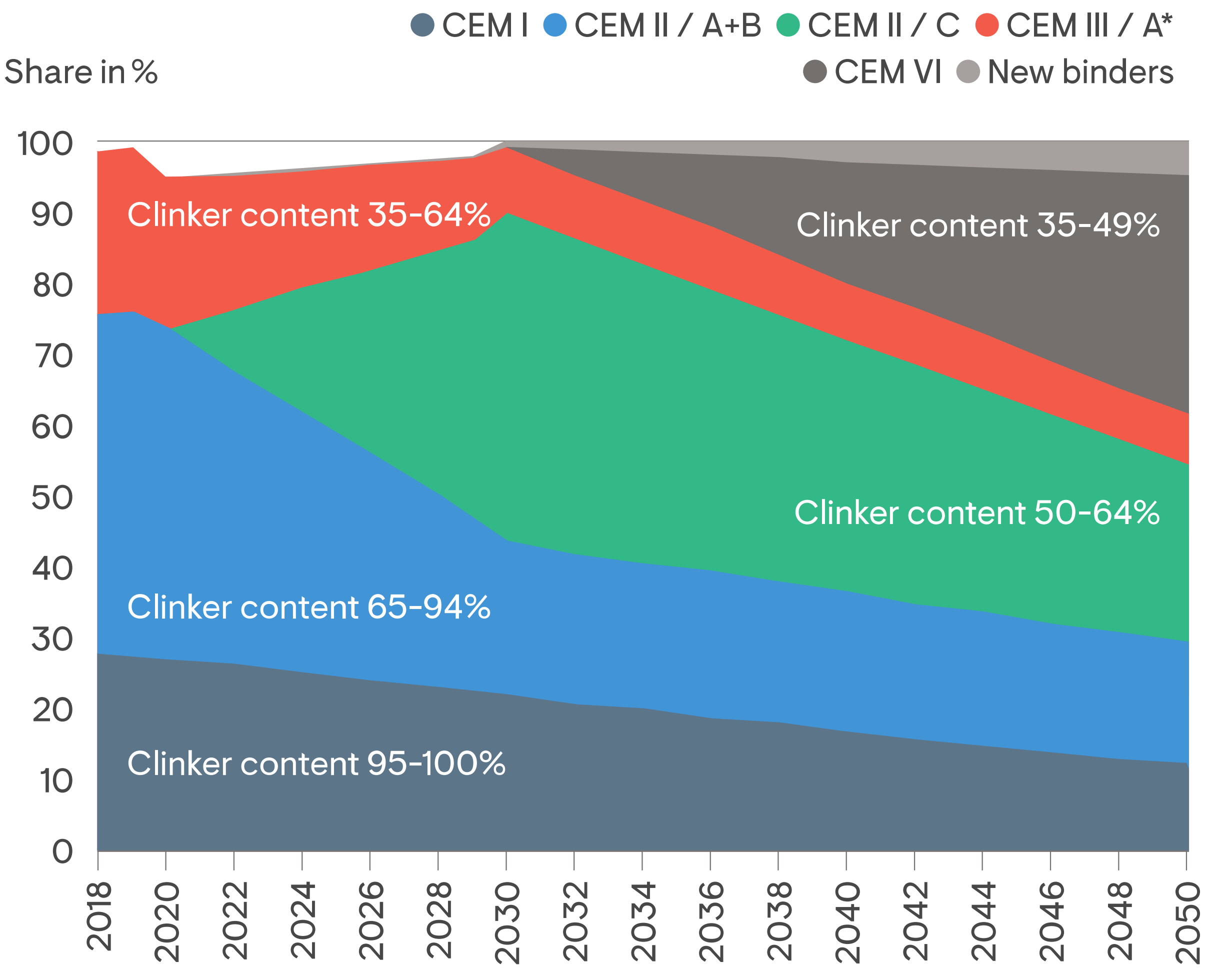
2050: Reduction of the clinker content in cements to 53%

approx. 8,6 Mio. t/a less natural ressources by reduction of clinker factor (0.70 → 0.53)

- demand for clinker decreases from around 24 million tonnes today to around 14 million tonnes in 2050
- more clinker-efficient cements in future, e.g. CEM II/C-M, CEM VI
- Limestone, calcined clays and crushed concrete fines substitute clinker and replace the missing quantities of granulated blastfurnace slag and fly ash



Resource savings along the value chain

In the 2050 scenario, primary raw material use can be reduced by 97 million t

Source: VDZ

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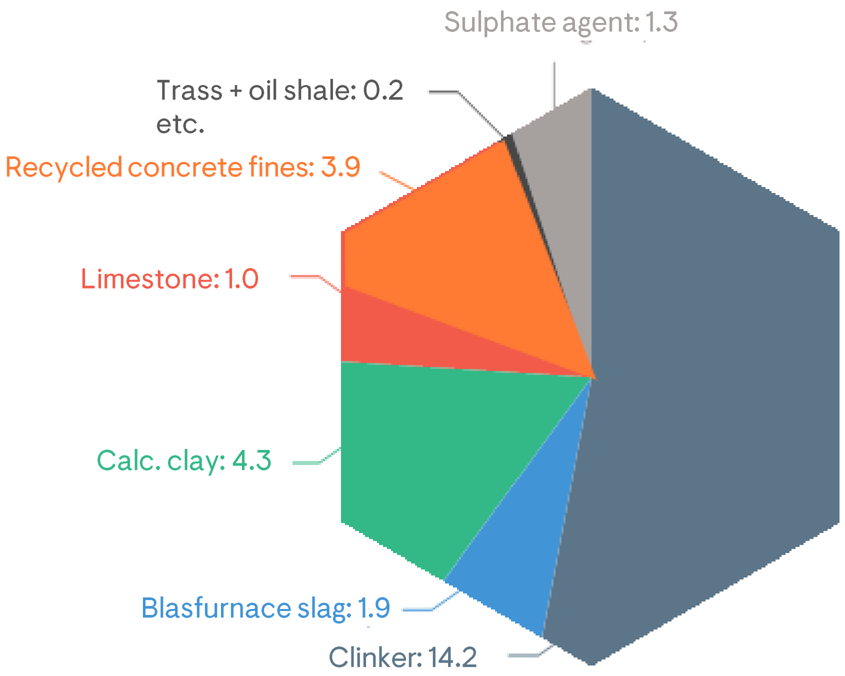
Resources for cement

2050: limestone, recycled concrete fines and calcined clays replace fly ash and parts of blast furnace slag

		2020	2050
Clinker		25.3	14.2
Blast furnace slag		5.0	1.9
Limestone		1.8	1.0
Recycled concrete fines		**0.0**	**3.9***
Calc. clay	in Mio. t	**0.0**	**4.3**
Fly ash		0.2	0.0
Sulfates		1.8	1.3
Others		1.4	0.2
Cement		**35.5**	**26.8**
Clinker / cement ratio		**0.71**	**0.53**

cement composition - scenario 2050



* Assumption: 75% of the limestone (L, LL) is replaced by recycled concrete fines

Resource savings along the value chain

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In the 2050 scenario, primary raw material use can be reduced by 97 million t

Source: VDZ

Note:

* *Includes primary main constituents and sulphate agents; clinker is considered separately.*

Resources for concrete

2050: Intensified circular economy - RC aggregates (> 2mm) replaces natural aggregates in concrete

approx. 53 Mio. t / a use of recycled aggregates from crushed concrete

(replace approx. 33% of the required aggregates)

	RC- aggregates [Mio. t][1)]	
	2020	2050
Common concrete	< 1	37
Prefab concrete		3
Concrete products		13
Plaster + mortar	0	0

1) Assumptions: max. input quantities according to DAfStb guideline per concrete group; appropriate processing of waste concrete / mineral construction waste

foto: Pixabay

Resource savings along the value chain

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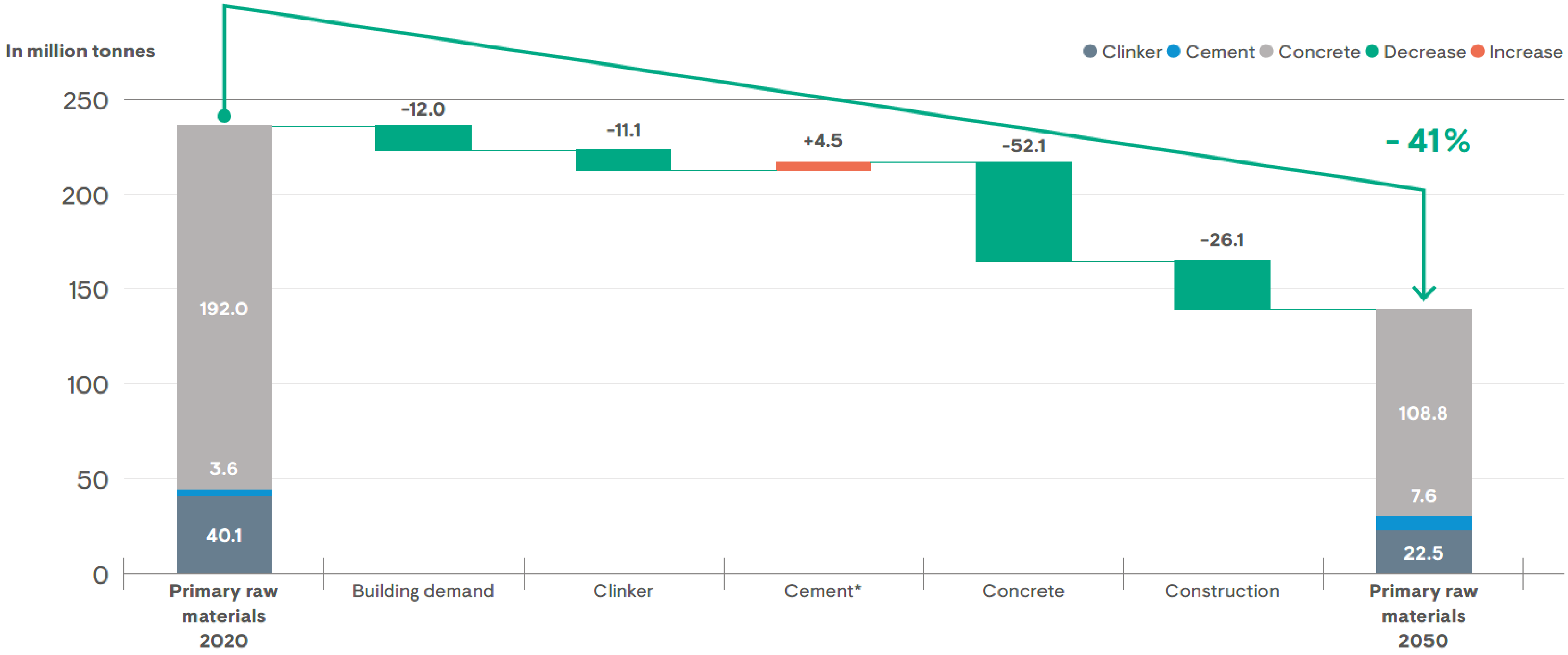
In the 2050 scenario, primary raw material use can be reduced by 97 million t



Source: VDZ

Note:

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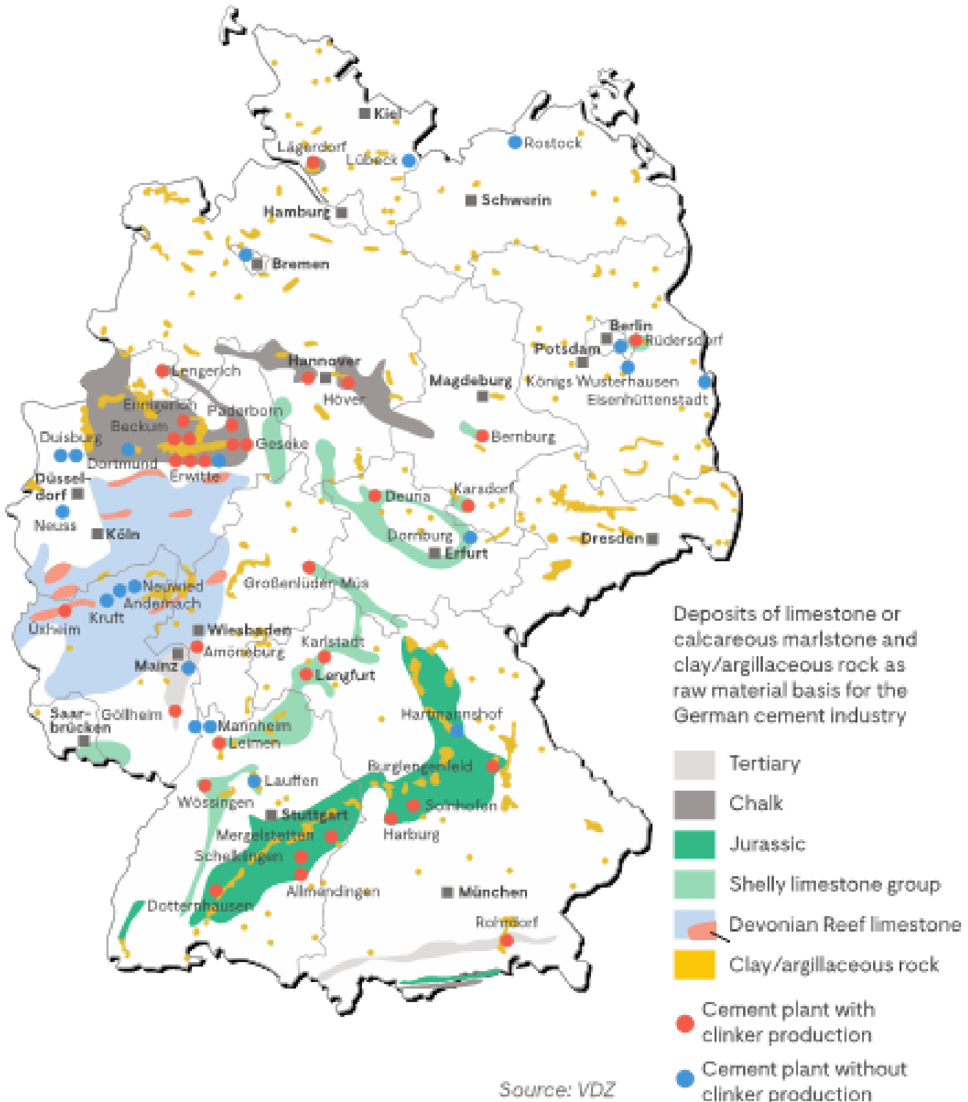
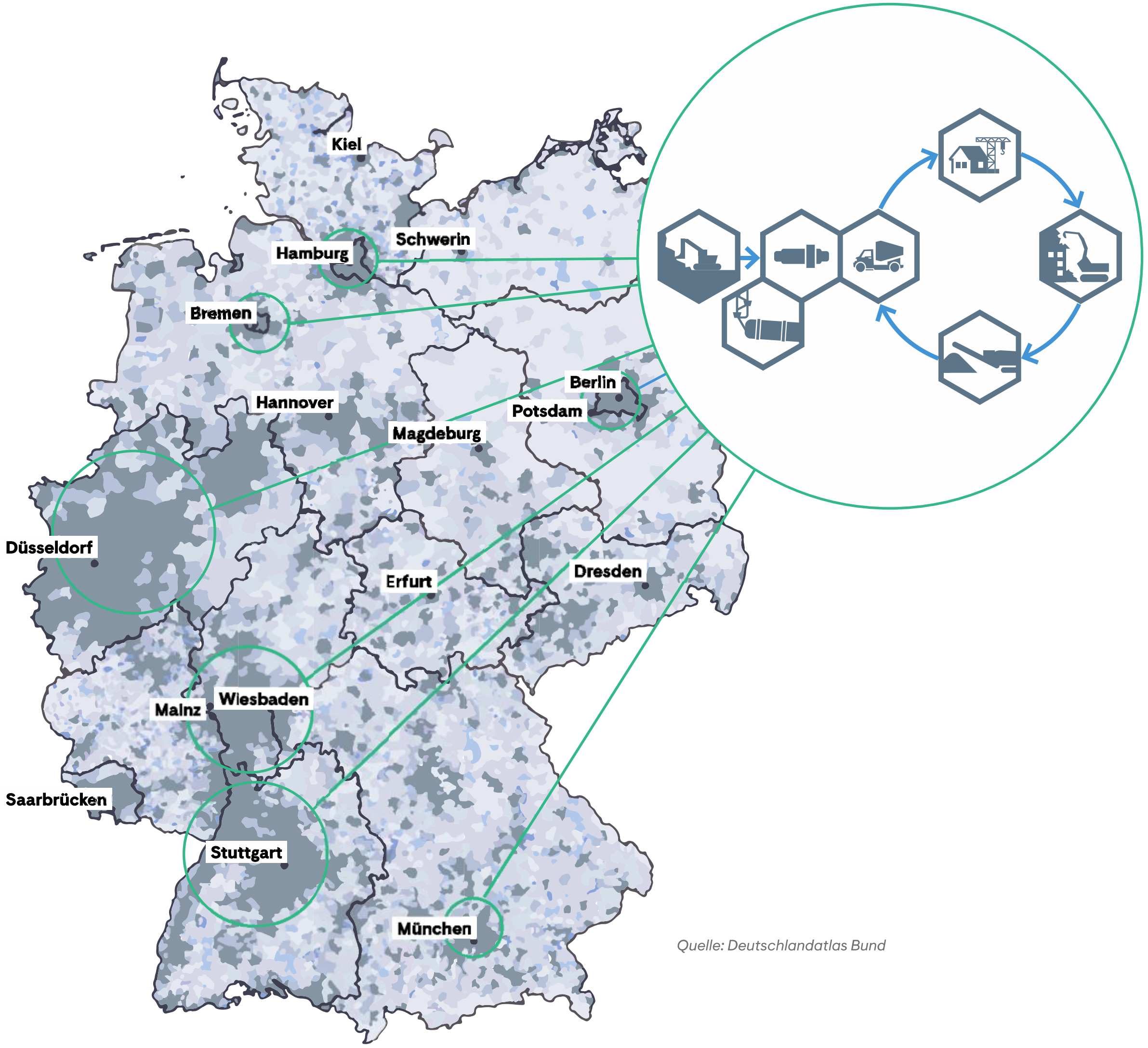
Raw material mix of the future

Beside primary raw materials, **urban mining** will play also an important role



Source: VDZ



Quelle: Deutschlandatlas Bund

Prerequisites for resource-saving concrete construction

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Four central fields of activity

Sustainable material flow management

Green lead markets for resource-saving cements and concretes

Communication and qualification along the value chain

Securing of primary raw materials

Thank you for your attention

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Please contact us for questions and feedback:

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