The Sustainability Credentials of Hollowcore Flooring

The aims and objectives of Life Cycle Assessment
based on the example of the German hollowcore industry

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18th Annual Conference of IPHA
Berlin, 27th of May 2013

Structure

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- Life Cycle Assessment - a short introduction
- Life Cycle Assessment of hollowcore flooring
  - Introduction to the approach
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Starting Point

Starting point I

- Hollowcore Floorings have a significantly lower proportion of concrete and steel per square meter of ceiling space than other types of floorings (half-finished slabs and cast-in-place slabs) at basically the same functionality.
- Due to this fact, one might expect that the environmental impact of hollowcore floorings are lower than for the competing products on the market.

Starting point II

Despite the mentioned advantages, some disadvantages could still be expected for hollowcore floorings:

- **How relevant are the impacts of production?**
- **How relevant is the transportation of the precast elements to the construction site?**
- **How relevant is the quality of the used steel and concrete?**
- **➔ A scientific study has to clarify these questions – Life Cycle Assessment (LCA) methodology is most suitable**

Life Cycle Assessment (LCA)
a short introduction

LCA – a short introduction

Definition:

Life Cycle Assessment is a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

Life Cycle Assessment

- **Is a scientific, internationally standardized methodology**
- **In principle has a life cycle spanning perspective "From Cradle to Grave"**
- **Is a methodology to quantify environmental impacts of products and services**
- **Helps to identify hotspots of environmental impacts, to identify improvement potentials, to do product comparisons (e.g. to competing products or to new products under development)**

Advantages and limitations of LCA

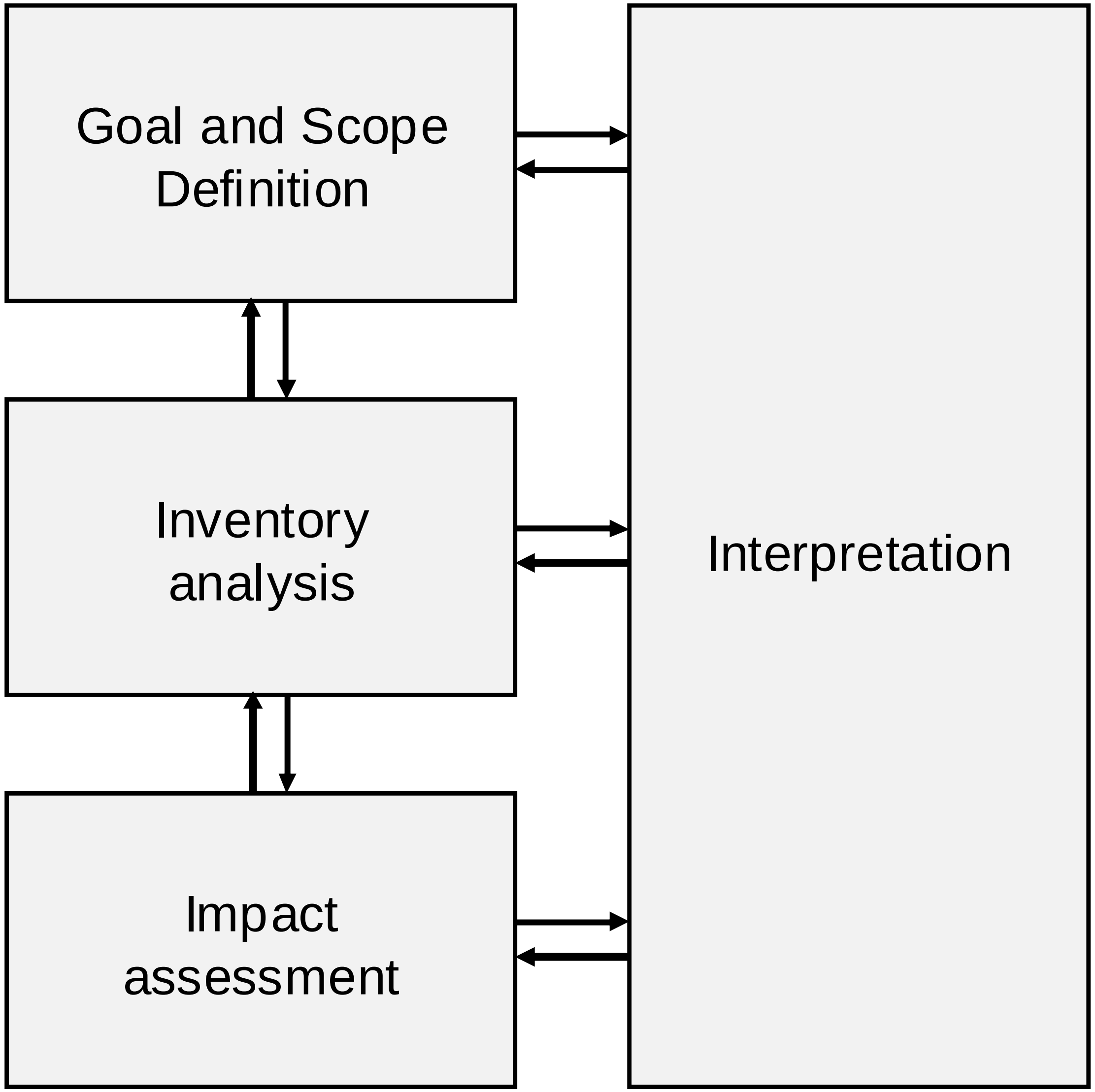
Advantages

- **Life CycleApproach**
  = (theoretically) ideal for the evaluation and comparison of the environmental impacts of different products/ different solutions.
- **LCA Studies base on a functional unit**
  = A comparison of products is possible that is independent from used technology.

Limitations

- **Aspects that are not (yet) quantifiable will be missing**
  = LCA results show an important part of the environmental impacts of a product/service but give not a complete picture of all its impacts.
- **Specific local impacts are not covered**
  = LCAs are not suitable for the assessment of local impacts.

The Four Phases of LCA



1. Goal and Scope definition

Definition of system boundaries, funciontal unit etc.

1. Inventory Analyses

Compilation and quantification of inputs and outputs for a product throughout its life cycle

1. Impact Assessment

Understanding and evaluating the magnitude and significance of the potential environmental impacts

1. Interpretation

Findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in

Life Cycle Assessment of hollowcore floorings

➔Introduction to the approach

LCA for hollowcore floorings

The methodological approach of the study was based on the LCA methodology, according to

- DIN EN ISO 14040:2009-11 environmental management - life cycle assessment - principles and framework and
- DIN EN ISO 14044:2006-10 environmental management - life cycle assessment - requirements and instructions

As in this case comparative statements were planned to be published, the LCA-study had been accompanied by an external critical review.

The study . . .

Titel:

LCA of concrete slabs – a comparative analyses of hollowcore floorings, half-finished slabs and cast-in-place slabs

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Commissioned by:

Seven companies of the hollowcore floorings industry

Accompanying Critical Review:

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Comparison of three alternatives of concrete slabs on the basis of a model office building

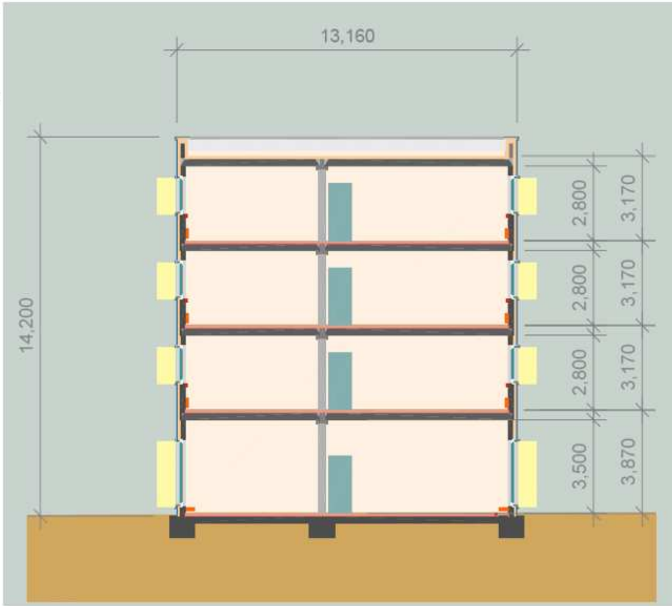
Functional unit (=bases for comparision)

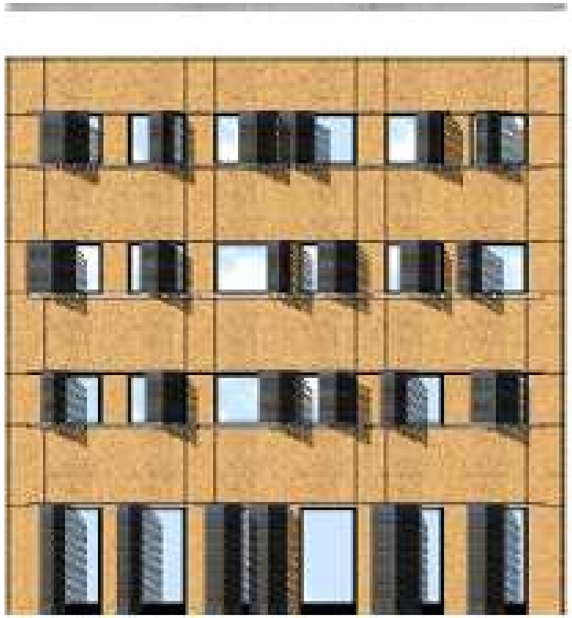
> **„Supply of the concrete slab areas, necessary in a defined three-story model office building over a period of 50 years"**
>
> **Any possible conversions withing the 50 years period were neglected.**

Function (=supposed to be the same for all alternatives)

> ***„The typical requirements for ceilings/floorings in an office building concerning sound insulation, fire protection, as well as the required technical characteristics related to the model building with regard to statics were fulfilled. "***

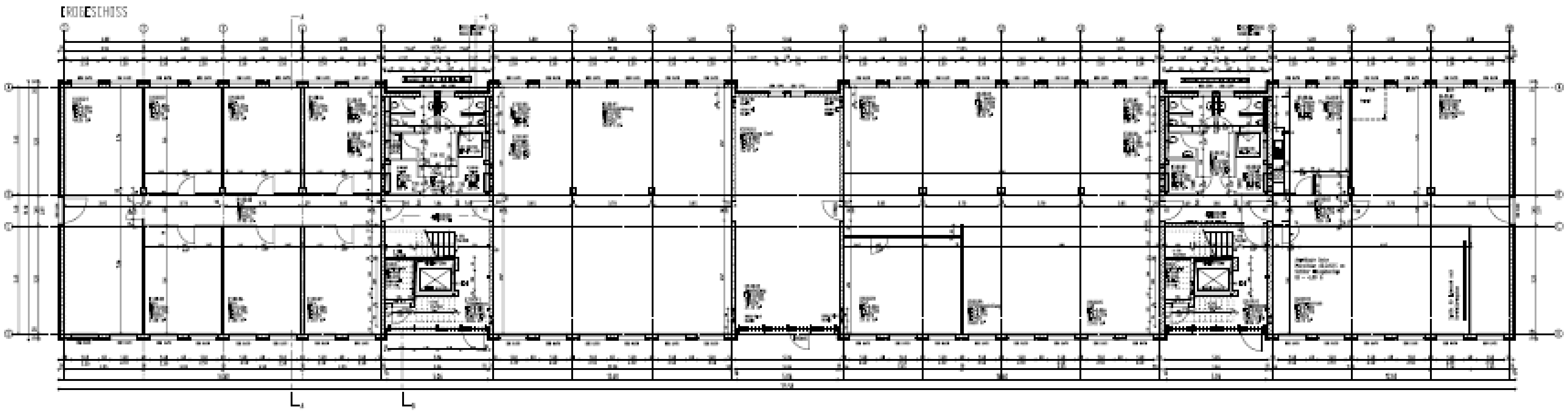
The chosen model office builduing





⇐ Cut and view of the model office building

⇓ Ceilings of the model office building (Ground Floor, 1. and 2. Floor)

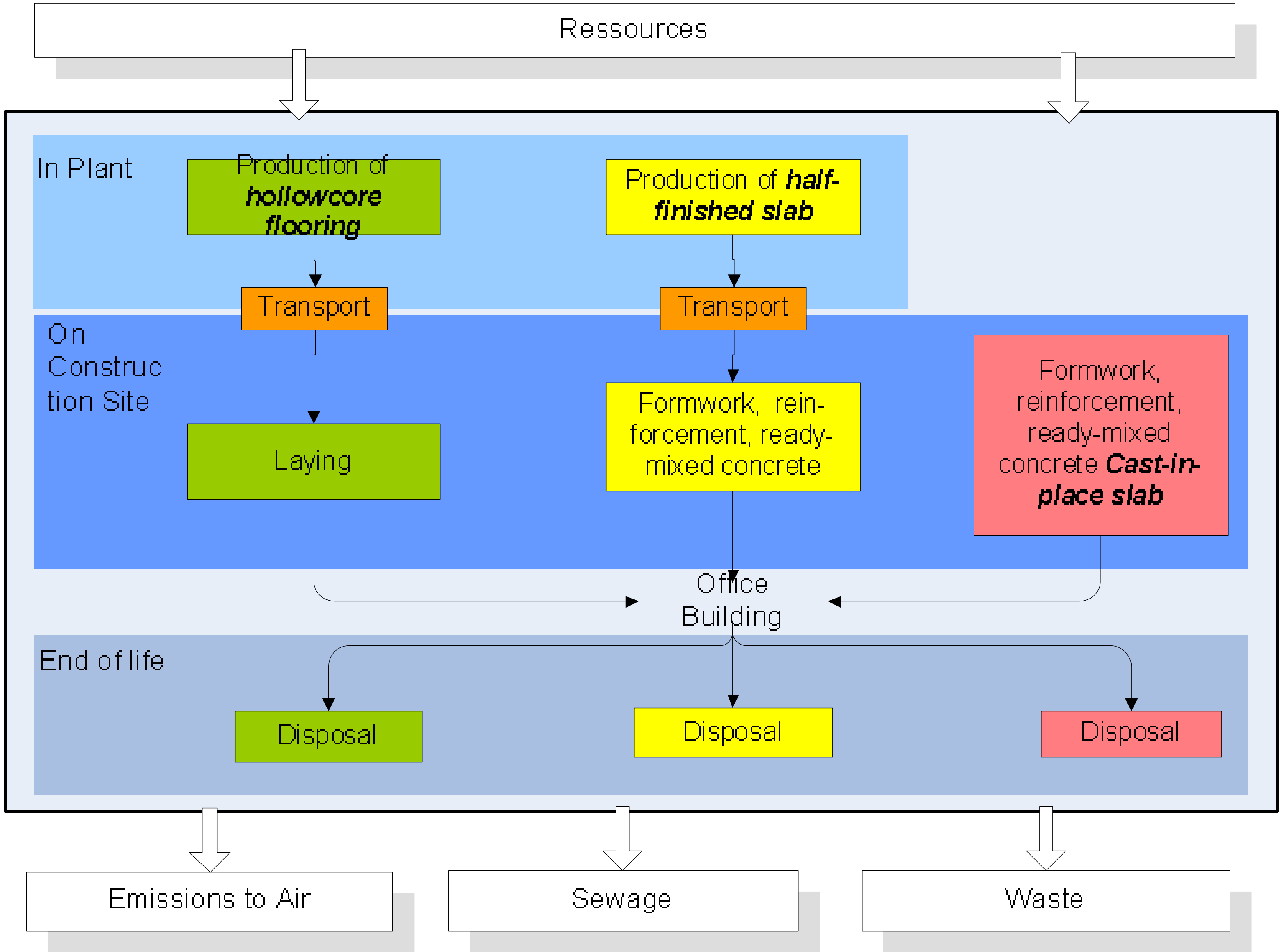


The analysed alternatives in the model office building

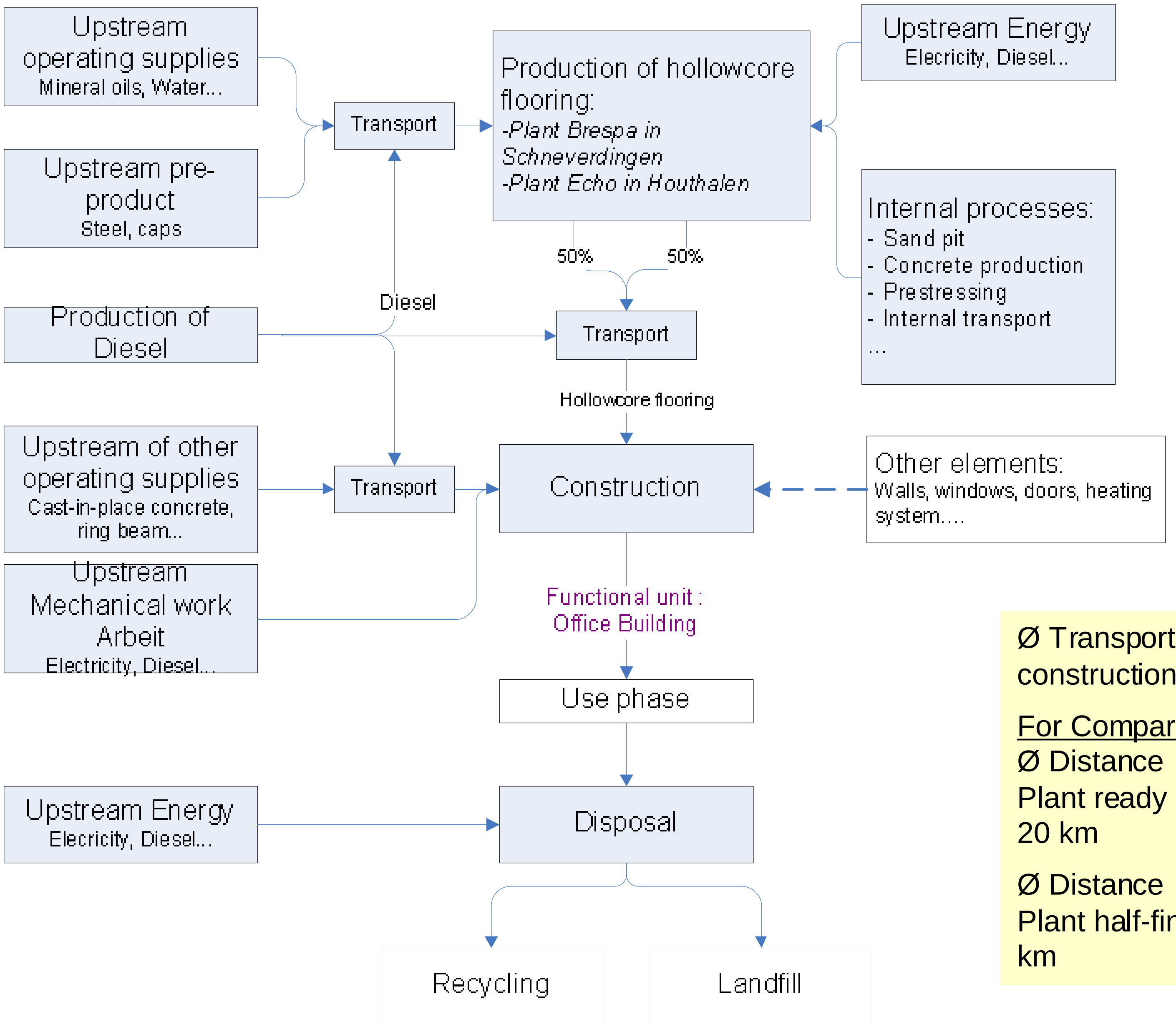
	Hollowcore flooring	Half finished slab	Cast-in-place slab
Gesamtdicke	20 cm	25 cm	25 cm
Total area	3.558,3 m²	3.557,2 m²	3.557,2 m²

Alternative	**Concrete** [t]	**Steel** [t]
Hollowcore flooring	**1.114,9**	**16,7**
In precast element	991,6	12,6 *prestressing steel*
On construction site	123,3	4,1 *reinforcing steel*
Half finished slab	***2.087,3***	**80,6**
In precast element	584,4	32,9 *reinforcing steel*
On construction site	1.502,9	47,7 *reinforcing steel*
Cast-in-place slab	***2.087,3***	*64,4*
On construction site	2.087,3	64,4 *reinforcing steel*

The analysed system



System hollowcore flooring: Overview

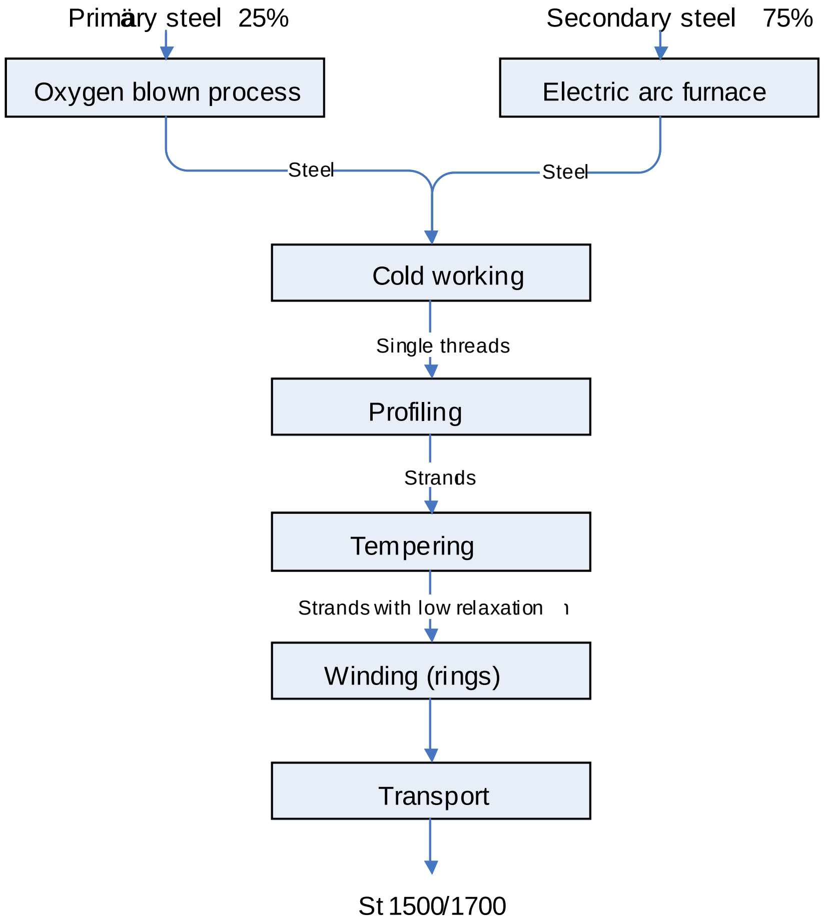


Ø Transport distance to construction site: 167 km

For Comparison:
Ø Distance
Plant ready mixed concrete: 20 km

Ø Distance
Plant half-finished slabs: 84 km

System hollowcore flooring: Production of prestressing steel



<u>For Comparison:</u>
For reinforcement steel tempering and winding is not necessary, instead welding has to be done.

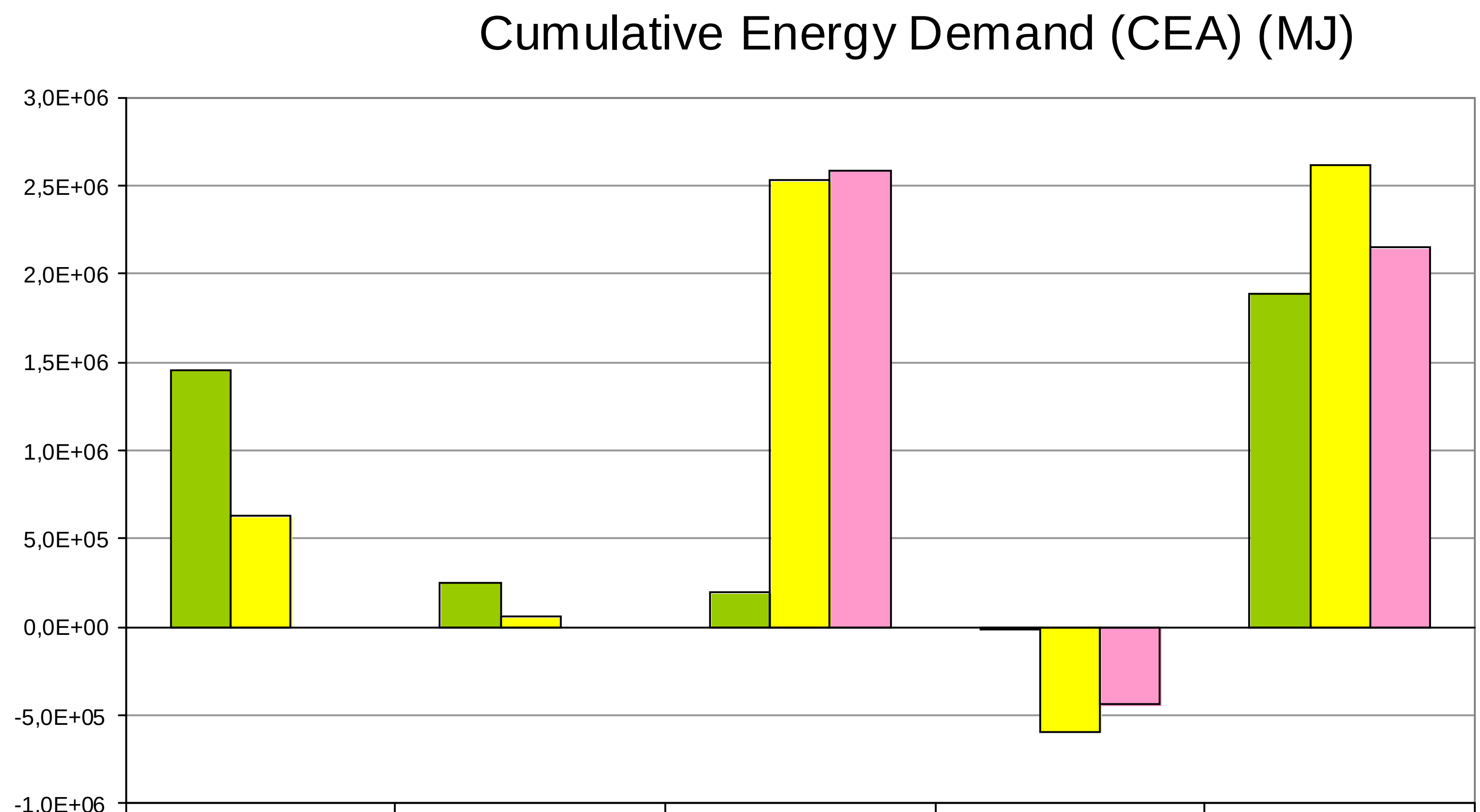
Database

- **The time-related coverage, geographical coverage and technology coverage of the used data was chosen according to the aim of the study.**
- **For the calculation as well primary data (production of hollowcore flooring) as well as secondary data (e.g. supply of electricity) were used.**
- **Gaps exist concerning the production of the prefabricated elements of the half finishes slabs and concering some processes (e.g. stranding of prestressing steel). There were neither primary nor secondary data available in these cases.**
- **Credits were given for the recycling at the end of life (steel, concrete) as well as in the context of production and manufacturing processes.**

Life Cycle Assessment of hollowcore floorings

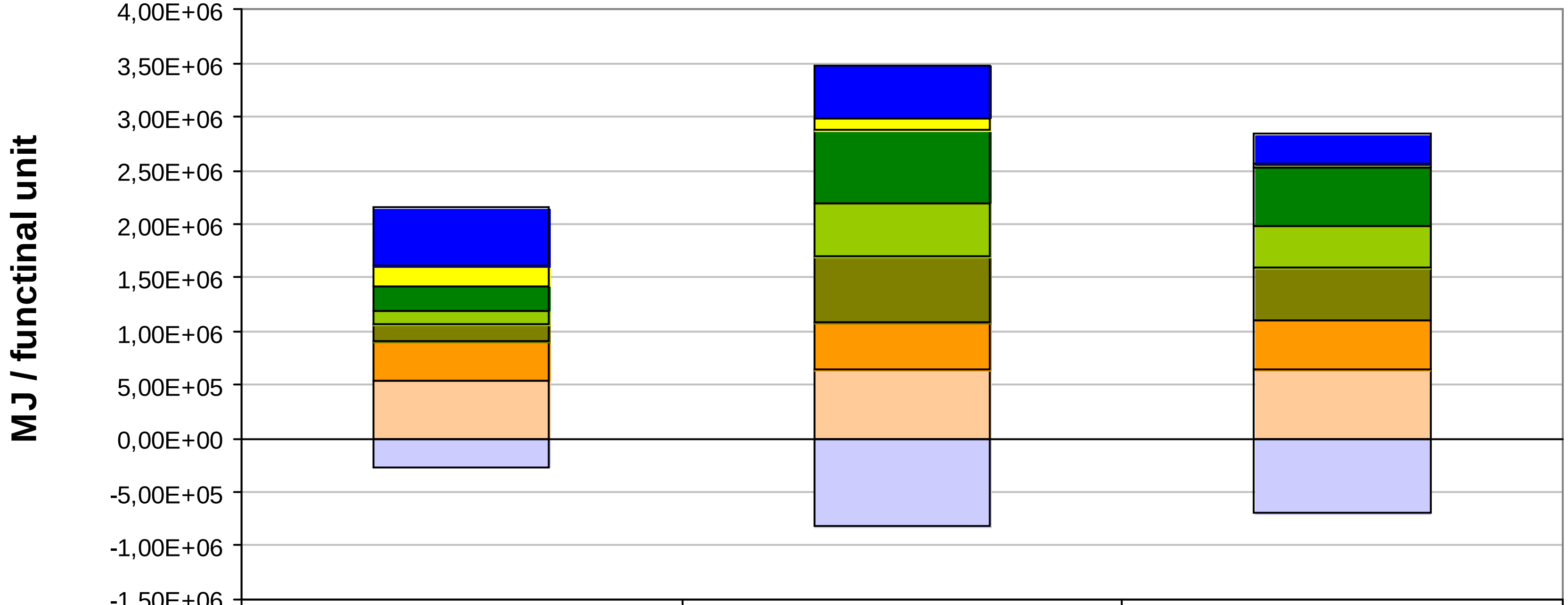
➔Results

Results for Cumulative Energy Demand (CEA) I



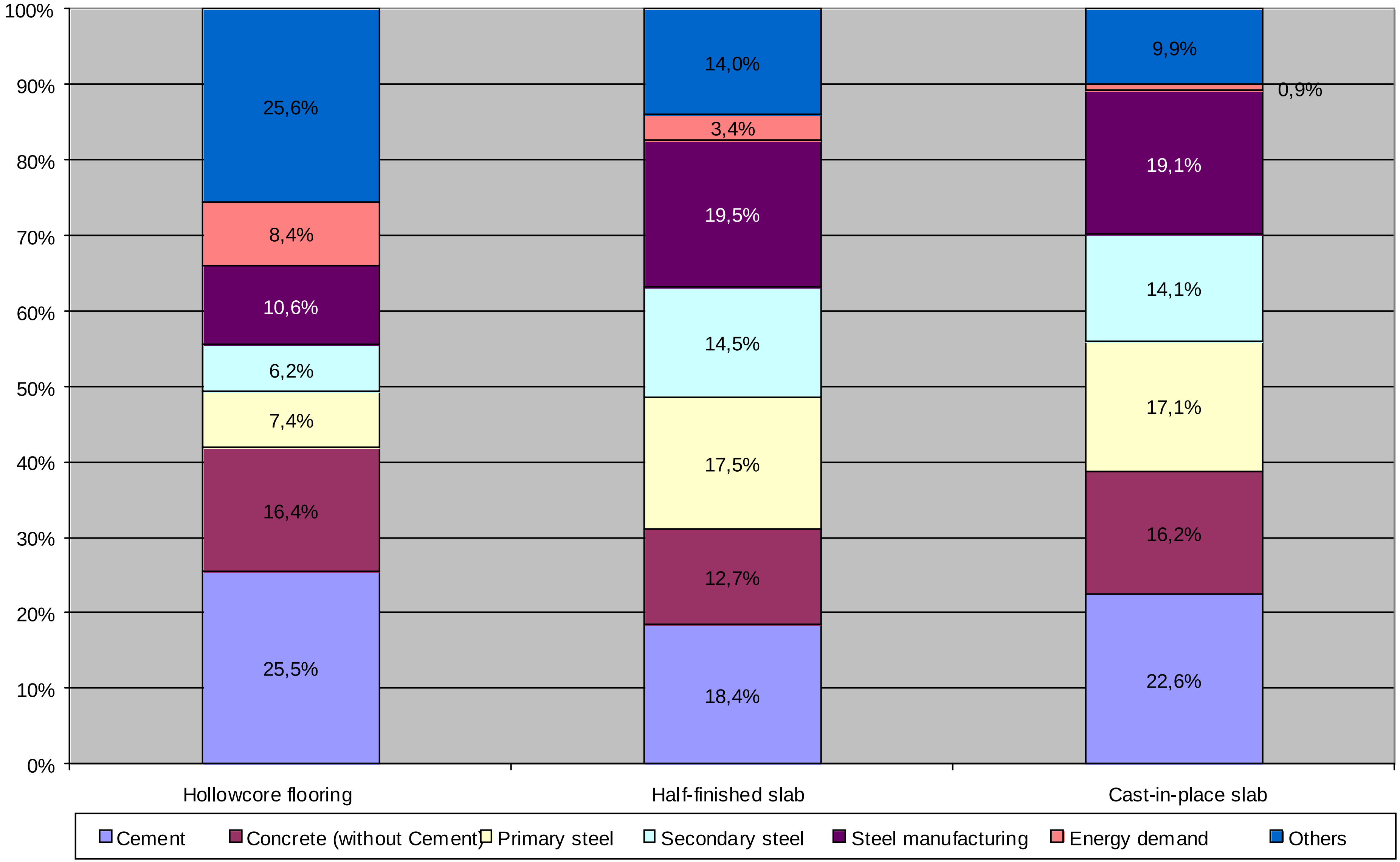
	Production in plant	Transport of Prefabricated elements	Processes on Construction site	End of life	Total
Hollowcore flooring	1.456.392,50	249.990,39	191.429,36	-7.867,27	1.889.944,98
Half-finished slab	629.043,96	54.685,40	2.531.890,24	-593.083,41	2.622.536,19
Cast-in-place slab	0,00	0,00	2.585.169,42	-437.783,28	2.147.386,14

Results for Cumulative Energy Demand (CEA) (II)

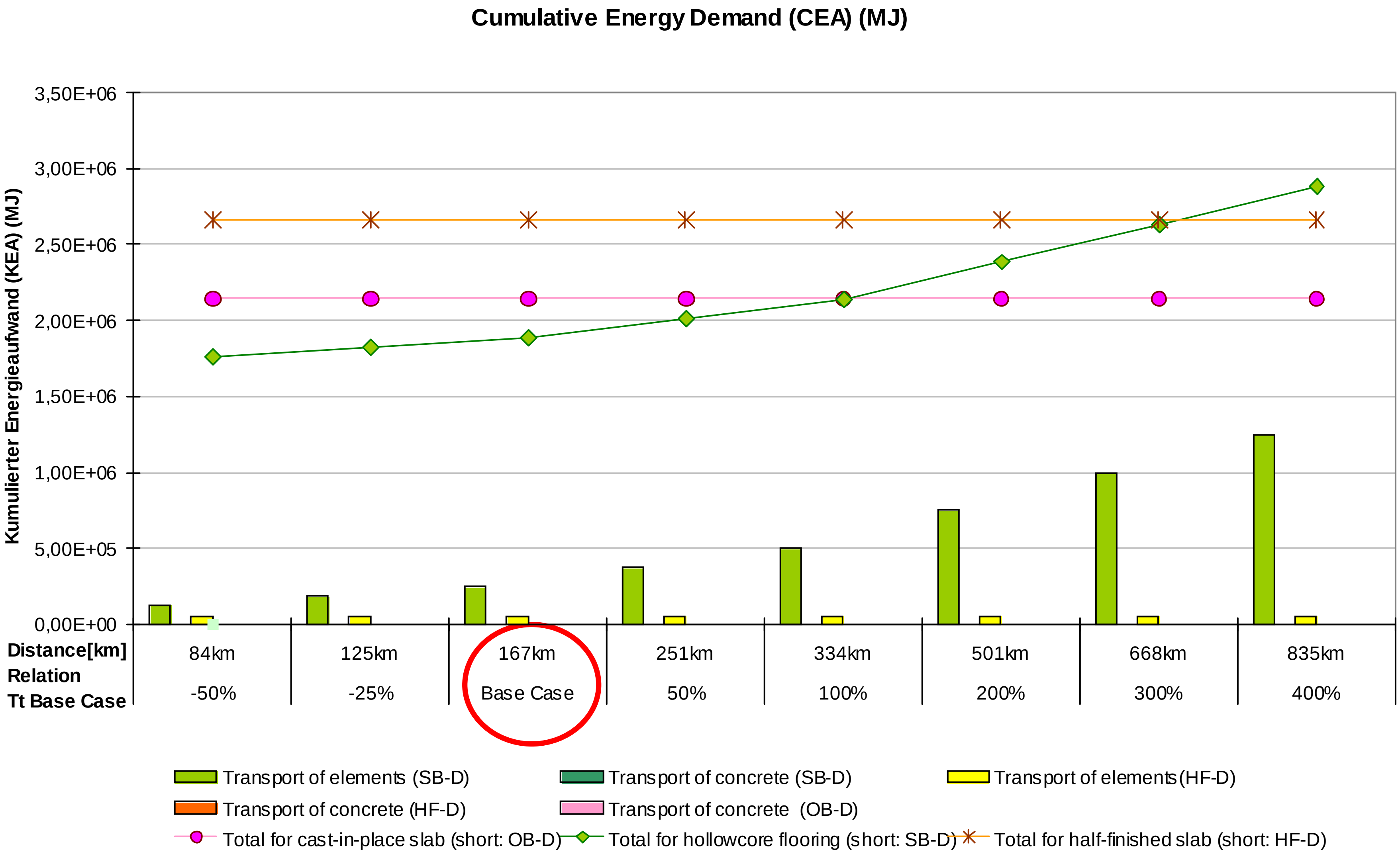


	Hollowcore flooring	Half-finished slab	Cast-in-place slab
Credit	-269.239,29	-818.762,84	-694.159,37
Others	551.802,62	486.665,44	281.090,96
Energy demand	180.877,22	118.495,47	26.196,28
Steel manufacturing	228.639,81	679.678,41	541.990,67
Secondary steel	133.044,21	504.023,46	401.919,51
Primary steel	160.493,82	610.951,60	487.186,39
Concrete (without cement)	354.681,82	441.825,83	461.213,94
Cement	549.644,76	641.948,07	641.947,76

Contribution analyses for cumulative energy demand

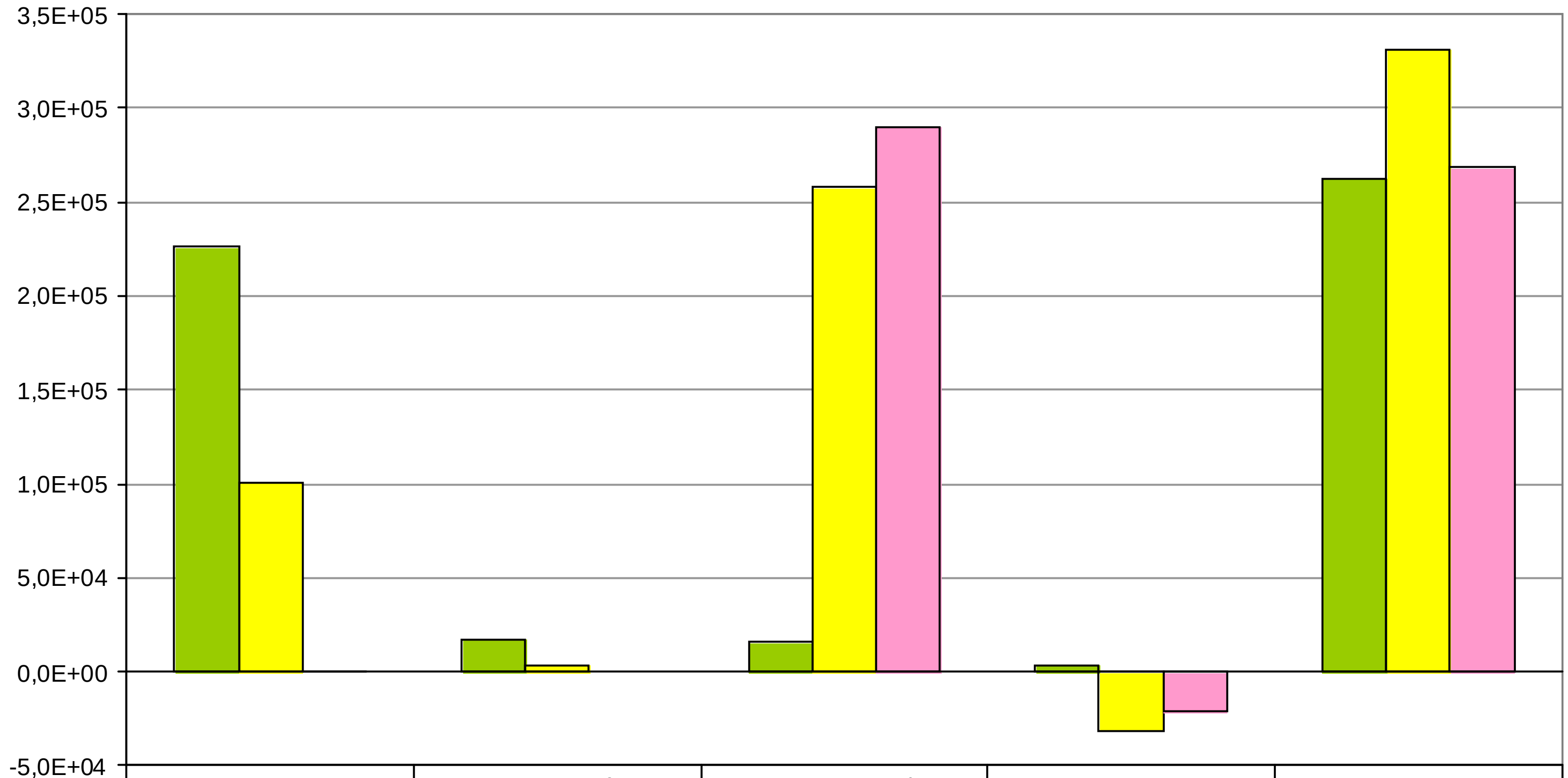


Variation of transport distance for the hollowcore flooring for the cumulative energy demand



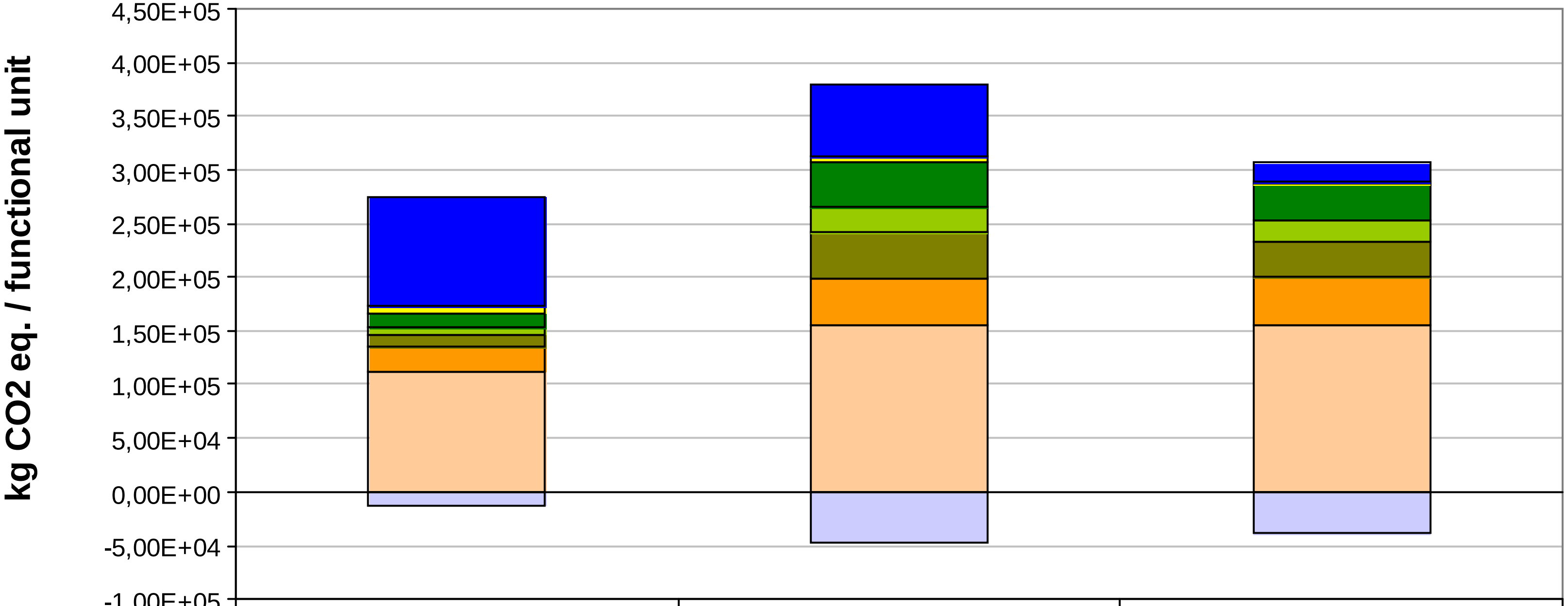
Results for global warming potential (GWP) I

Global warming potential (GWP) (kg CO2-eq.)



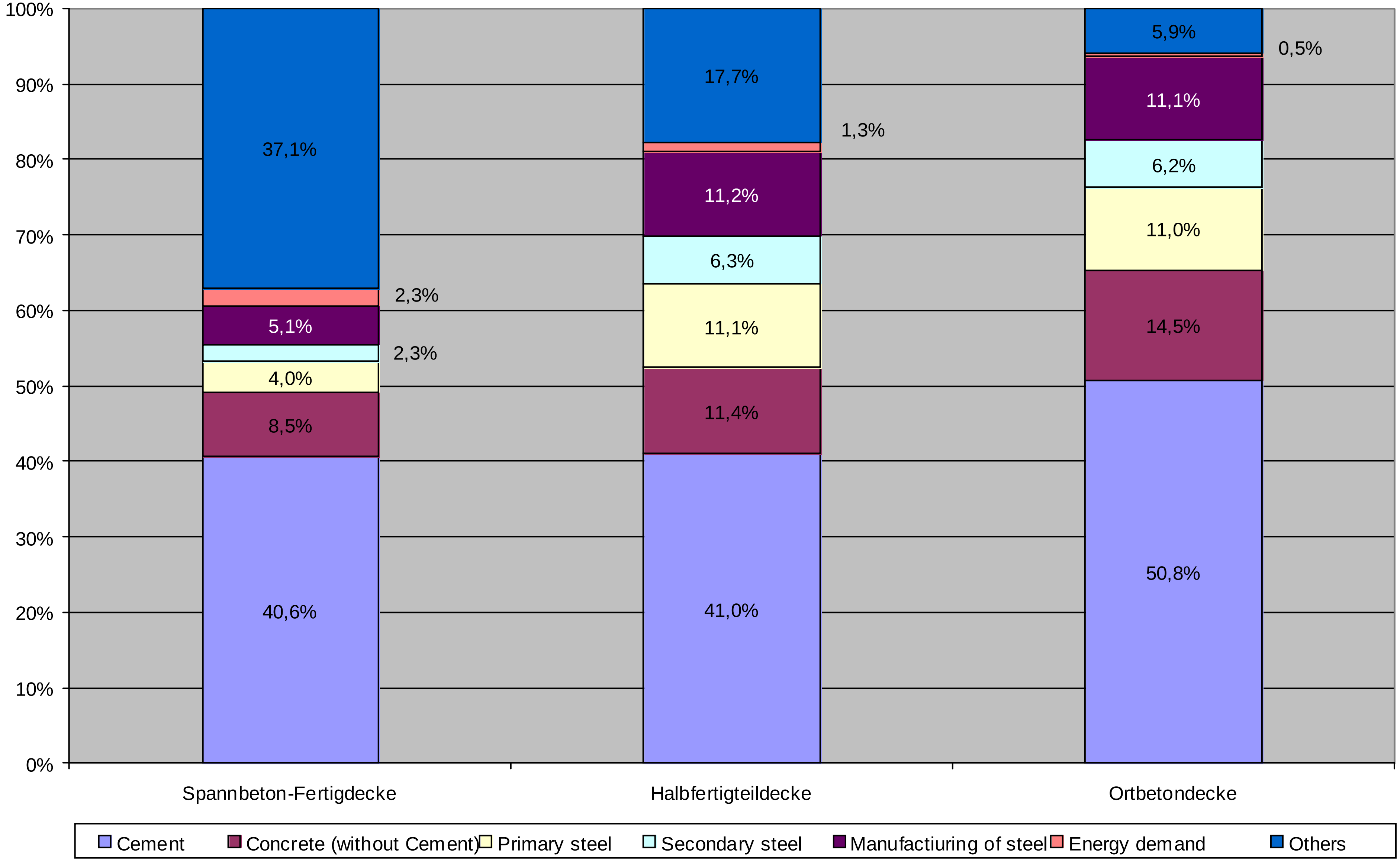
	Production in plant	Transport of prefabricated elements	Processes on the Construction site	End of life	Total
Hollowcore flooring	225.870,36	17.398,89	15.617,67	3.698,20	262.585,13
Half finished slab	101.051,32	3.806,01	257.780,96	-31.610,86	331.027,42
Cast-in-place slab	0,00	0,00	289.757,12	-21.369,90	268.387,22

Results for global warming potential (GWP) II

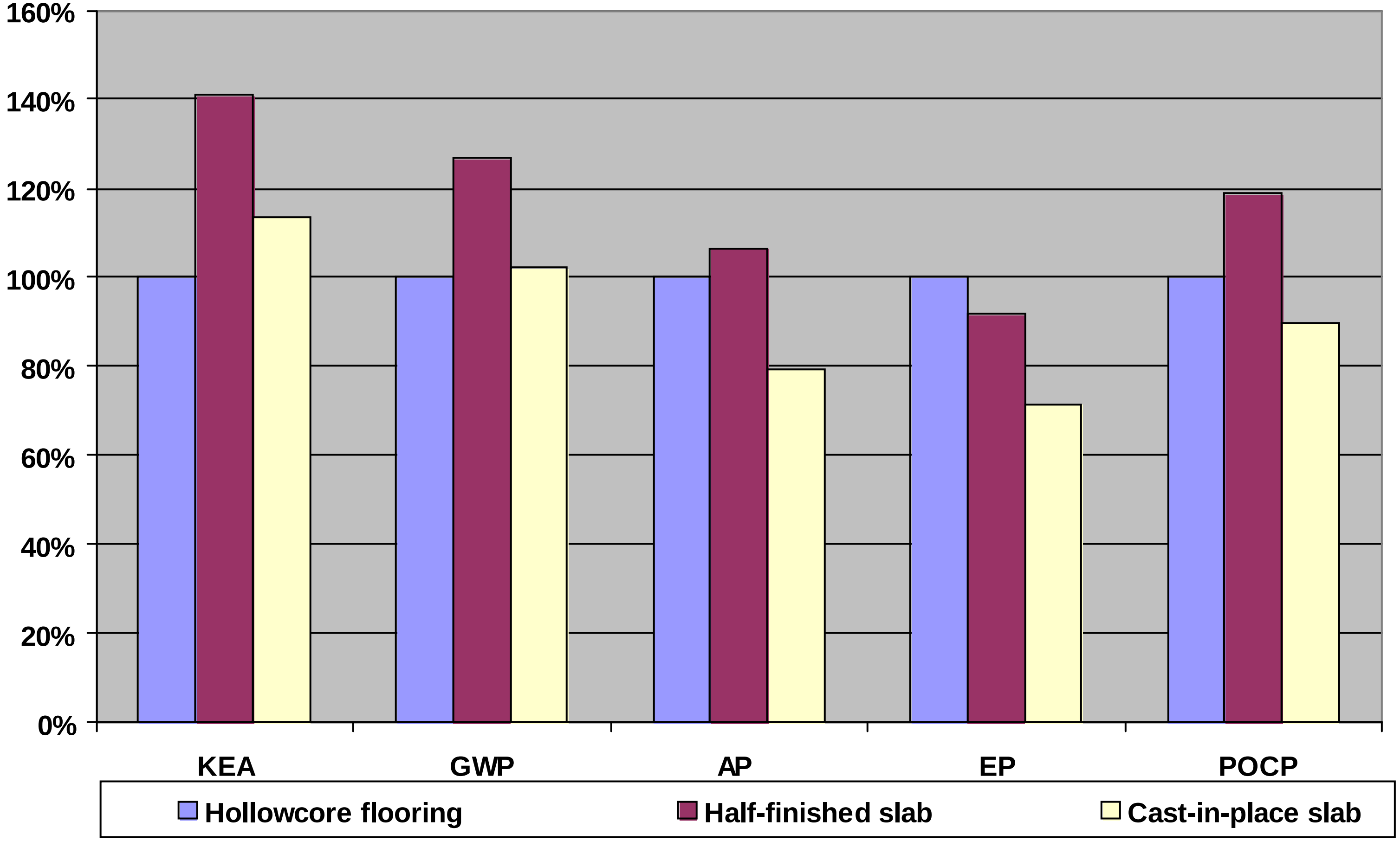


	Hollowcore flooring	Half-finished slab	Cast-in-place slab
Credits	-12.466,10	-46.603,81	-38.185,59
Others	101.996,91	67.129,39	18.109,92
Energy Demand	6.447,34	4.861,69	1.499,69
Steel manufacturing	14.008,41	42.522,01	33.907,99
Secondary steel	6.334,16	23.993,54	19.132,99
Primary steel	11.072,88	42.132,32	33.597,25
Concrete (without Cement)	23.404,02	43.203,65	44.523,28
Cement	111.787,51	155.801,78	155.801,70

Contribution analyses Global warming potential



Overview of all considered impact categories



Impact category	Unit	Hollowcore flooring	Half-finshed slab	Cast-in-place slab
KEA	MJ	1.889.945	2.664.825	2.147.386
GWP	kg CO2äq.	262.585	333.041	268.387
AP	kg SO2äq.	775	826	616
EP	kg PO4äq.	126	115	90
POCP	kg CH4äq.	44	52	40

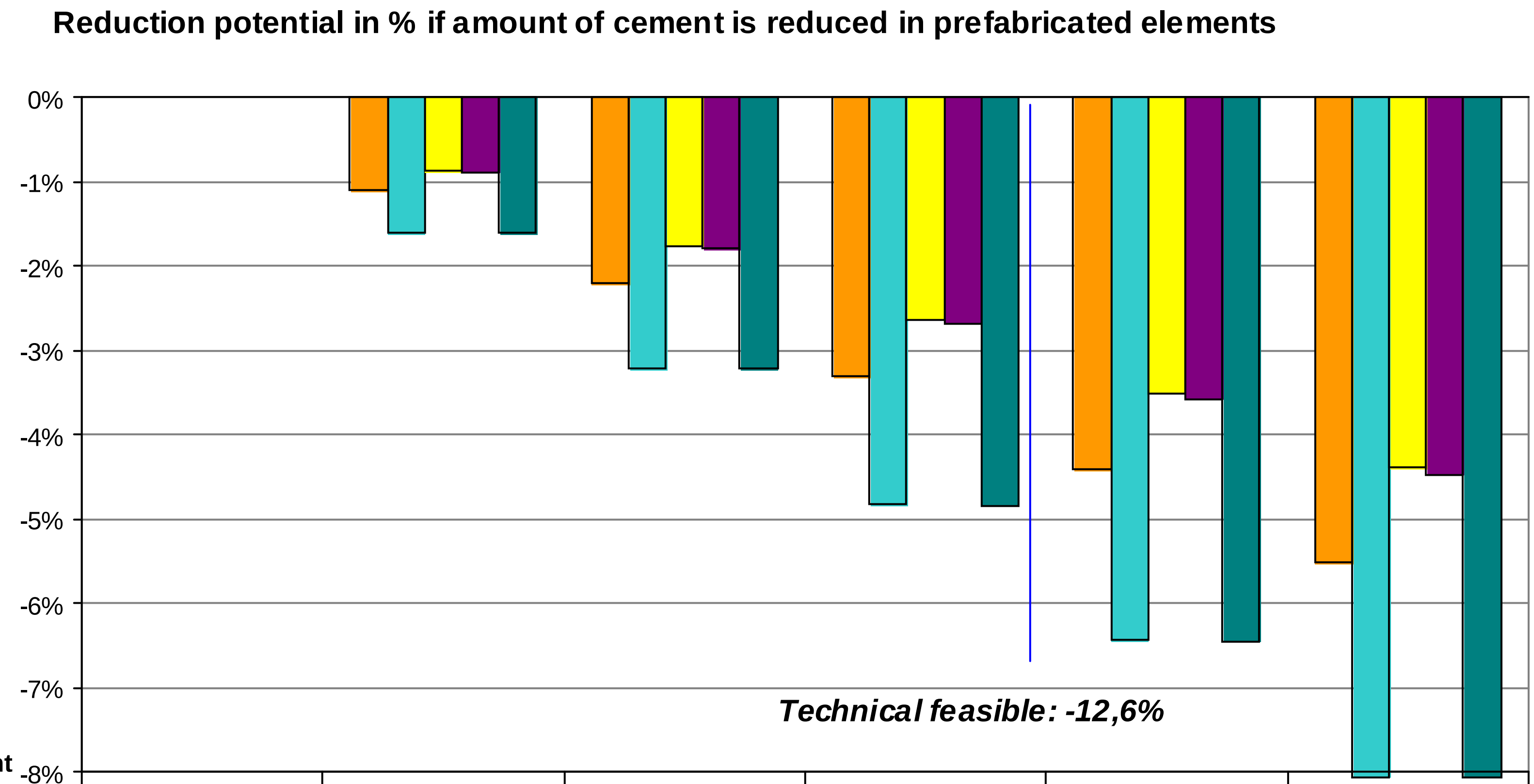
Life Cycle Assessment of hollowcore floorings

➔Discussion

Discussion of results

- Important contributions are the environmental impacts from the production of the concrete, particularly cement, and steel.
- For hollowcore floorings it has significant influence that the cement type, used for the production of the prefabricated elements, has a high share of cement clinker (CEM I cement) and – additionally is made with a rather high amount of cement.
- For hollowcore floorings presstressing steel is used, which has a higher impact than reinforcement steel (e.g. tempering). Additionaly it is unclear to what extent prestressing steel is produced from primary or secondary steel typically. The latter has only a small impact.

Reduction of the amount of cement in the prefabricated elements of the hollowcore flooring



Amount of cement In prefabricated element (kg)	142.715 0%	137.006 -4%	131.298 -8%	125.589 -12%	119.881 -16%	114.172 -20%
KEA (MJ)	0,0%	-1,1%	-2,2%	-3,3%	-4,4%	-5,5%
GWP (kg CO2 eq.)	0,0%	-1,6%	-3,2%	-4,8%	-6,4%	-8,1%
AP-EU (kg SO2 eq.)	0,0%	-0,9%	-1,8%	-2,6%	-3,5%	-4,4%
EP (kg PO4 eq.)	0,0%	-0,9%	-1,8%	-2,7%	-3,6%	-4,5%
POCP (kg Eth eq.)	0,0%	-1,6%	-3,2%	-4,8%	-6,5%	-8,1%

Thank you for your attention!

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