Resource efficiency in the production of cement and concrete

Christoph Müller, VDZ gGmbH, Germany

Resource Initiative -
Leveraging efficiency to meet India's needs
Thursday, May 23, 2013, 9.30 AM - 5.30 PM
Jacaranda Hall, India Habitat Centre, Lodhi Road, New Delhi

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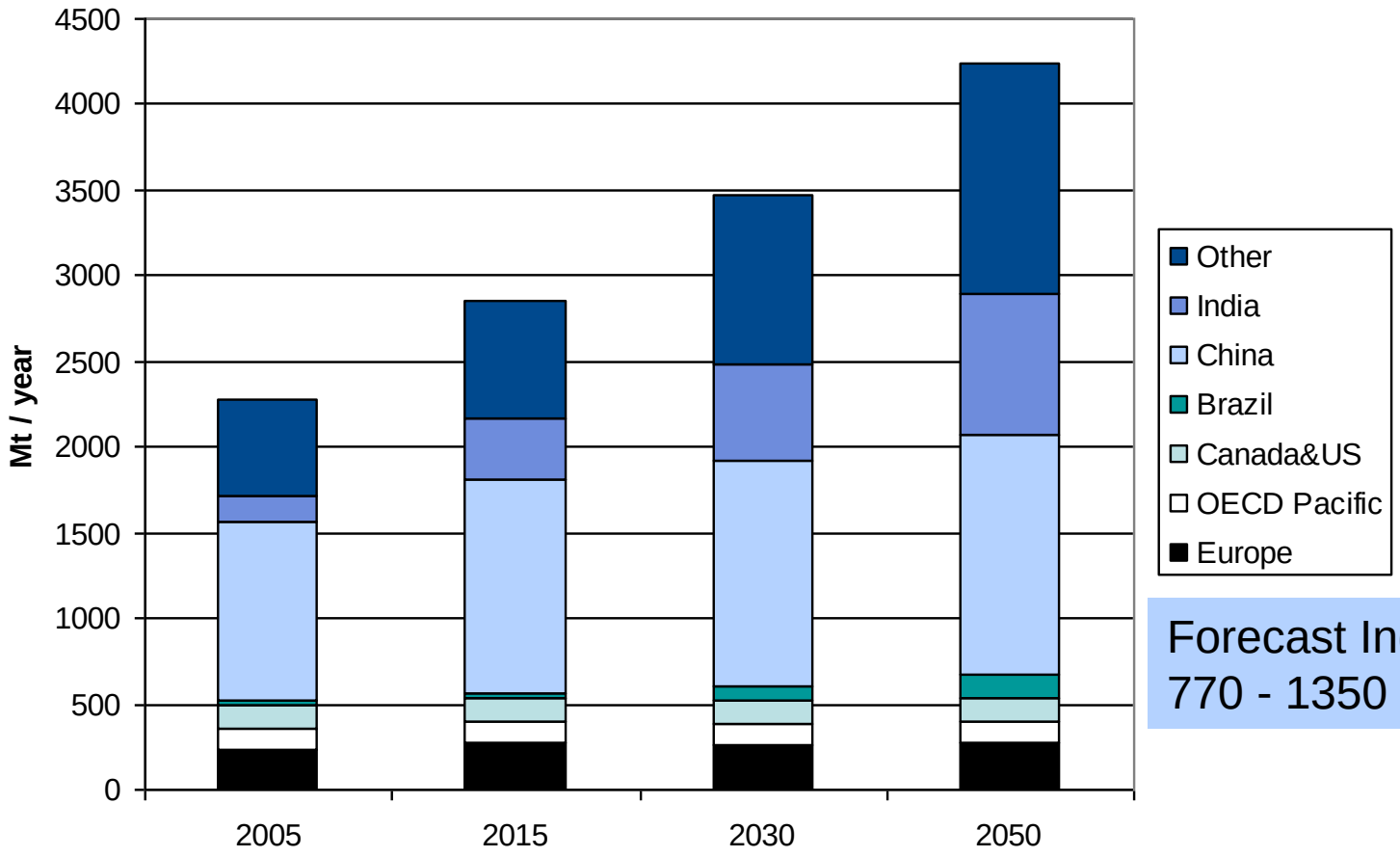
Development of world wide cement consumption



Forecast India:
770 - 1350 Mio. t in 2050?

source: VDZ Congress 2009, data: IEA 2008

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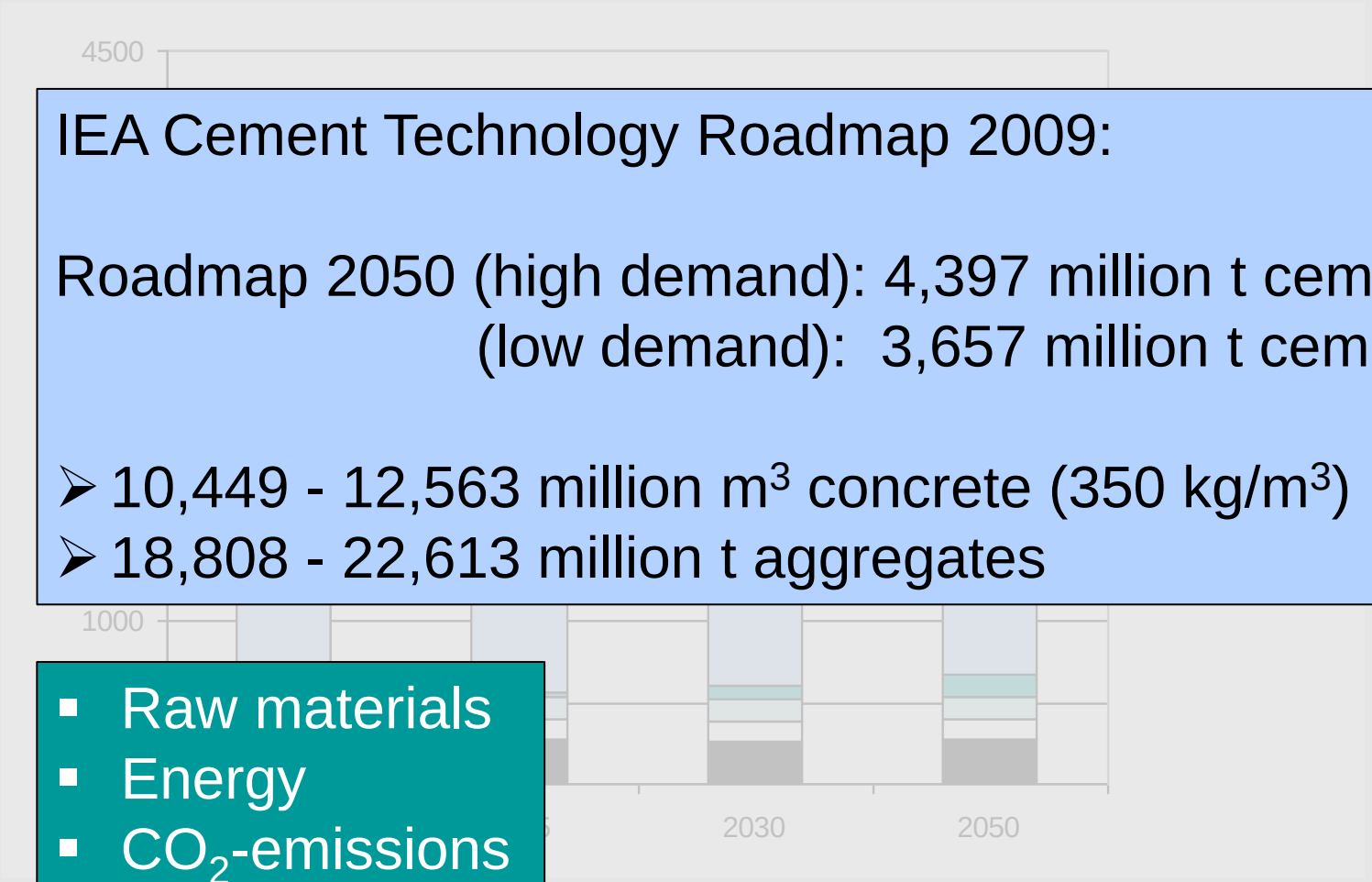
Development of world wide cement consumption



IEA Cement Technology Roadmap 2009:

Roadmap 2050 (high demand): 4,397 million t cement
(low demand): 3,657 million t cement

- 10,449 - 12,563 million m^3 concrete (350 kg/m^3)
- 18,808 - 22,613 million t aggregates

- Raw materials
- Energy
- CO_2-emissions

source: VDZ Congress 2009, data: IEA 2008

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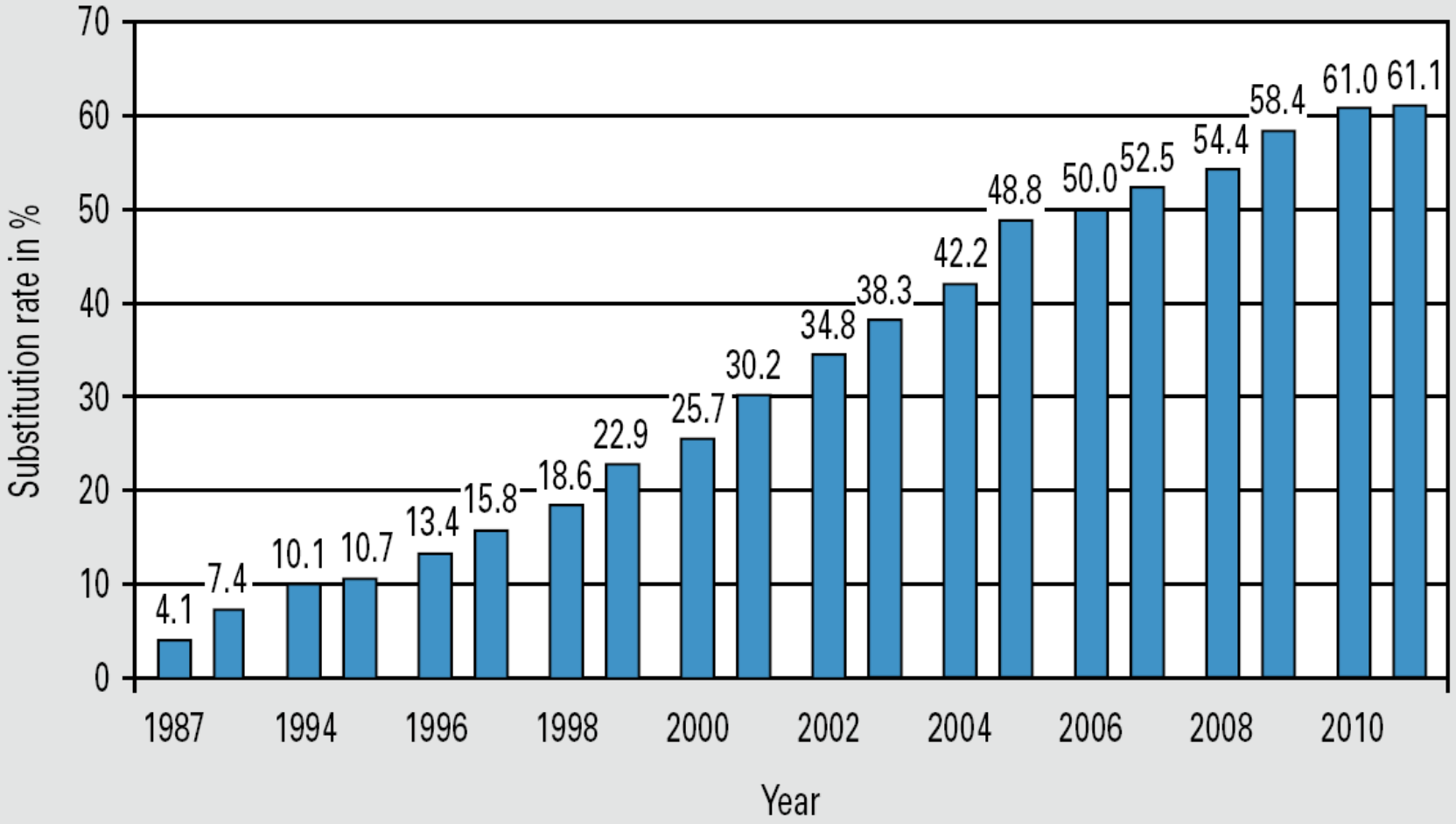
Use of secondary fuels in Germany



An option for India: 15 -20 % in 2050?

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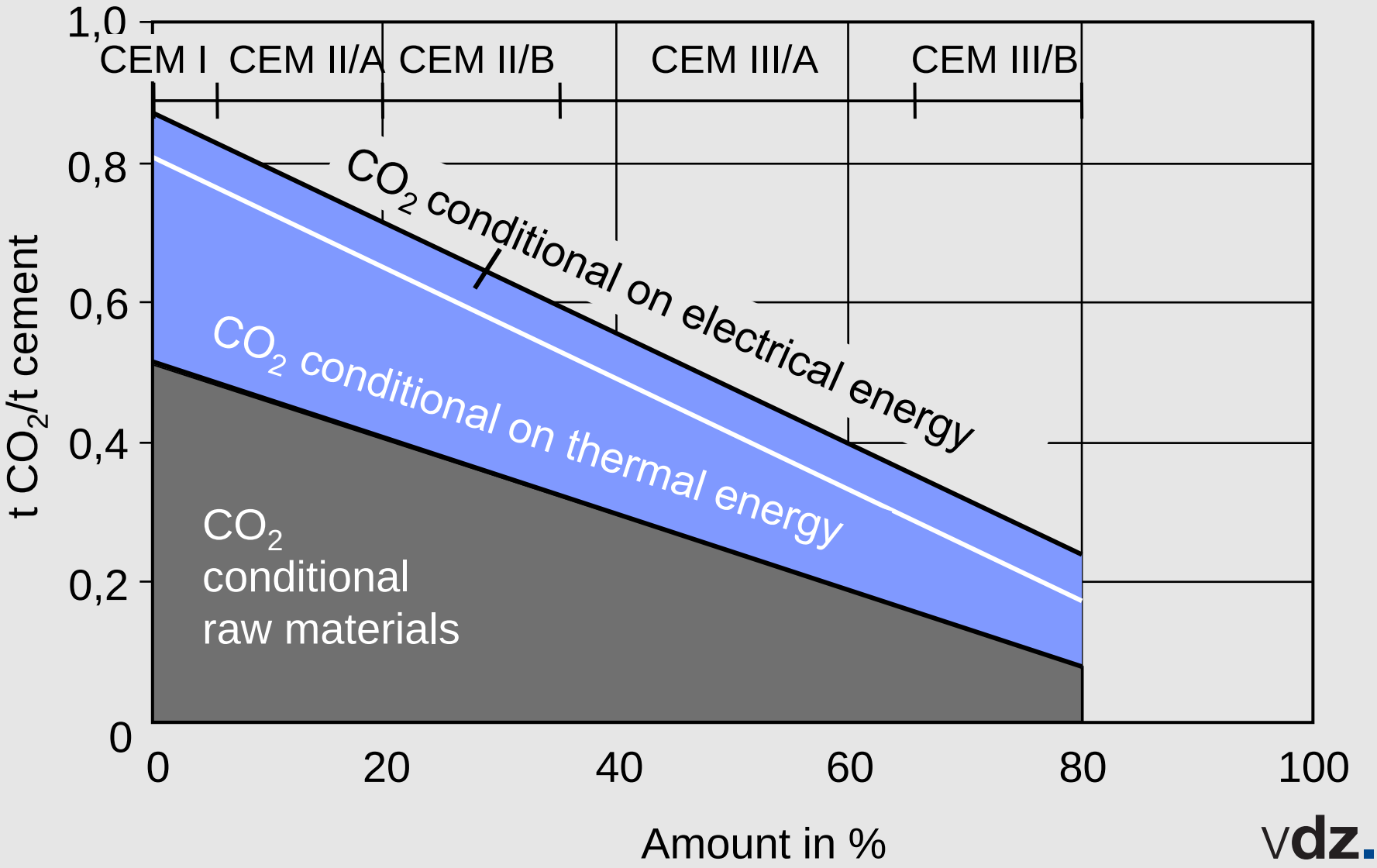
CO_2 per t of cement



GWP and energy use for the production of cement and concrete (average 1996 and 2010)

1 t cement	1996	2010	
Global Warming Potential (GWP)	872	692	kg CO_2-Eq.
Primary energy (not renewable)	4355	2451	MJ

1 m^3 concrete (C20/25)	1996	2010	
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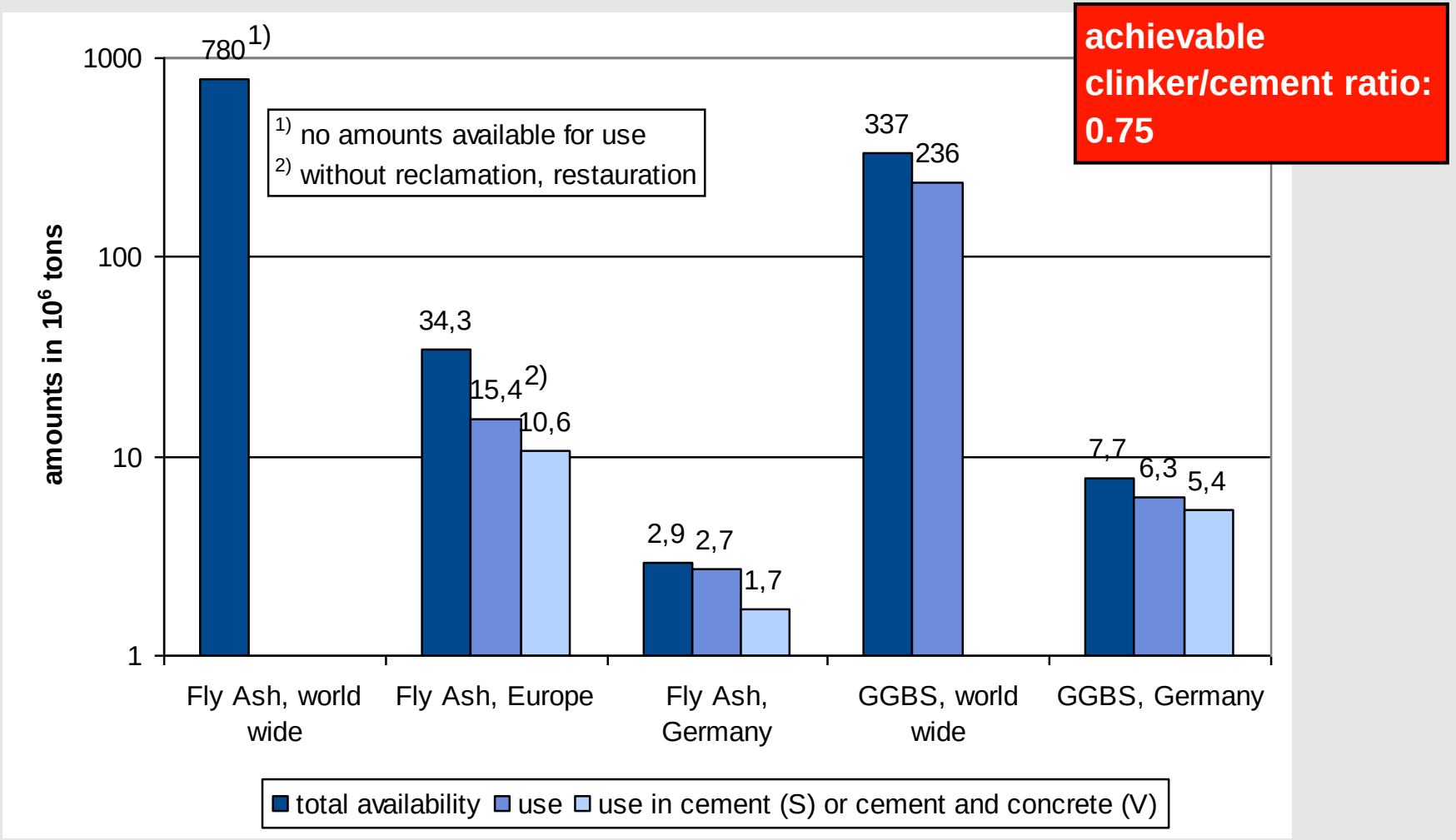
The Worldwide Quantity of GGBS and Fly Ash 2010



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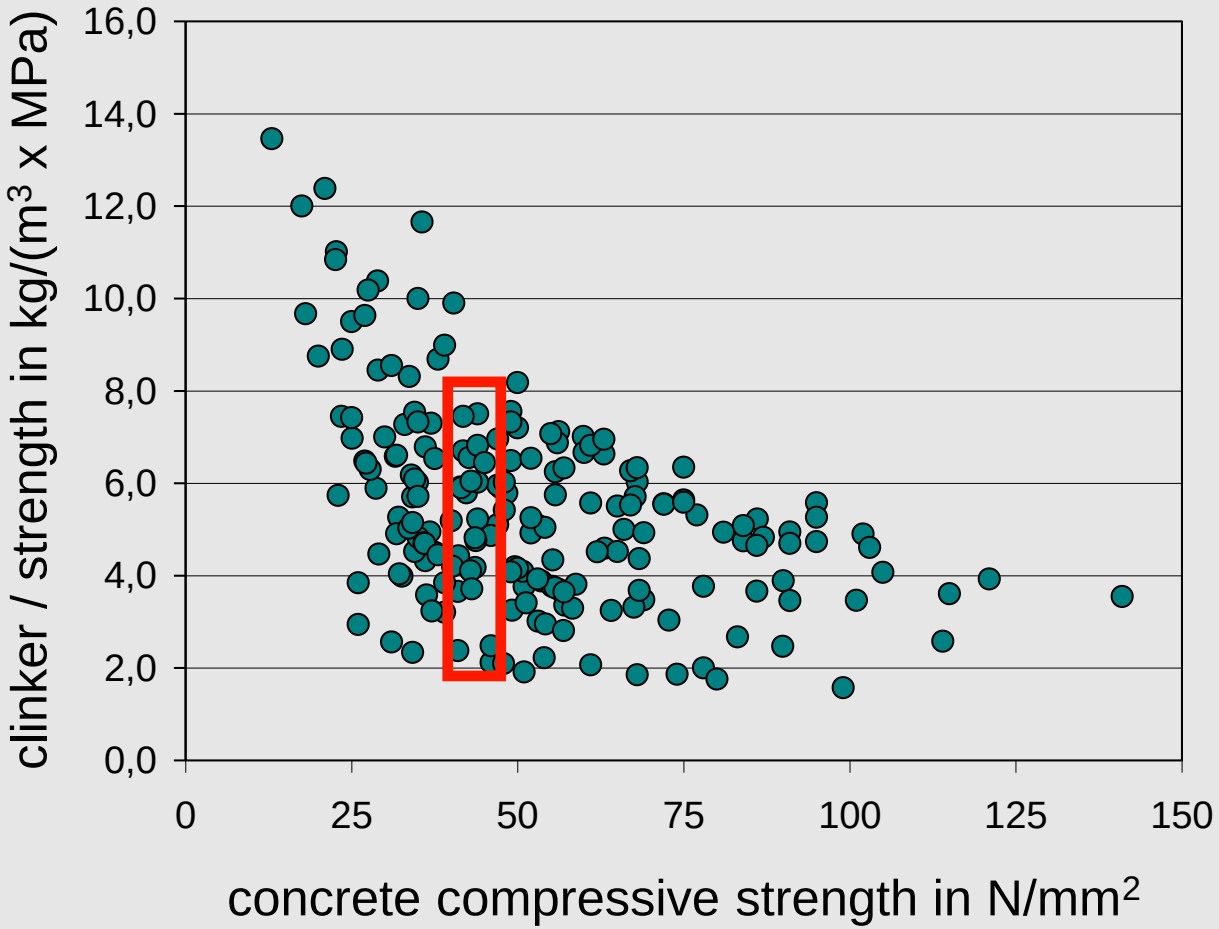
Clinker performance



Influences:

- cement content
- cement strength
- content of fines
- $(w/c)_{eq}$ resp. w/(c+F)

with
c = clinker
F = fines < 125 µm

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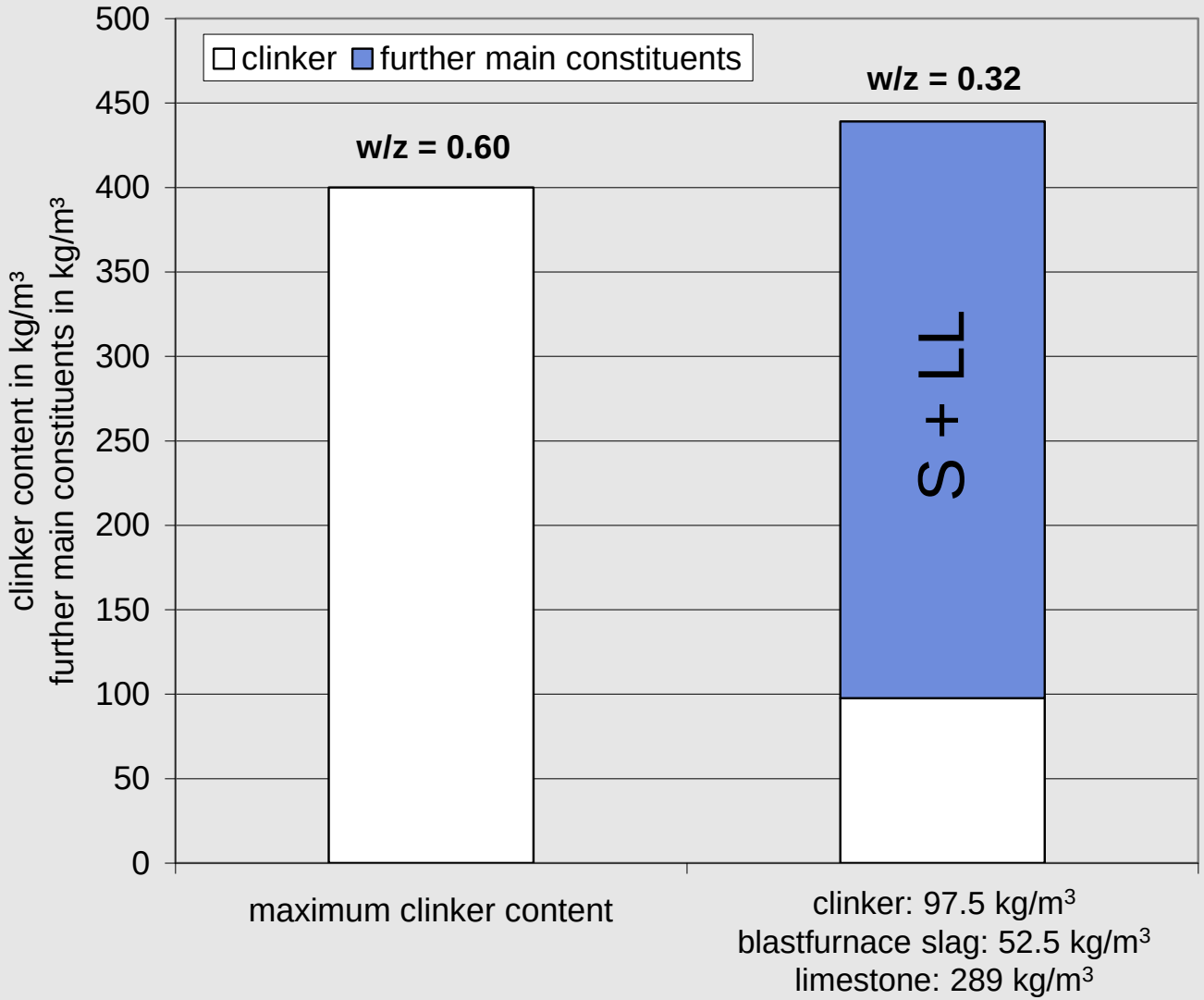
Minimum and maximum values of the highlighted area (concrete compressive strength (40 ± 5) N/mm²)



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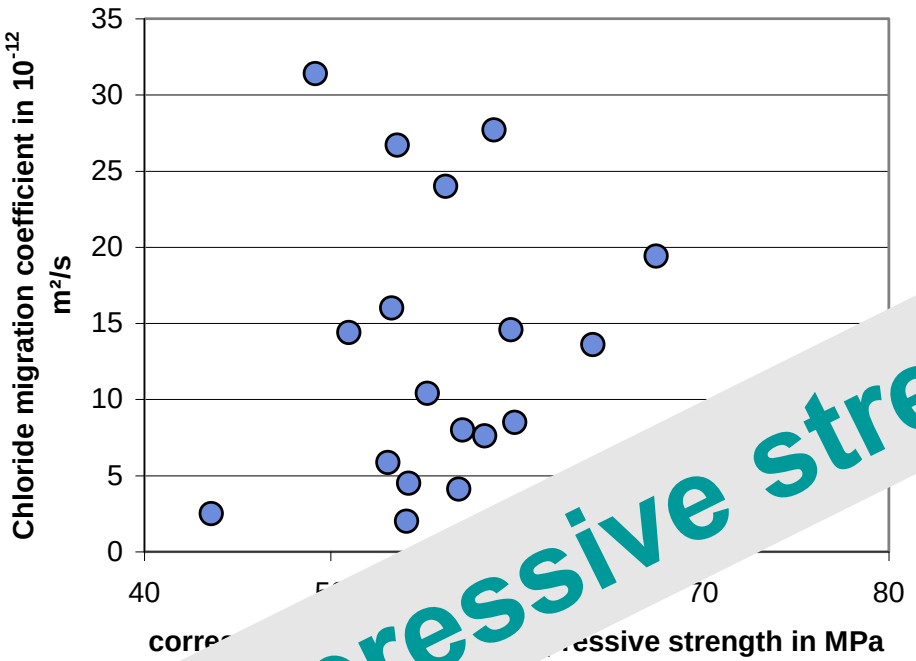
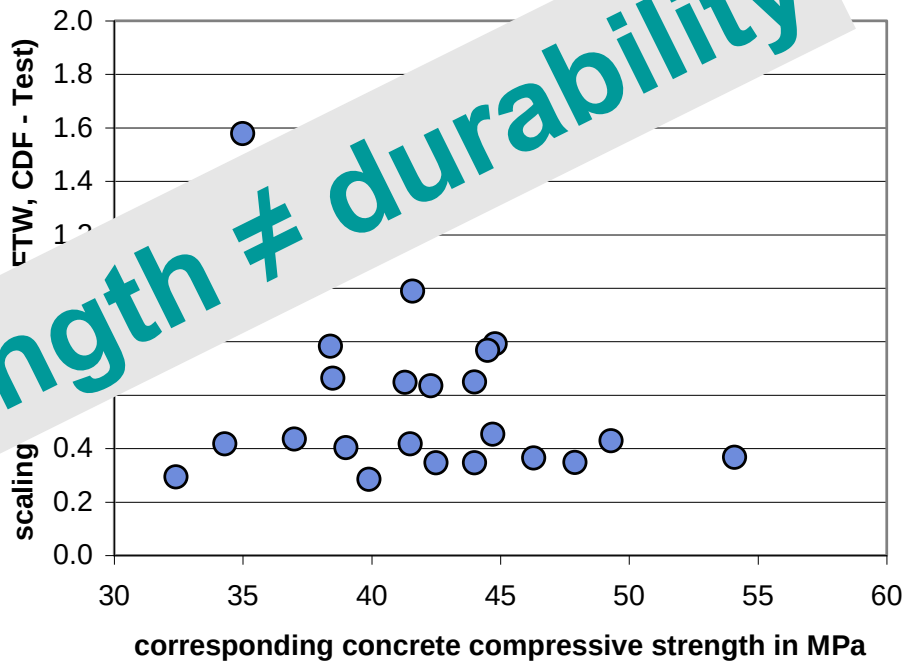
Compressive strength vs. durability





compressive strength ≠ durability

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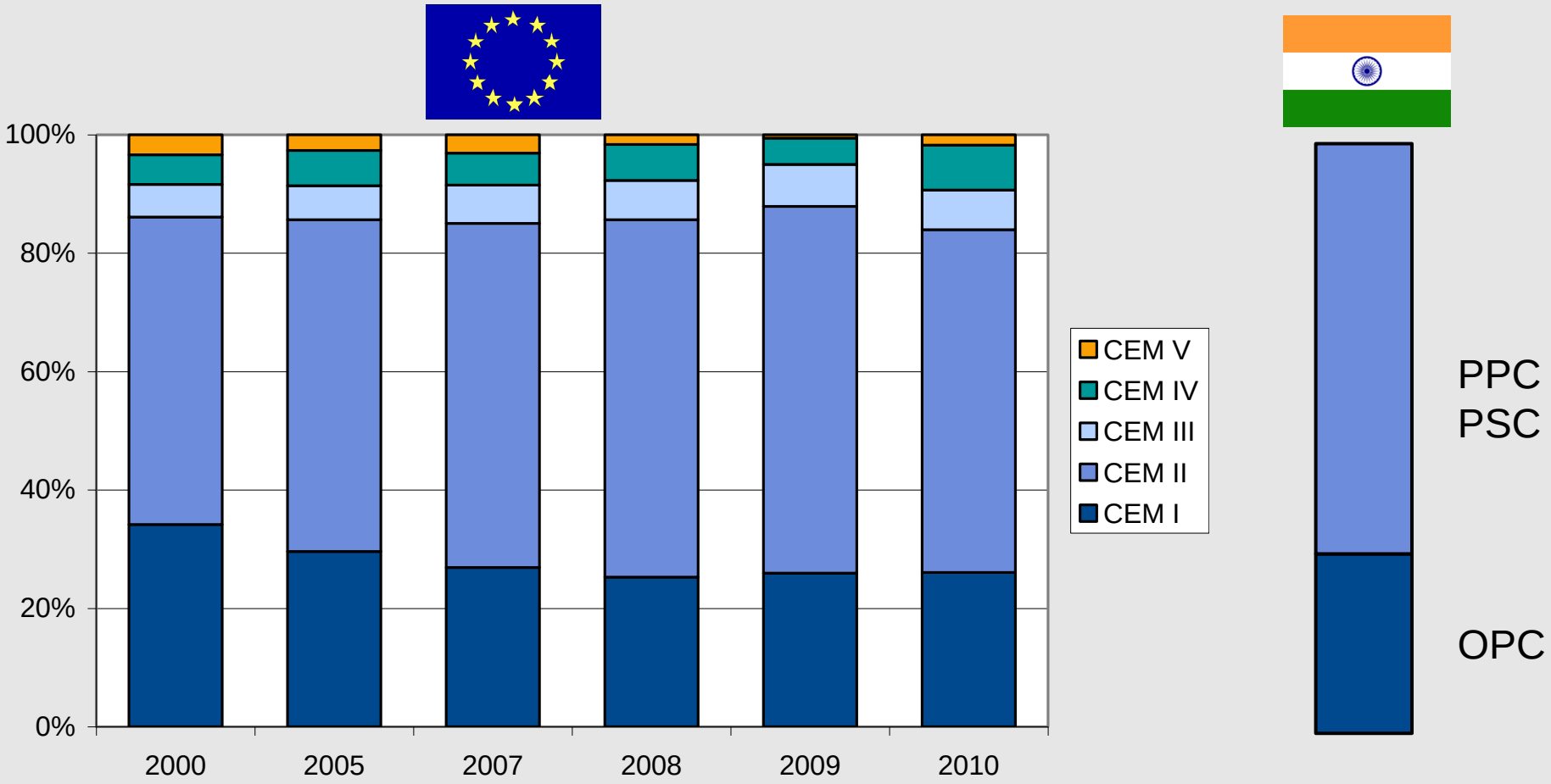
India vs. Europe: Cement types



sources: CEMBUREAU /Technical Report TR-ECRA-120/2012

India vs. Europe: Cement properties (examples)

Cement/Standard	Grade in MPa	Typical cement fineness in cm^2/g (Blaine) [1)]	
		India	Europe
OPC / CEM I	43 /42.5 53 /52.5	3.000	3,600 4,880
PSC / CEM III	33 / 32,5 43 / 42,5	3,600 n.a. [2)]	3,920 4,440
PPC / CEM II/B-V (W)	33 / 32,5	3,400	4,470

1) acc. to VDZ Database
2) not included in BIS (Bureau of Indian Standard)

source: Technical Report TR-ECRA-120/2012

India vs. Europe: Cement testing (examples)

Standard	Temperture in °C	Test conditions
BIS 	27	standard (constant) **consistency**
EN 	20	standard (constant) **water/cement ratio**

- Indian cement standard is adapted to **local conditions** with respect to market, **available materials** and **ambient conditions**
- Indian cement producers can grind their **cements much more coarsly** compared to other world regions and to **minimise their electrical power consumption** in cement grinding

source: Technical Report TR-ECRA-120/2012

India vs. Europe: Concrete requirements (examples)

Exposure of the construction element	EN 206-1 (DIN 1045-2)			IS 458-2000		
	min cement content in kg/m^3	max w/c	exposure class	min cement content in kg/m^3	max w/c	exposure class
Inside	260 (240) [1)]	0.65 (0.75)	XC1	300 [2)]	0.55	mild
Outside	300 (280) [1)]	0.50/0.55 (0.6)	XC4/XF1	300 [2)] 320 [2)]	0.5 0.45	moderate severe

1) acc. to ERMCO statistics average cement content DE: ~ 300 kg/m^3
2) acc. to Indian experts, in practice mainly three types of concrete exist, containing 330, 400 and 500 kg/m^3

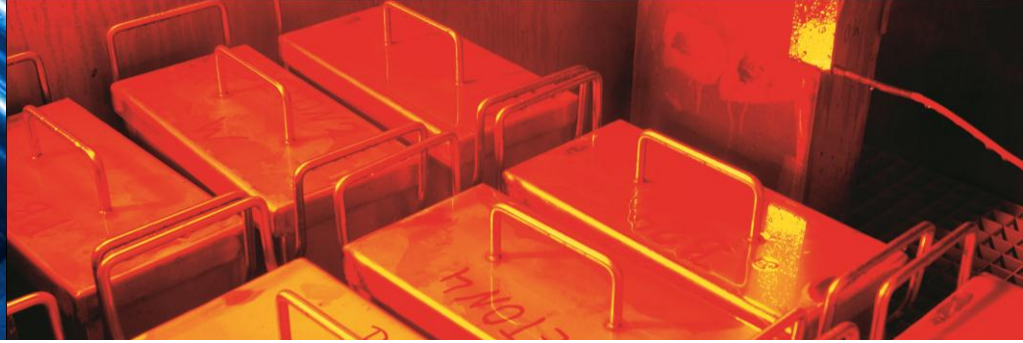
source: Technical Report TR-ECRA-120/2012

Conclusions

- The strategy with regard to resource efficiency in the production of cement and concrete has to be adapted to local conditions with regard to

  - availability of raw materials
  - concrete technology
  - ambient conditions
  - building tradition including quality of the execution

- Further reduction of CO_2 emissions when building with concrete can be reached by use of cements with several main constituents
- **Durable concrete structures** ensure resource efficiency
- Strength **≠ Durability**



Thank you for your kind attention

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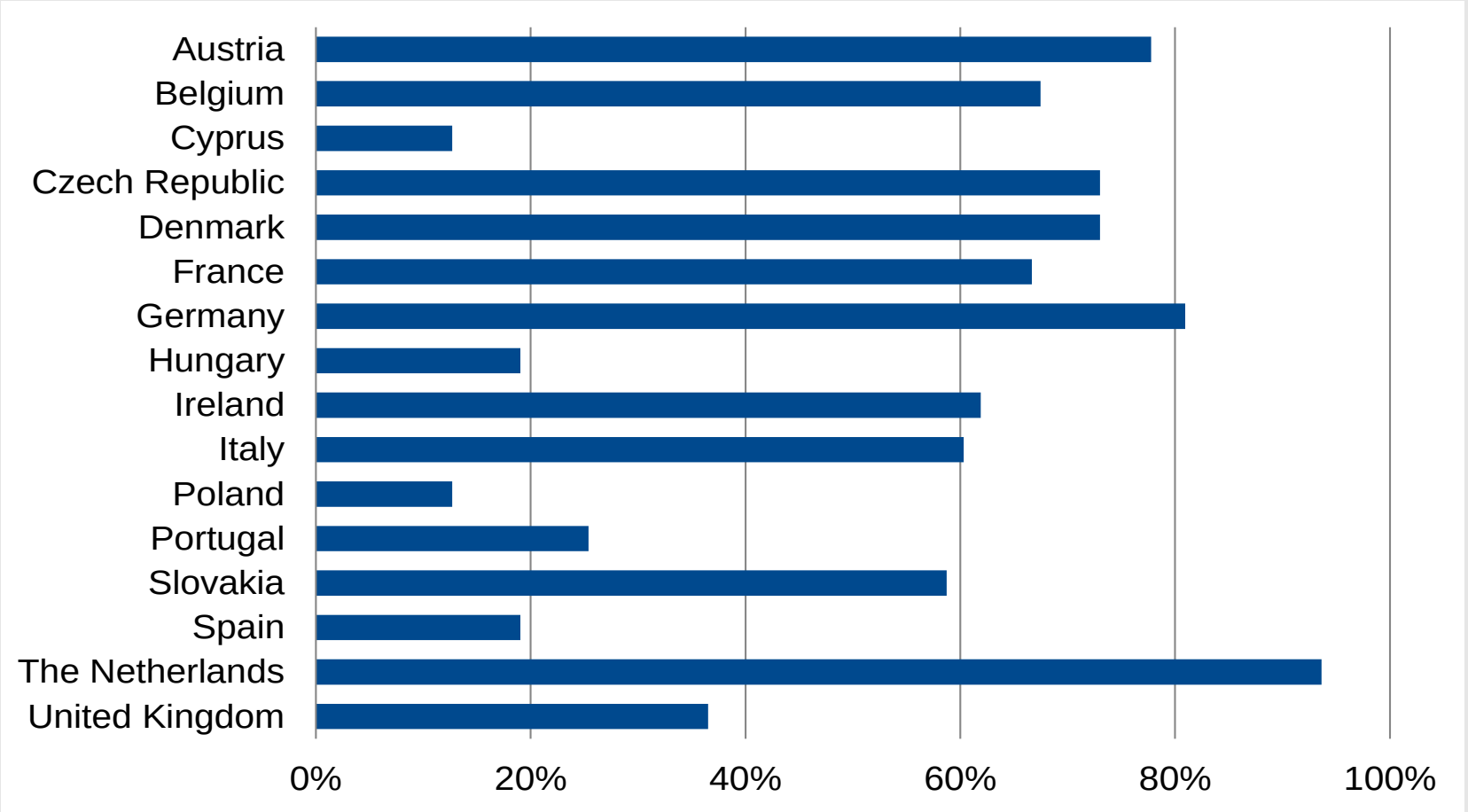
Recycling rates in Europe, data of EQAR



source: data of EQAR - European Quality Association for Recycling e.V.

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Requirements on recycled aggregates (RA) in Europe

		Ger-many	Great Britain	The Nether-lands	Aus-tria	Switzer-land	Nor-way	Den-mark	Bel-gium
Number of RA type		2	2	1	2	2	2	1	1
Particle size [mm]		>2	>4	>4	nrd	nrd	nrd	>4	nrd
Fraction (depending on type) [%]	Concrete	0-100	nrd	0-100	nrd	25-100	95-100	nrd	95-100
	Tile	0-10	0-100	0-10	nrd	0-5	nrd	nrd	nrd
	Asphalt	0-1	0-10	nrd	nrd	0-3	nrd	nrd	nrd
	Other	0-4	0-1	nrd	0-12	0-0,03	0-5	nrd	0-1
Maximum content of RA in exposure class (depending on type) [%]	XC0	45[1]	100	0-20[1]	100	100	0-30	100	100
	XC1-4	35-45[1]	100	0-20[1]	100	25-100	0-30	100	100
	XF1	25-35[1]	100	0-20[1]	100	0-25[2]	nrd	100	nrd
	XF2-4	0-35[1]	0	0-20[1]	100	0-25[2]	nrd	nrd	nrd

nrd: no requirement determined, 1: related to total aggregates; 2: > 25 % with pretesting

different sources

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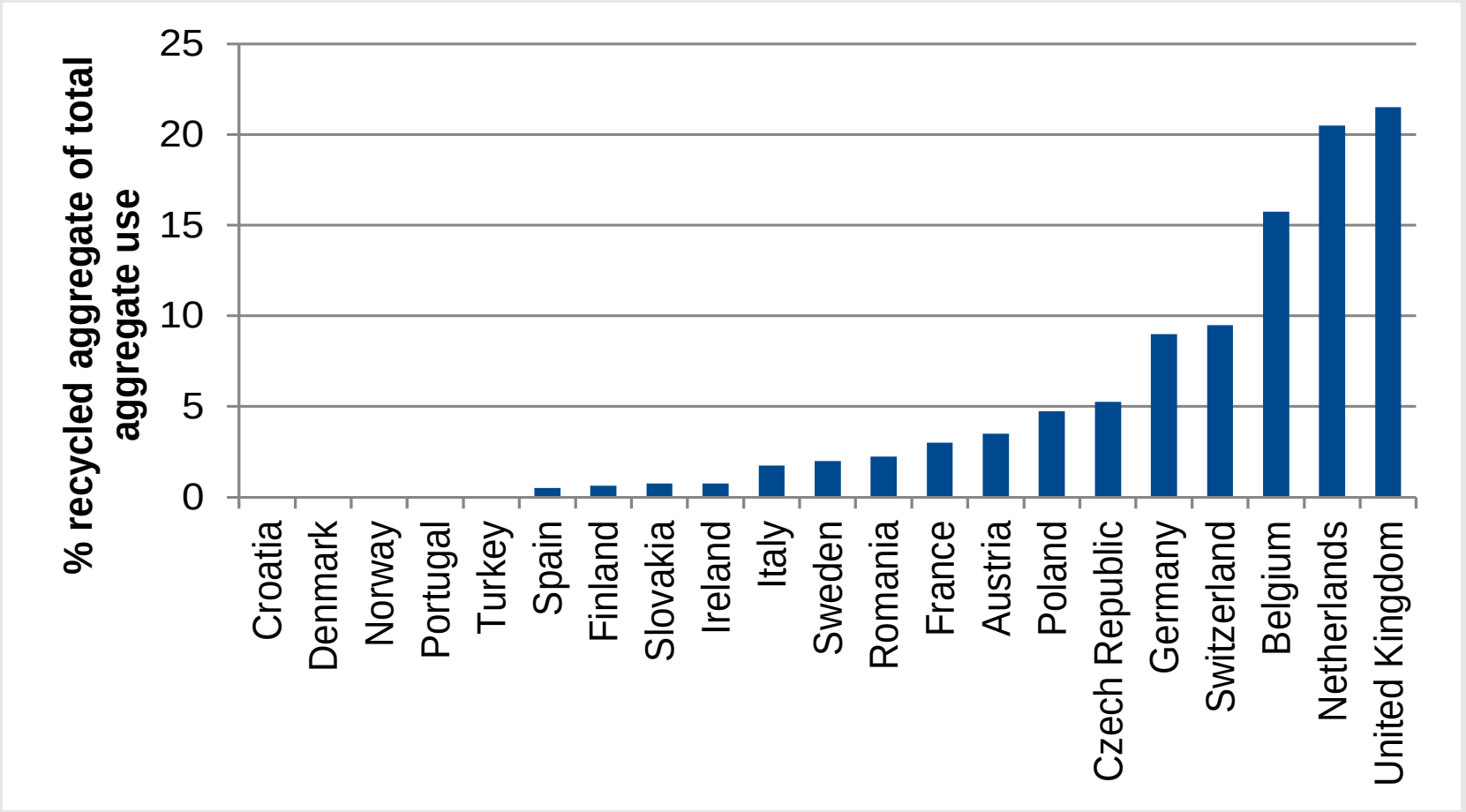
Recycled aggregates of total aggregate use



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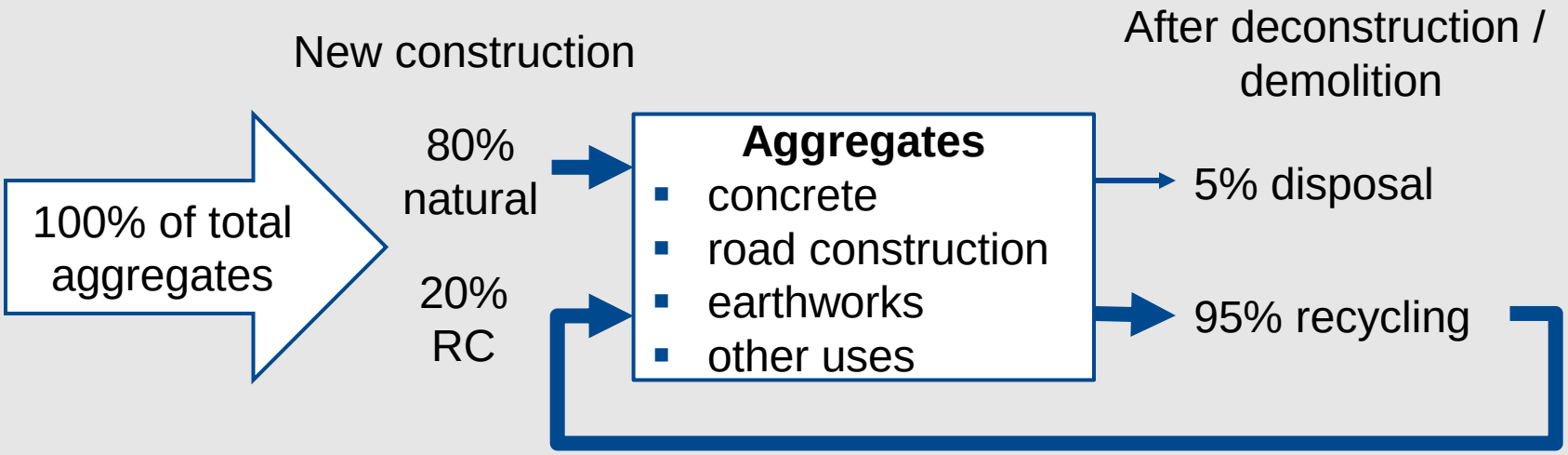
Demand for aggregates and use of recycled material

Example for The Netherlands



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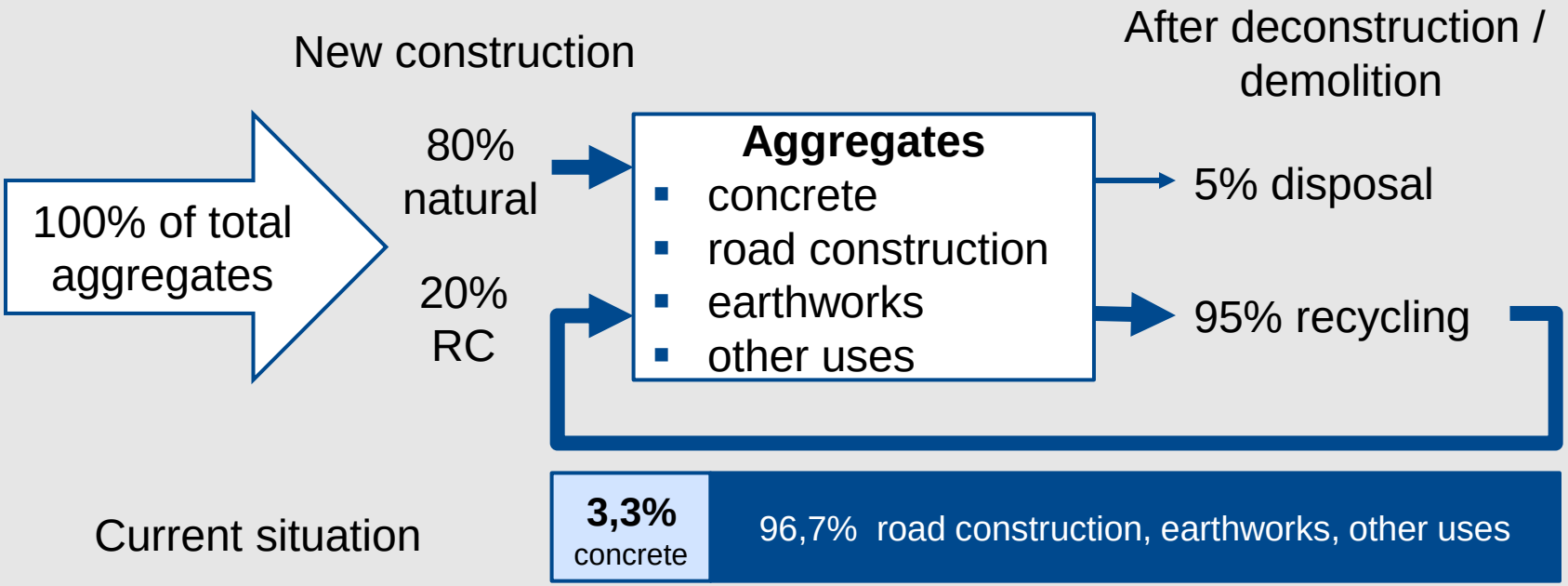

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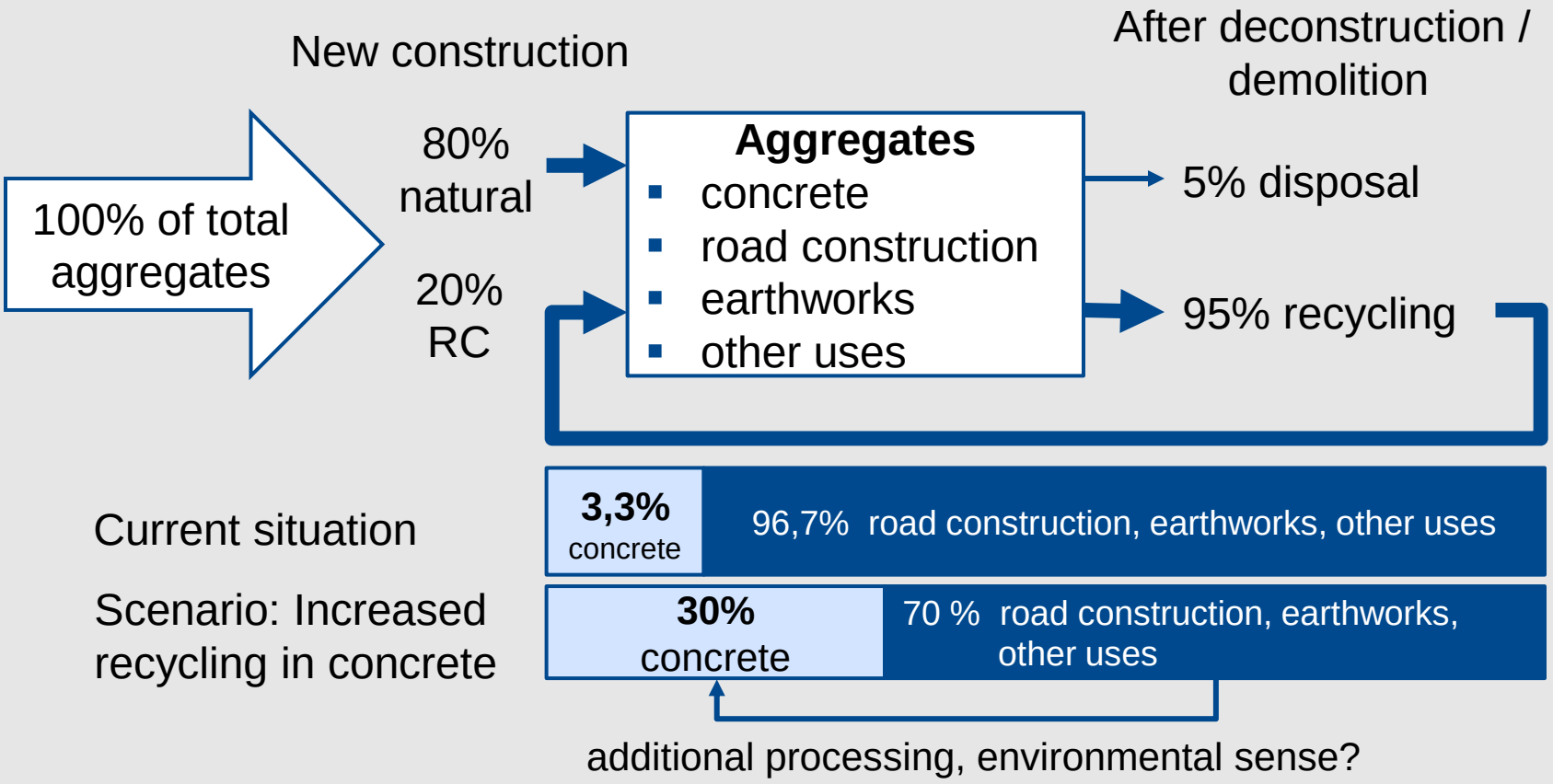

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Conclusions

- On the basis of several studies and corresponding regulations it can be concluded: **concrete can be recycled.**

- Different Recycling rates in Europe

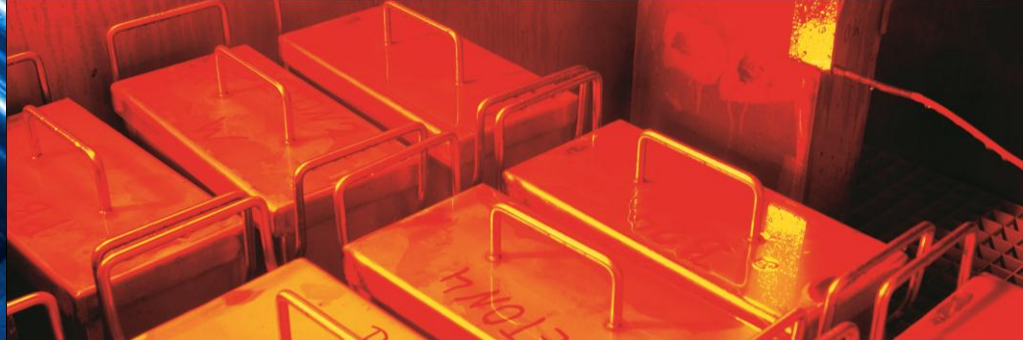
  - Paths of use: Small parts in new concrete?

- Amount of recycled materials not enough to meet the demand for aggregates

- CPR: A driving force for potential recycling rates?

- Open question

  - LCA „Concrete recycling“ vs. „Re-use in other applications“



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