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Decarbonizing the cement and concrete sector:

Integration of the full value chain to reach net zero emissions in Europe

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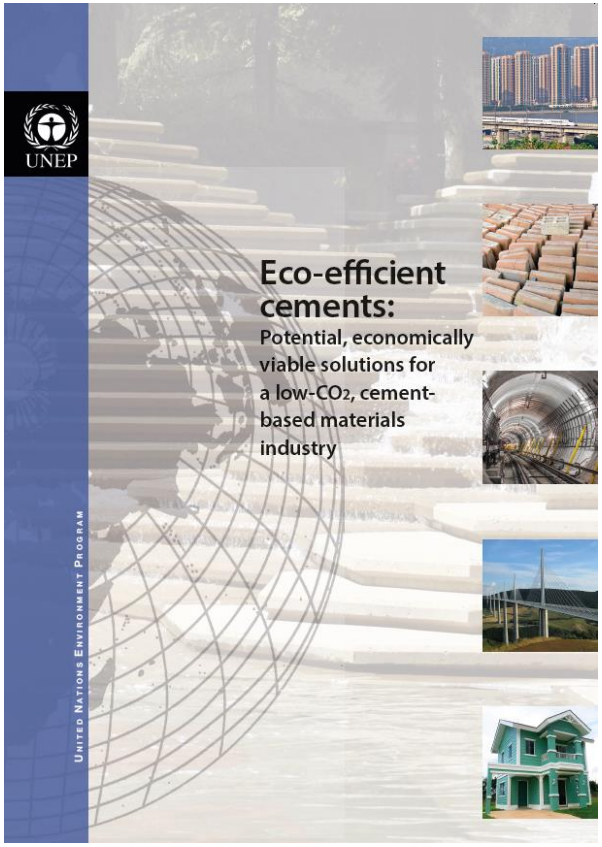
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 642384.

Objective:

How to decarbonise cementitious construction sector in Europe in the short, medium and long term ?



The project was funded by the European Climate Foundation

It is a follow up of the UNEP study which looked only Target only at cement and concrete

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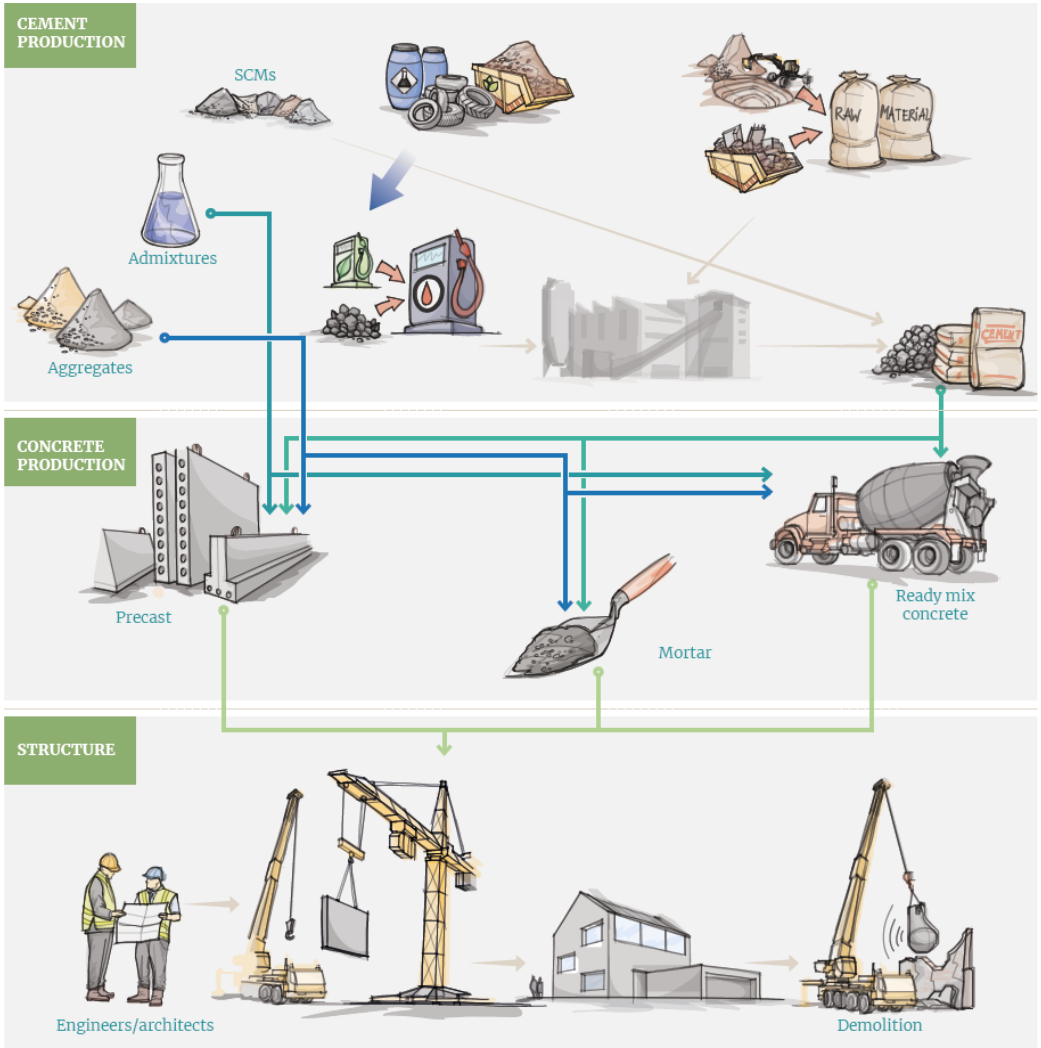
Strategy: Look at the complete value chain



Different level of actions among all stakeholders

Interviews with

- European associations
- Constructors
- Cement producers

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Technology assessment:

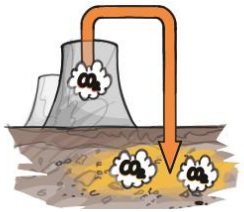
Look at all technologies available along the value chain

Less CO_2 in clinker production

Dry technologies

Alternative fuels

Carbon capture and storage



Alternative binders

Less clinker in cement (or blended in concrete)

% SCM substitution

Technologies used by cement and concrete roadmaps.

& by IPCC Chapter on industry

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Technology assessment:

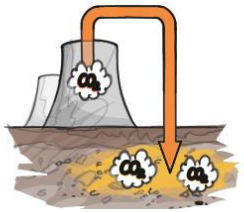
Look at all technologies available along the value chain

Less CO_2 in clinker production	Less clinker in cement (or blended in concrete)	Less cement in concrete	Less concrete in buildings

Dry technologies

Alternative fuels

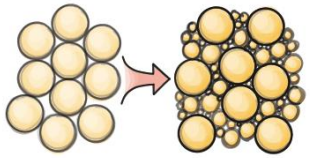
Carbon capture and storage



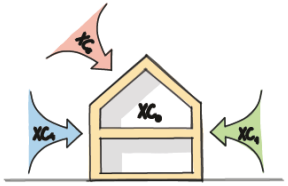
Alternative binders

% SCM substitution

Improved packing



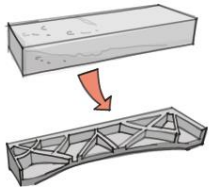
Exposure class



Technologies used by engineers & architects

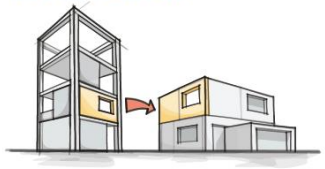
And absent of both Industry and buildings chapter in IPCC

Optimization



Alternative raw materials including recycling fines

Re-use of cement



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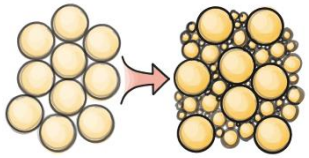
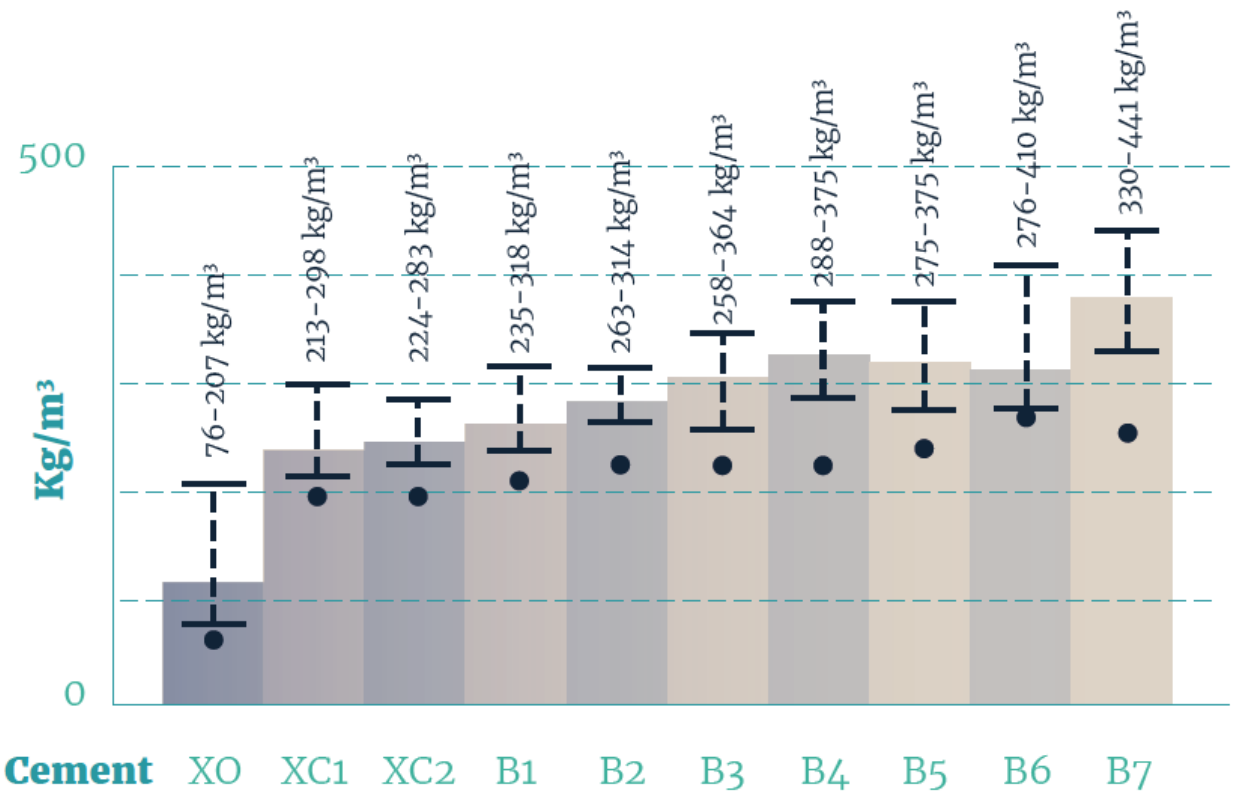
Detail concrete technology :

Over consumption of cement can be reduced by better granular packing

Improved packing





Sce: Passer Alexander, Deutsch Richard, Beton-LCA – Wie grün ist grau?, in: 2018.

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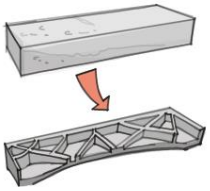
Detail concrete technology :

Over consumption of concrete can be reduced by better structural design

Optimization



> 10 x

Bejing Olympic Stadium, China
Arup, 2008

4’500 kgCO_2 /seat

London Olympic Stadium, UK
Buro Happold, 2012

450 kgCO_2 /seat

Sce: De Wolf, Catherine, Optimization in Structures Scenario, MIT (2018).

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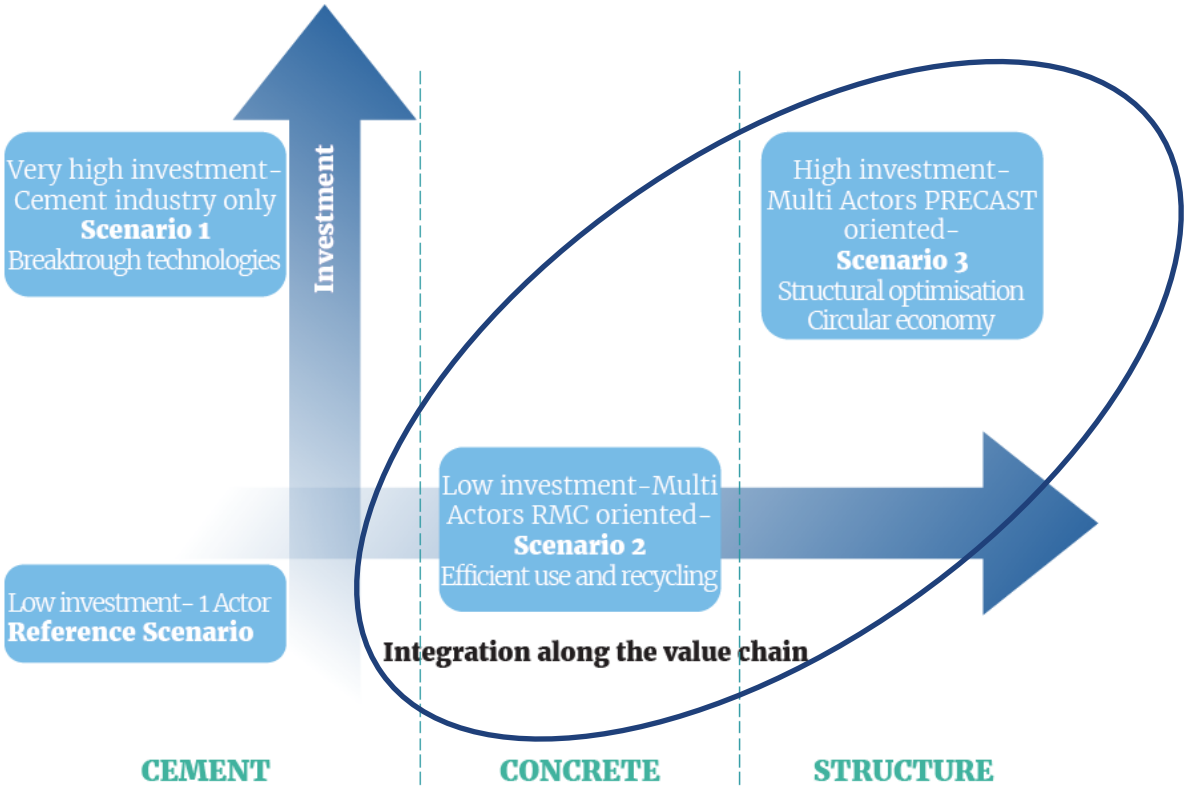
Definition of scenarios :

2 main bottlenecks for innovation in construction have been identified:

- Lack of investment
- Lack of integration of the different stakeholders in the value chain



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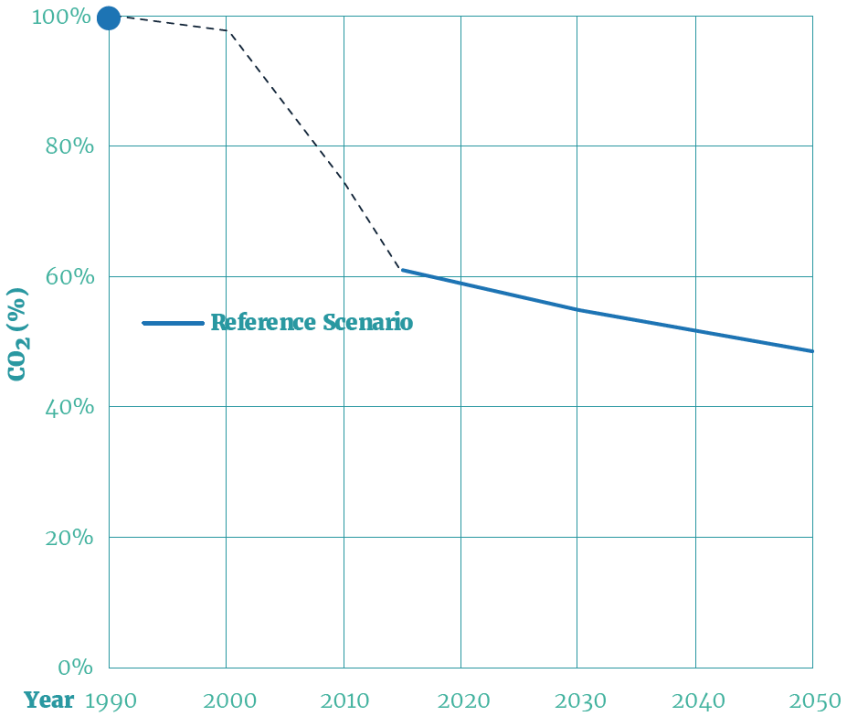
Reference scenario: BAU



REFERENCE SCENARIO	DEGREE OF IMPLEMENTATION			
	2015	2030	2050	SCALE
Efficiency of clinker production	80%	83%	84%	Clinker scale
Alternative fuels	33%	40%	60% (No data IEA-CSI at EU level –global 17.5%in RTS- 30% in 2DS)	Clinker scale
Clinker substitution	23%	30%	35% (No data IEA-CSI at EU level –global 34% in RTS and 40% in 2DS)	Cement Scale
CO_2 savings compared to 1990	40%	45%	55%	

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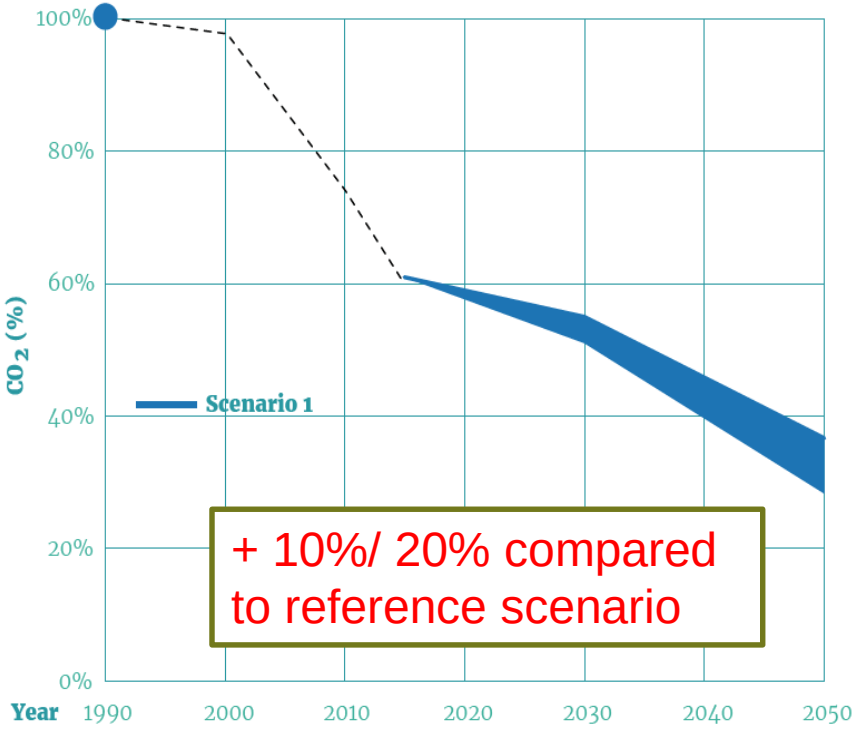
Scenario 1: High investment

Technology breakthrough



SCENARIO 1: BREAKTHROUGH TECHNOLOGY	DEGREE OF IMPLEMENTATION			
	2015	2030	2050	SCALE
Efficiency of clinker production	80%	83%	84%	Clinker scale
Alternative fuels	33%	40%	60%	Clinker scale
% SCM substitution	23%	30%	35%	Cement
Carbon capture and storage	0%	0-5%	25-50%	Clinker scale
Alternative binders	0%	0-12%	10-25%	Cement
CO_2 savings compared to 1990	40%	50%	65-75%	

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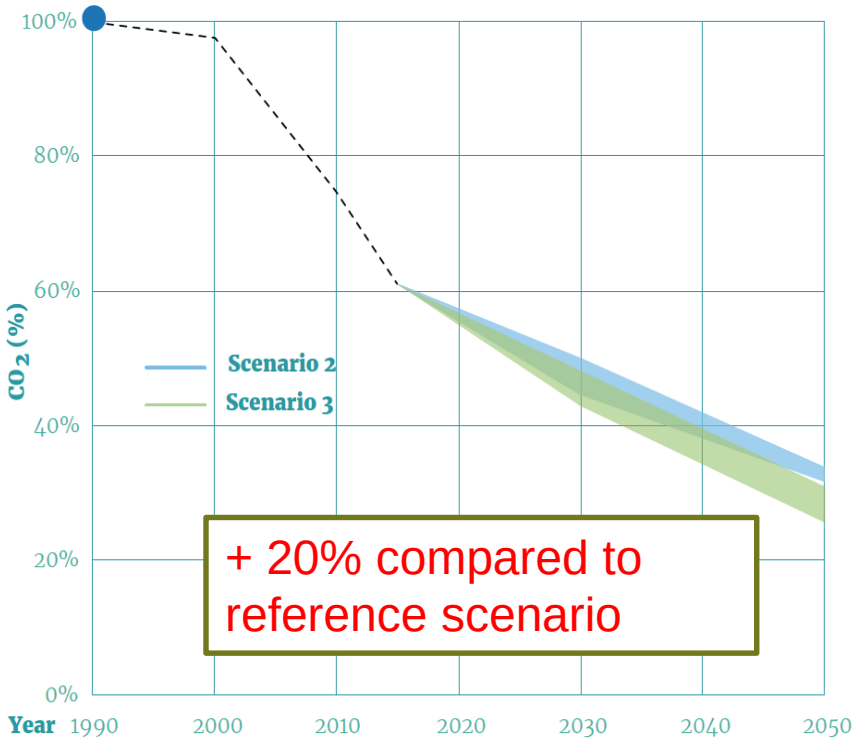
Scenario 2 & 3: Low investment

Optimisation & circular economy



SCENARIO 3: STRUCTURAL OPTIMISATION	DEGREE OF IMPLEMENTATION									
	2015			2030			2050			SCALE
	RMC	PRECAST	MORTAR	RMC	PRECAST	MORTAR	RMC	PRECAST	MORTAR	
Efficiency of clinker production	80%			83%			84%			Clinker
Alternative fuels	33%			40–60%			80%			Cement
Alternative raw materials including recycling fines	3–4 %			10%			20%			Clinker
Clinker substitution	23%			30%	30%	30%	40%	40%	40%	Cement
Binder per m³ of concrete per MPa	8 kg/m³/MPa			5 kg/m³/MPa	5 kg/m³/MPa	–	5 kg/m³/MPa		5 kg/m³/MPa	Concrete
Appropriate use of standards	300 kg/m³			292 kg/m³	–	–	285 kg/m³	–	–	Concrete
Re-use of cement	N/A			–	0–10%	–	–	10–20%	–	Structure
Optimization	N/A				10–20%				20–40%	Structure
CO_2 savings compared to 1990	40%			55%			75%			

Different implication of the stakeholders along the value chain

Dry technologies

- Dry technology implementation → Savings by cement producers

Alternative fuels

- Alternative fuels → Savings by waste managers

% SCM substitution

- %SCM → Savings by cement producers

  → Savings by the construction companies

Alternative raw materials including recycling fines

- % fine recycling → Saving as demolition recycling companies

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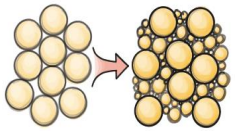
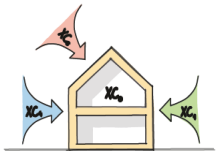
Different implication of the stakeholders along the value chain

Improved packing



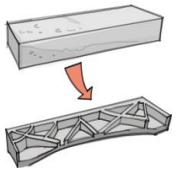
- Improve packing & reduce overestimation → Savings by concrete producers

Exposure class



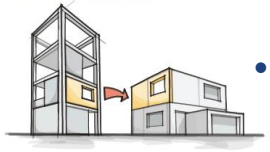
- Use appropriate exposition class → Savings by engineering offices

Optimization



- Optimise structure → Savings by engineering offices

Re-use of cement



- Reuse structure → Savings by demolition companies

Carbon capture and storage

- Carbon Capture and Storage → Savings by cement producers

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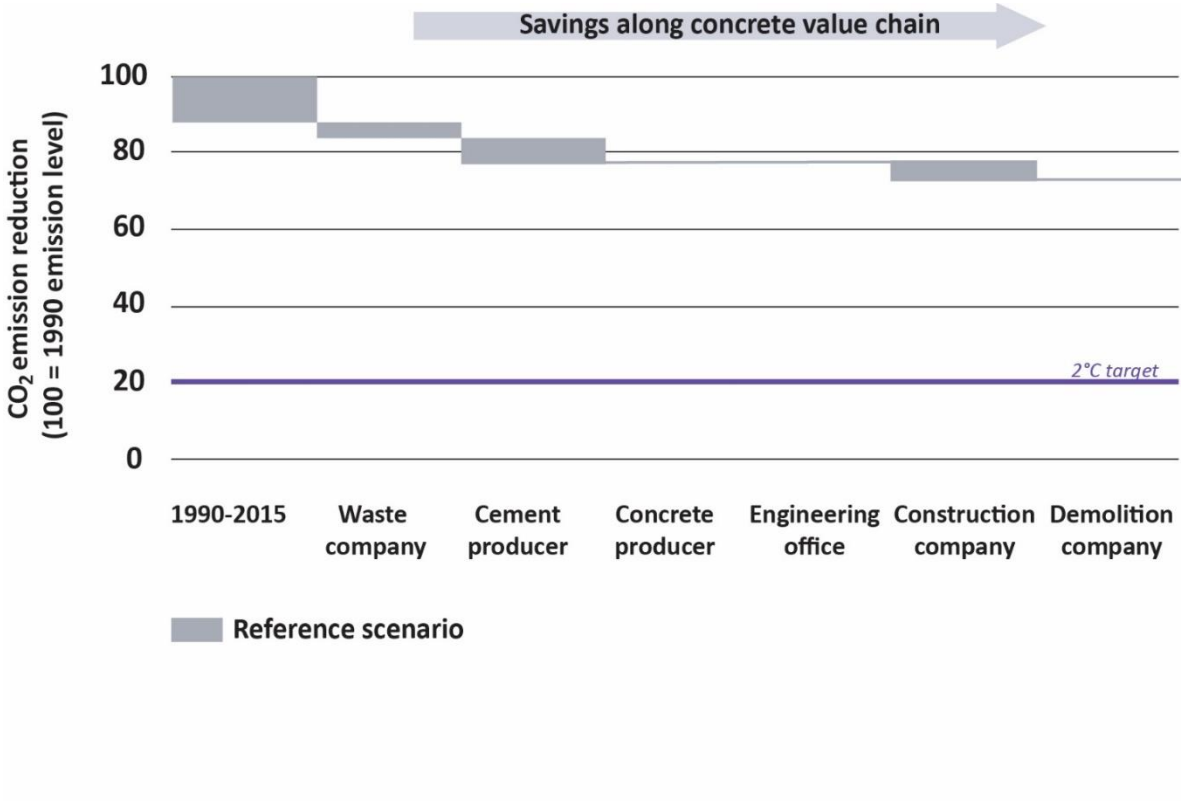
Different implication of the stakeholders along the value chain



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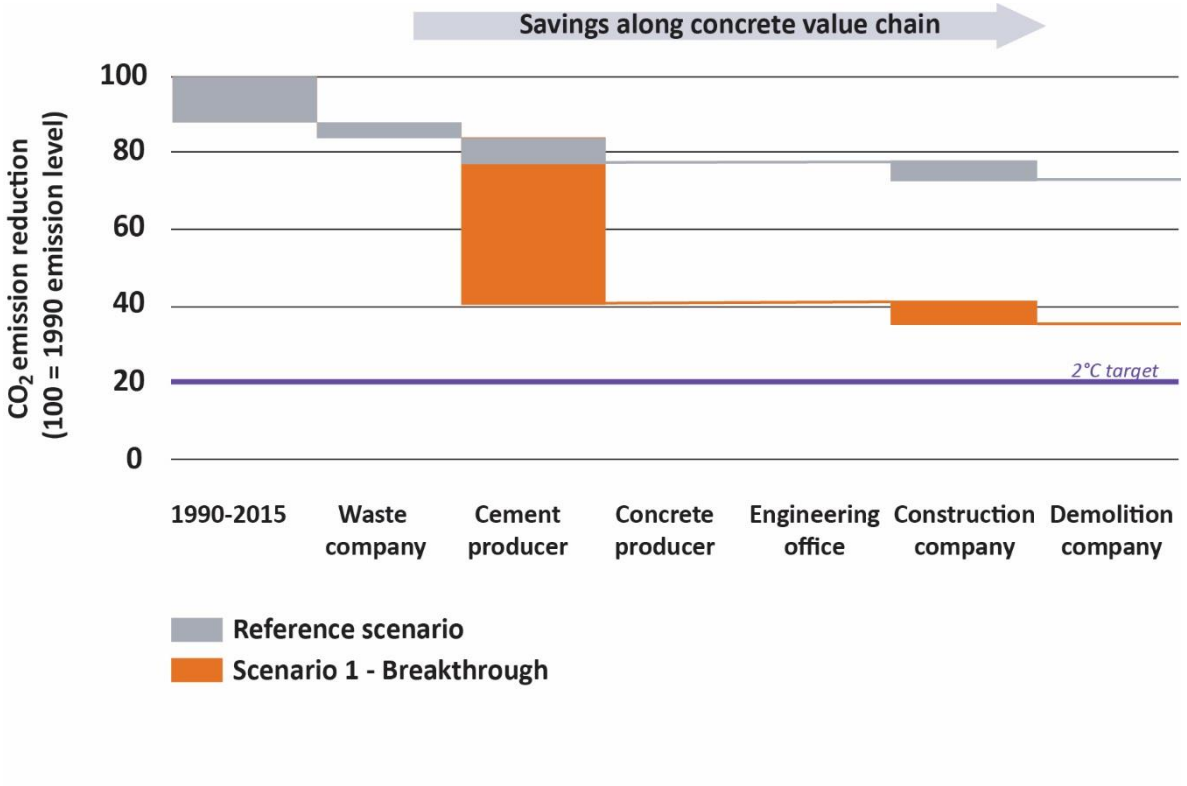

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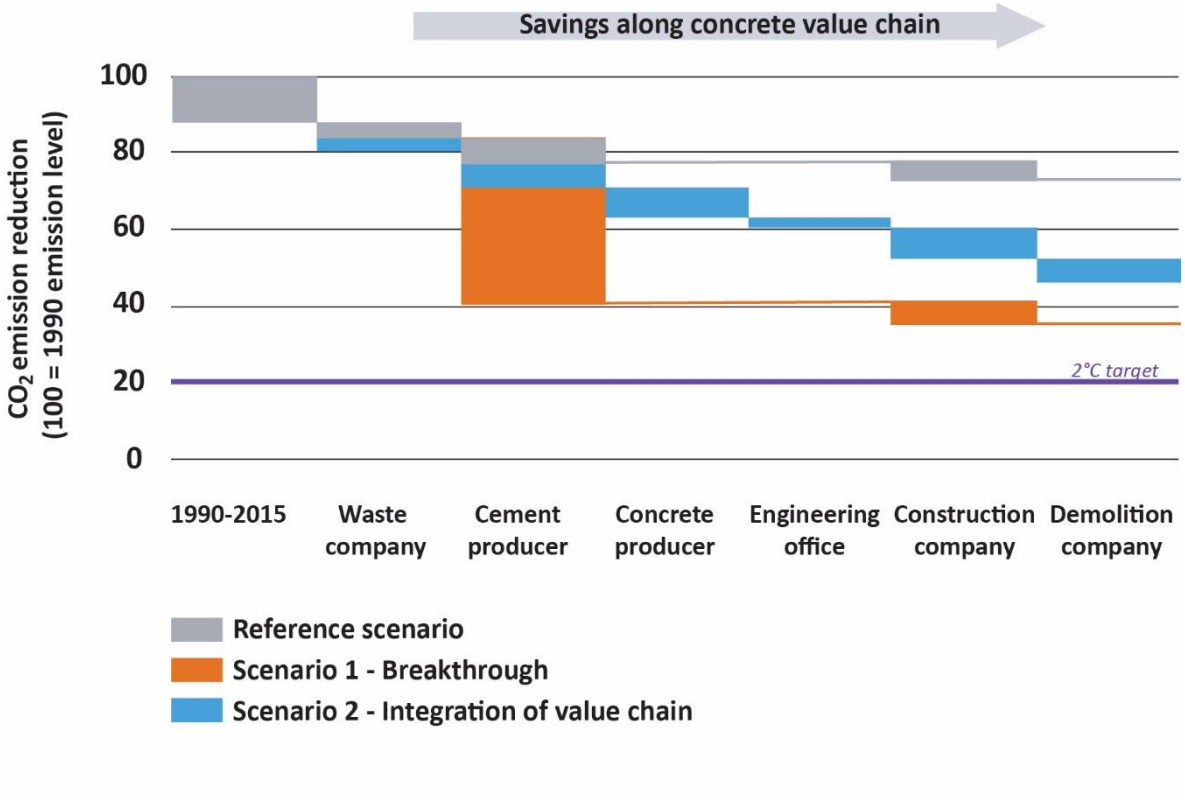

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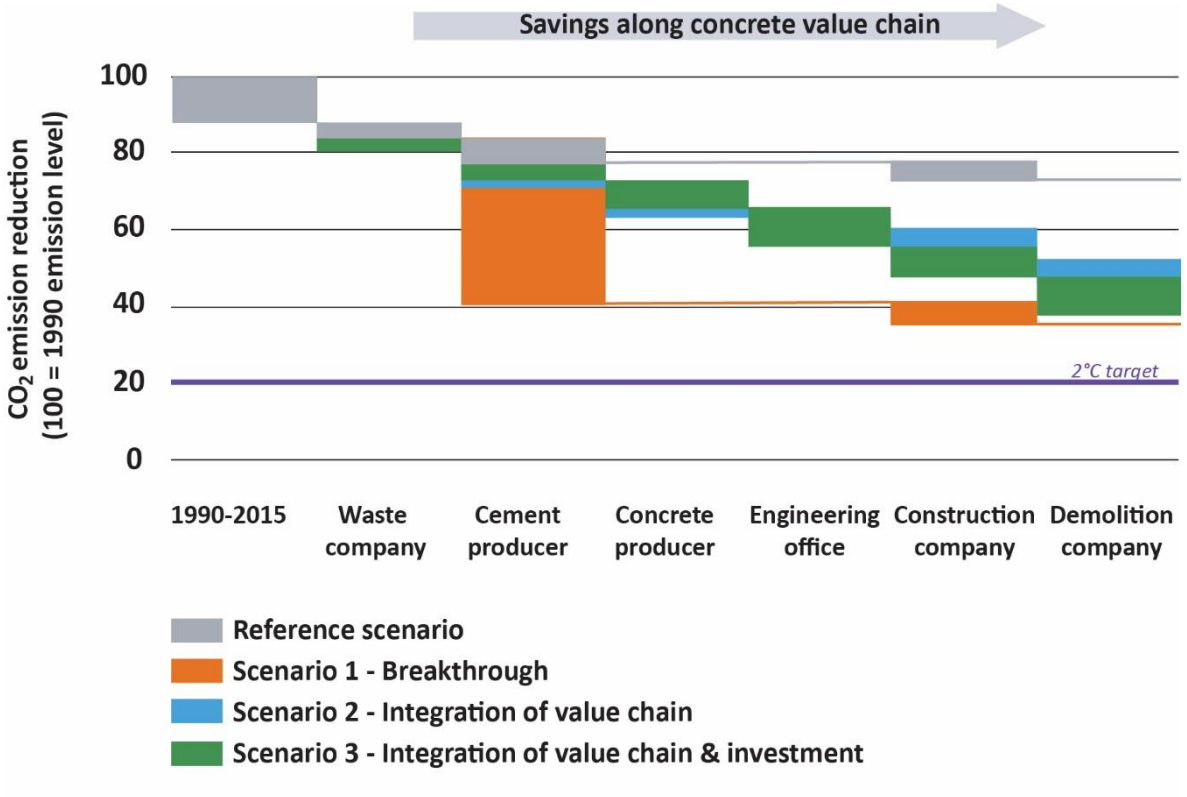

we can achieve similar results with much lower investment by implementing savings along the value chain

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Stakeholder involvement

Barriers to act

- Dry technology implementation
  - ➔ Savings by cement producers
- Alternative fuels
  - ➔ Savings by waste managers
- %SCM
  - ➔ Savings by cement producers
  - ➔ Savings by the construction companies
- % fine recycling
  - ➔ Saving as demolition recycling companies

Require high investment on old infrastructures or closing old cement plants

Require better waste management and increase of incineration practices inside EU

As EU will run out of GBFS and FA, it requires investment in calciner for the development of calcined clays

Higher SCM content is slowing down the construction speed. It requires more formwork on construction site *(space and cost pb)* **or slower demolding** *(productivity pb)*

Require good separation technique on demolition site *(time pb)* **and better crushing & sorting technique on recycling facilities** *(cost pb)*

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Stakeholder involvement

Barriers to act

- Improve packing & reduce overestimation
  - → Savings by concrete producers

  But it requires more silos *(space pb)* **and can lead to a loss of robustness of the mix** *(higher risk for customers)*
- Use appropriate exposition class
  - → Savings by engineering offices

  But it requires more time for design and forces engineering office to take a risk in case of problem *(no constraints in bidding call)*
- Optimise structure
  - → Savings by engineering offices

  But it requires more time for design and forces engineering office to take a risk in case of problem *(no constraints in bidding call)*
- Reuse structure
  - → Savings by demolition companies

  But it requires more time for deconstruction and space for storage
- Carbon Capture and Storage
  - → Savings by cement producers

  But it involves high investment *(CAPEX)* **and will induce additional cost for cement production** *(OPEX)*

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Indicators

KPI to involve all actors

- We need indicators by stakeholders
  - Upstreams indicators already exist
  - Downstream (building scale) also – voluntary basis
  - No indicators to involve concrete companies, engineering offices

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Indicators

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  - No indicators to involve concrete companies, engineering offices

- Example of possible indicators
  - For cement producers: a clinker with less than 0.7 t CO_2/tclinker
  - For concrete producers: a standard concrete containing less than 3.5 kg clinker/m^3/MPa
  - For structural engineers: a structure containing less than 250 kg CO_2/ m^2 of building
  - For construction companies: a building containing less than 500 kg CO_2/m^2

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  - For construction companies: a building containing less than 500 kg CO_2/m^2

- Example of possible incentives to drive transformation
  - Extra m^2 allowance for contractor when using low carbon to counterbalance reduction of productivity
  - Subsidies for extra silo capacities in concrete and gravel producers

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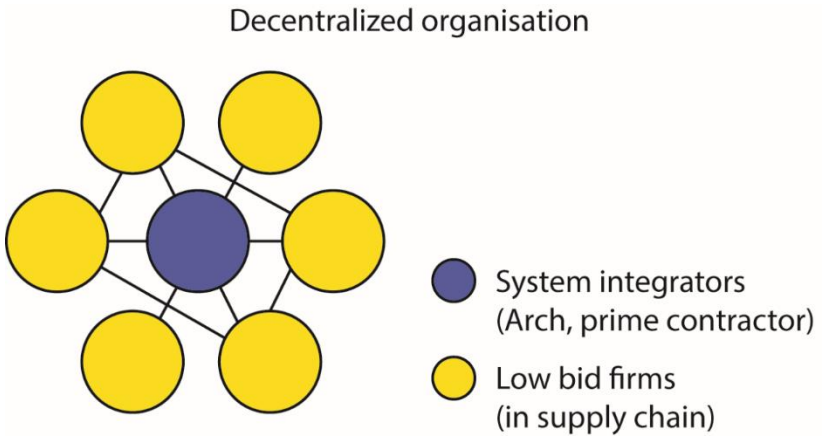
Change in the risk culture



(From D. Hall, 2017)

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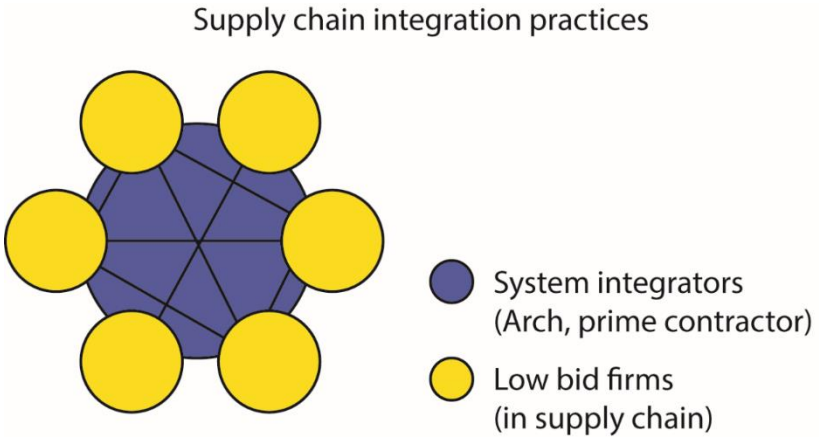
Change in the risk culture



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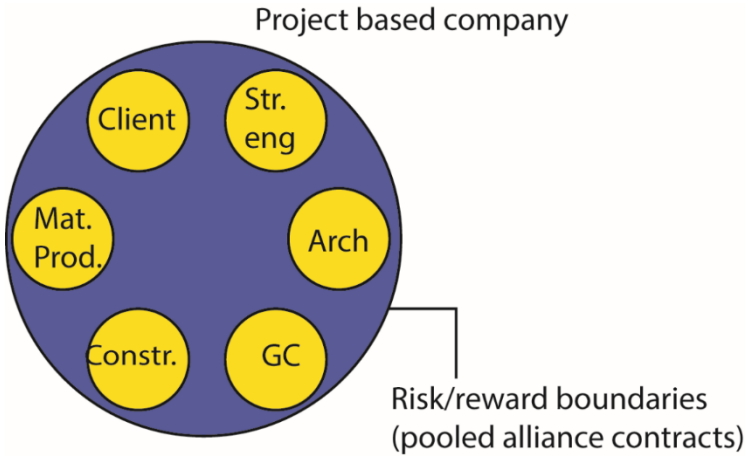

(From D. Hall, 2017)

Development of integrated Project delivery

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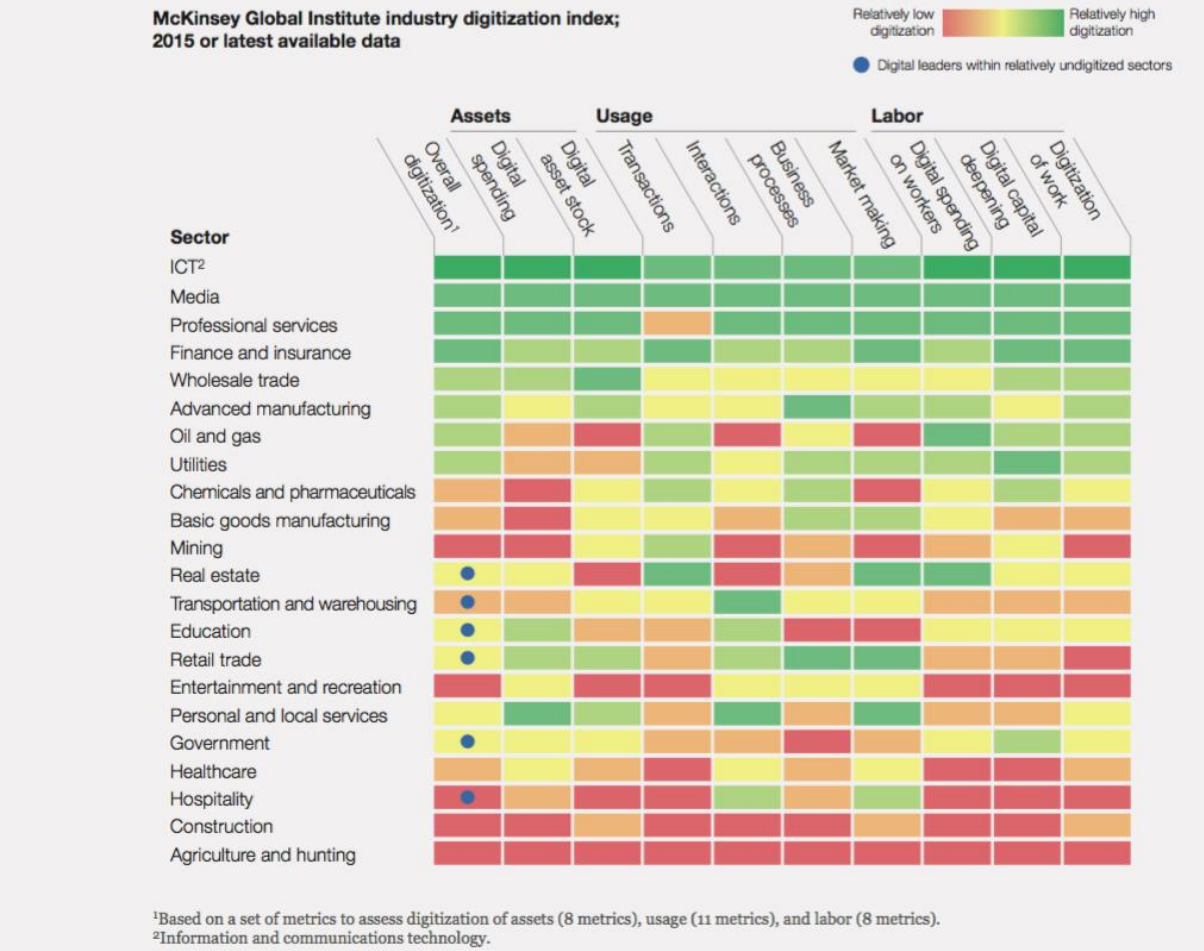
Change will happen



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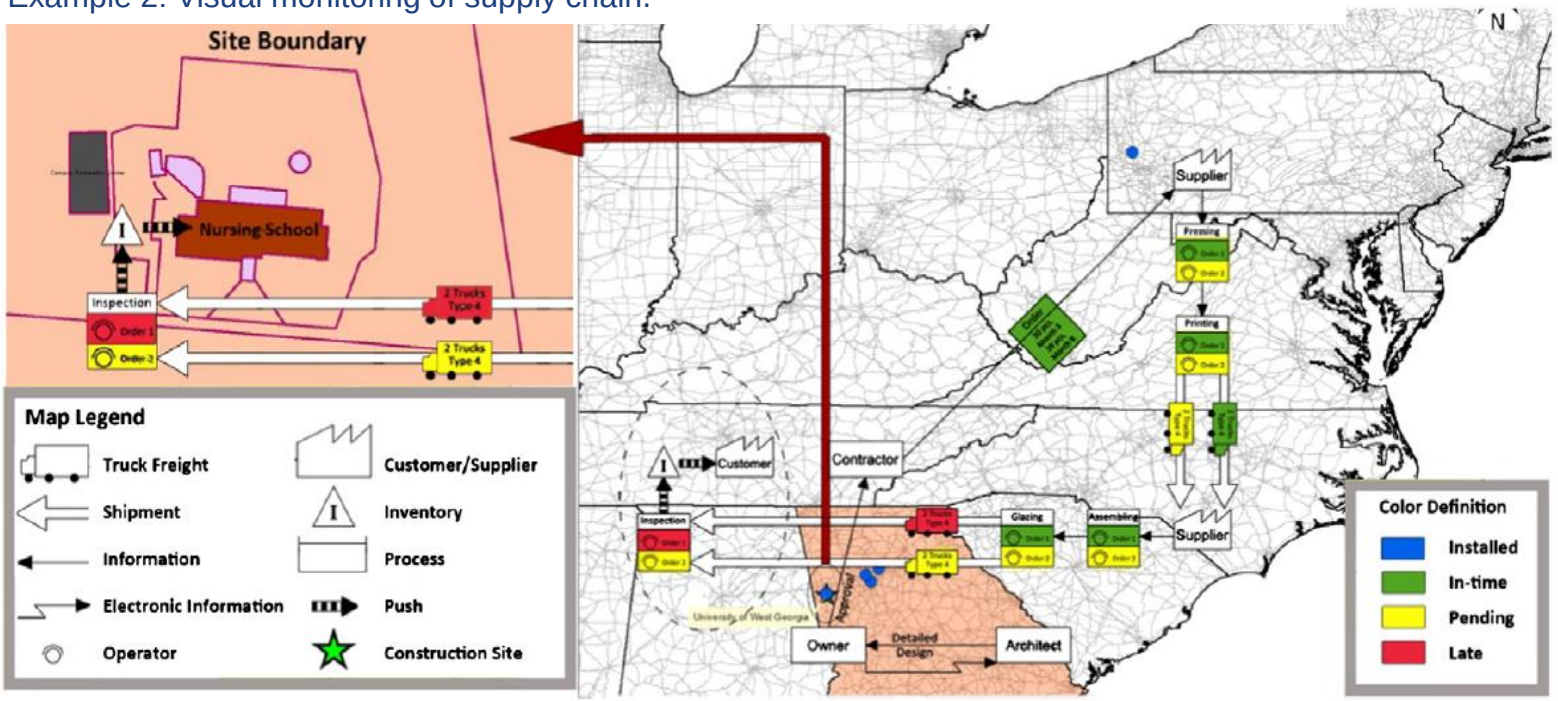
Potential of digitalization

Possibilities to involve all stakeholders through digitalization

Example 2: Visual monitoring of supply chain.



Sce: Irizarry et al., 2013. Integration BIM and GIS to improve the visual monitoring of construction supply chain management. *Automation and Construction*

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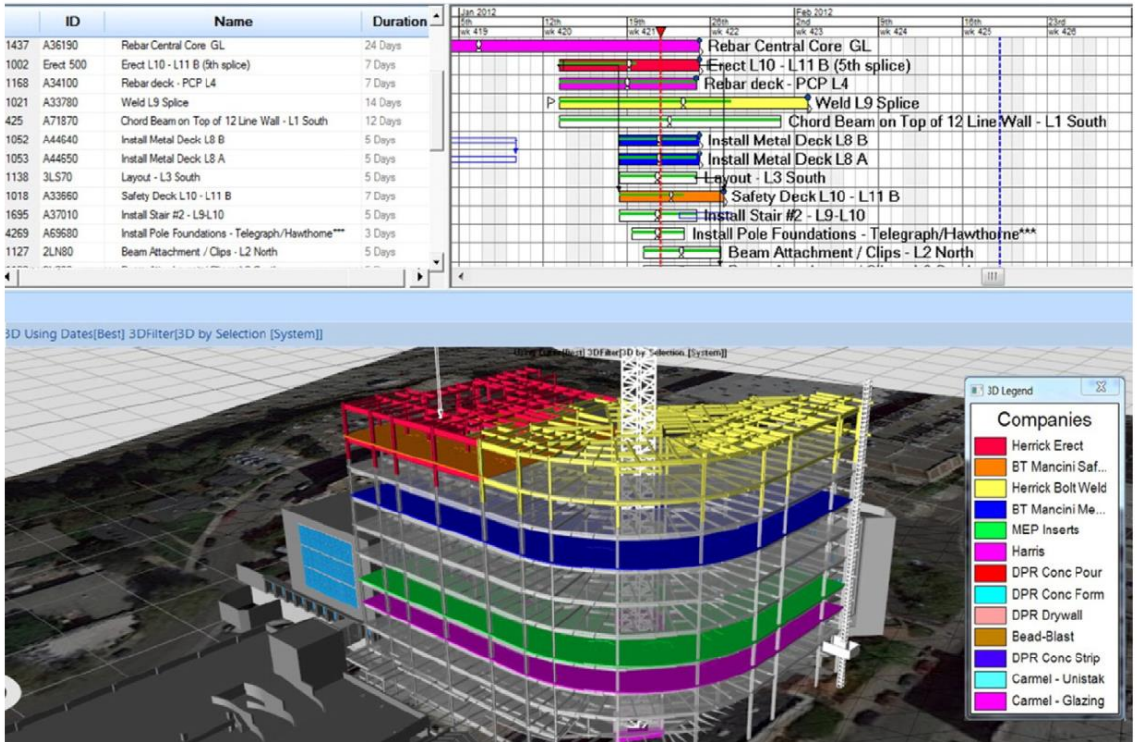
Potential of digitalization

Possibilities to involve all stakeholders through digitalization

Example 3: Tracking of construction companies and task planning.



Sce: Aram et al., 2013. Requirement for BIM platforms in the concrete reinforcement supply chain. *Automation and Construction*

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Conclusion

Climate change reduction potentials

- Integration of efforts all along the value chain allow to reach 2050 objectives

- Reduces the need for carbon capture and storage and allow short term and low cost roadmap for European construction industry

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Conclusion

Future development in the construction sector

- An increase in the digitalization of the sector will occur, leading to more prefabrication and the use of building information modelling.
- Resource conservation and the circular economy approach are gaining traction in economic and political circles. The construction industry will have to position itself in the conversation.
- Breakthrough technologies all require very high investment costs and will not be implemented in due time to counteract climate change. The industry is not willing to invest so much in the current situation.

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Thank you for your attention

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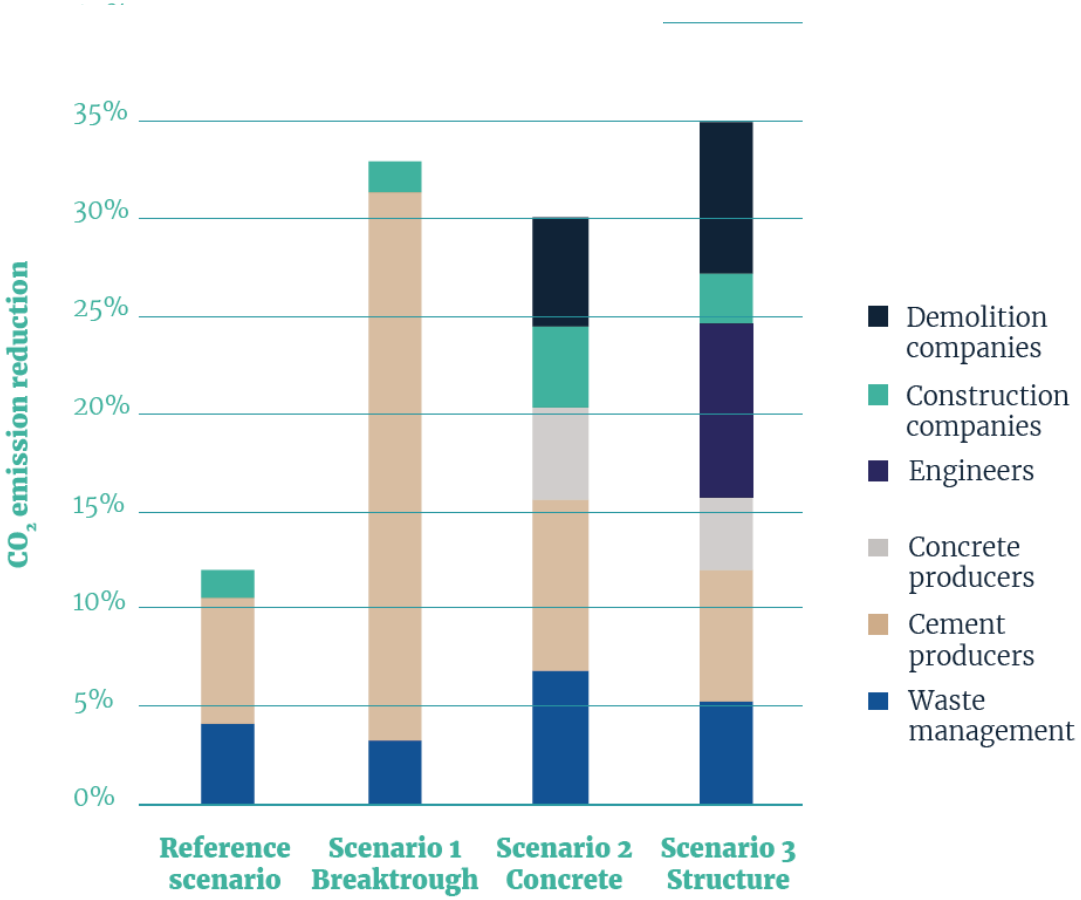
Different implication of the stakeholders along the value chain

Shared efforts or concentrated on the cement sector



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