COMPOSITE CEMENTS VS ORDINARY PORTLAND CEMENT

QUALITY, APPLICATION, STANDARDS AND ADVANTAGES

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KEY FIGURES OF THE CEMENT INDUSTRY COMPARISON: GERMANY VS INDONESIA

- **In post-industrialized as well as in emerging economies the total share of industry on the GDP is in the range of 30-40 %.**
- **In 2021 the total cement production was 30 MT/a in Germany, in Indonesia 64 MT/a. However per capita consumption of 237 kg/capita/a in Indonesia indicates the state of an emerging nation.**
- **In Germany as well as in Indonesia the share of the cement industry on the total GDP is much lower than 1 %. This share is negligible.**
- **Nevertheless the cement industry and its product is of strategic essence and not replaceable.**

Industrial part on GDP	%
Germany	30
Indonesia	40

	Cement production MT/a	Consumption kg/capita/a
Germany	30 MT/a	361
Indonesia	64 MT/a	237

Germany	GDP Trillion USD/a	Year
GDP	4.26	2021
Revenue Cement Industry	0,003	2021
Share on GDP	0,07	%

Indonesia	GDP Trillion USD/a	Year
GDP	1.186	2021
Revenue Cement Industry	0,004809	2021
Share on GDP	0,41	%

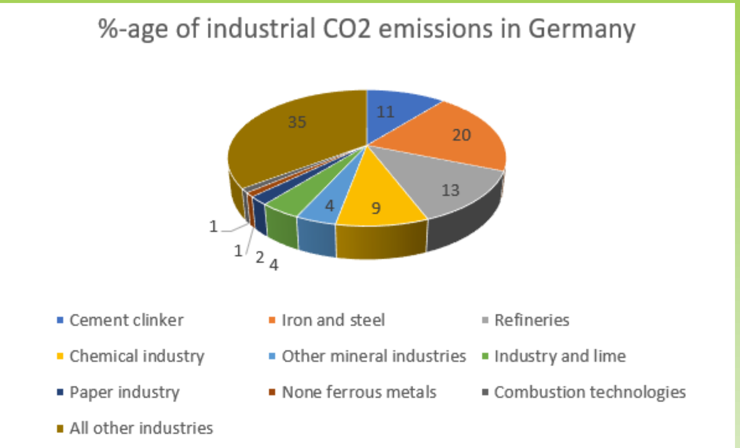
SHARE OF THE CEMENT INDUSTRY ON CO_2 EMISSIONS - EXAMPLE: GERMANY

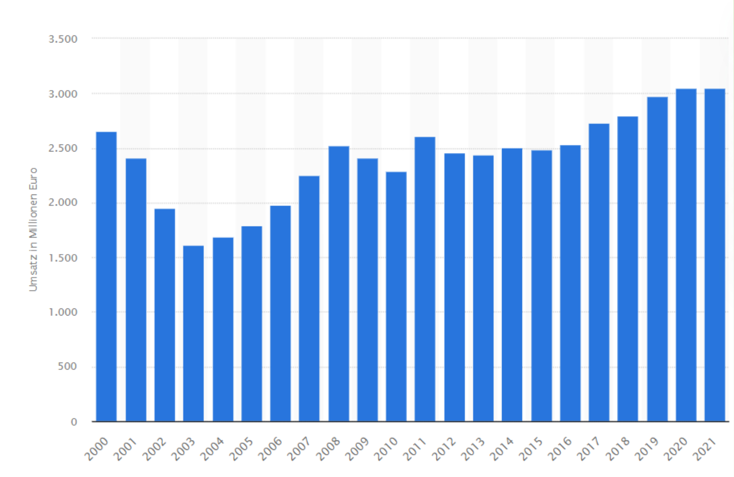
- **In Germany less than ¼-th of all CO_2 emissions are originating from industrial production. Major emission source is the service sector at 70 %, followed by the construction industry at 6 % and the agriculture at 1 %.**

- **The total share on CO_2 emission of industry in Germany is around 25 %.**

- **Out is this 25 % of industrial CO_2 emissions, the CO_2 emissions caused by clinker production is over proportionally at 11 %.**

- **This results in a share of 2.75 % on the total CO_2 emissions in Germany which are caused by clinker production.**

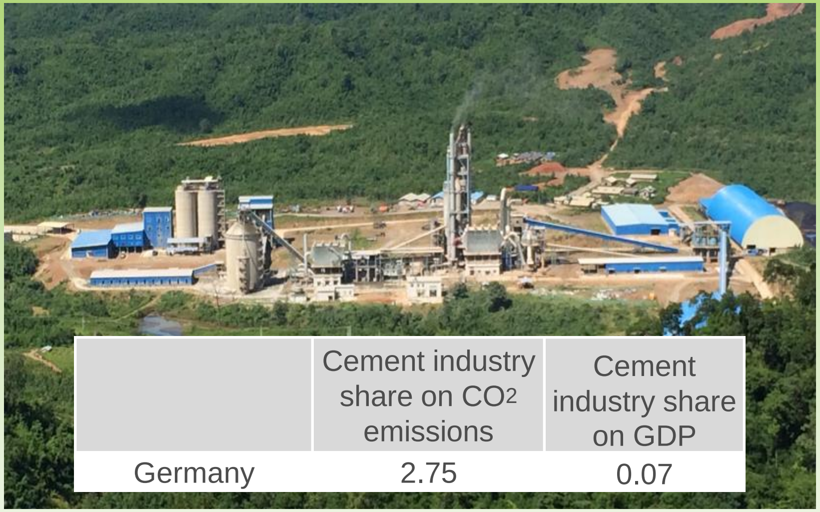




CEMENT INDUSTRY UNDER PRESSURE

- **There is a significant mismatch between the share on GDP and the share on total CO_2 emissions of the cement industry. In Germany the ratio between CO_2 emissions and GDP is 39. This means that 39 times more CO_2 are emitted compared to the GDP participation.**

- **The German Cement Industry contributes 2.75 % to the total CO_2 emissions of the country. Globally this share is at a level of 8 %. This is mainly caused by cement production in emerging countries like China and India.**



	Cement industry share on CO_2 emissions	Cement industry share on GDP
Germany	2.75	0.07

- **This mismatch between share on CO_2 emissions and participation on the GDP is the reason why the cement industry is under pressure from environmental organizations, governments and finally from the society to reduce CO_2 emissions.**

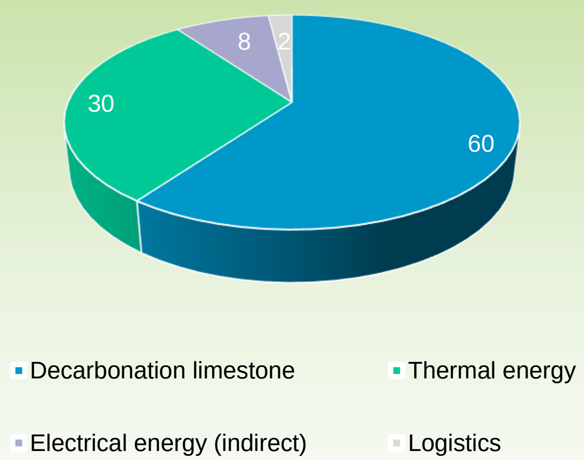
SOURCES OF CO_2 EMISSIONS IN CEMENT PRODUCTION

- **The major share on the CO2 emissions in cement production is related to the decarbonation of limestone. This is a production immanent cause and cannot be directly reduced.**

- **Further 30 % of the CO_2 emissions are related to the combustion energy required for the clinker manufacturing. Nowadays most thermal production lines are consisting of preheater/calciner lines, achieving a specific heat consumption of lower than 800 kcal/kg clinker. Further improvement of technology is extremely cost intensive and results in negligible CO_2 savings.**

- **Finally, 8 % and 2 % respectively are related to CO_2 emissions caused by electrical energy used for cement grinding and logistics.**

Source of CO2 emissions cement manufacturing in %

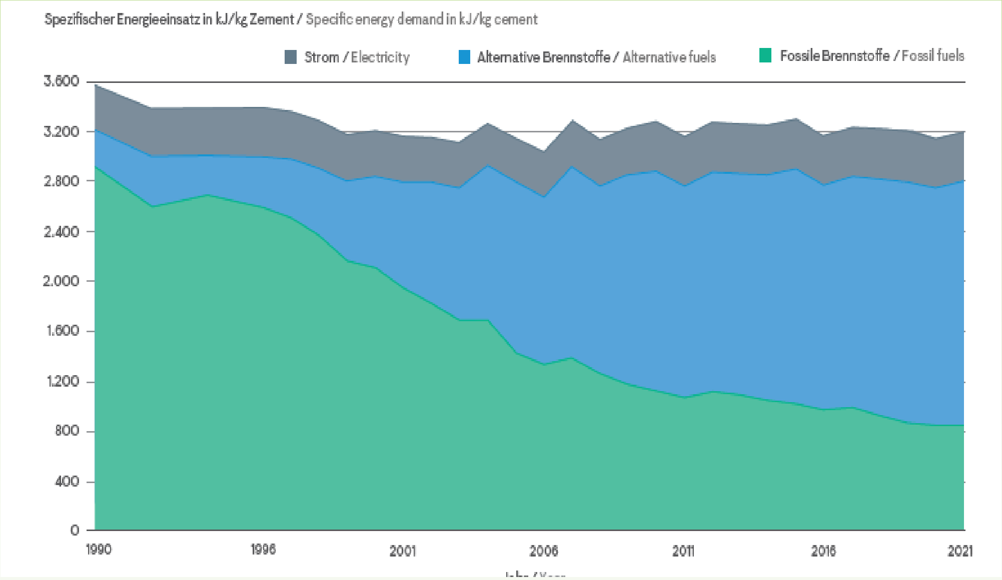


RECUTIONS OF THERMAL EMISSIONS

- Considering modern and state of the art preheater and calciner technology, further reductions of CO_2 emissions are mainly related to the substitution of fossil fuel by secondary, regeneratable or alternate fuels.

- However alternate or waste derived fuels are often related to sophisticated separation and collection systems, which are not established in Asian countries. Hence substitution rates of more than 70 % of primary fuels, like in European countries are not achieved.

- Nevertheless, there is a significant potential in all Asian countries to use alternate fuels from agricultural, industrial and municipal sources.



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SOLUTIONS FOR FUTHER CO_2 REDUCTION

- Every measure to reduce CO_2 emissions is valuable for the cement industry, but the major impact is achieved by the substitution of cement clinker with additives.

- In this context the following, essential questions need to be addressed:

- Why is there still OPC produced in huge quantities?
- Are there sufficient additives available?
- Are there composite cements with comparable properties to OPC?
- What obstacles are existing in Asia?
- What is recommended to be initiated?

REDUCTION OF THE CLINKER/CEMENT RATIO

- **The reduction of the clinker/cement ratio is to be considered the major and realistic step to significantly decrease CO_2 emissions in the cement production. To do so, the following major additives are available.**

LATENT HYDRAULIC MATERIALS	Material	Remarks
Natural latent hydraulic additives	Pozzolana & Trass*	*Pozzulana and Trass are both volcanic ash products. Difference in name is caused by local apprearance, e.g. Pozzulana from Italy and Trass from Germany. The chemical composition is similar. Both names have been transferred to other countries of origin.
	Shale	
Industrial latent hydraulic additives	Ganulated blast furnace slag	
	Copper slag	
	Fly ash	
	Calcined clay	
	Silica foam	
NONE HYDRAULIC ADDITIVES (FILLERS)	Limestone	
	Basalt	

EXAMPLE: OPC VS FLY ASH CEMENT

COMPOSITION OF FLY ASH (1/3)

- **The following example is from cements made using production clinker, gypsum and admixed with increasing proportions of fly ash.**

- **The fly ash used was from a coal fired power plant using Indonesian lignite coal. It is characterized as follows:**

Parameters	Unit	Test Results	Test Methods
• LOI Content	%	1.11	Loss on ignition at 950° C, Gravimetric
• Aluminium trioxide (Al_2O_3)	%	22.54	PO-MOM-01 (XRF)
• Iron trioxide (Fe_2O_3)	%	11.32	PO-MOM-01 (XRF)
• Calcium oxide (CaO)	%	8.36	PO-MOM-01 (XRF)
• Magnesium oxide (MgO)	%	3.87	PO-MOM-01 (XRF)
• Sulfur trioxide (SO_3)	%	1.27	PO-MOM-01 (XRF)
• Kalium oxide (K_2O)	%	1.82	PO-MOM-01 (XRF)
• Silica dioxide (SiO_2)	%	43.53	PO-MOM-01 (XRF)
• Natrium oxide (Na_2O)	%	4.47	PO-MOM-01 (XRF)

- **One essential indication is the LOI. It indicates usually the content of TOC (total organic carbon) and is a measure for the efficiency of the boiler and the suitability of the fly ash as cement additive. LOI should be ≤ 5 %. In the above case the fly ash is well suitable as cement additive.**

EXAMPLE: OPC VS FLY ASH CEMENT

COMPOSITION AND FINENESS OF CEMENTS (2/3)

- **The composition of the OPC and various PCC's tested and compared are given below. The fineness of the OPC is approximately 1000 Blaine lower compared to PCC.**

PCC Composition	Clinker %	Gypsum %	FA %	Limestone %	Pozzolan %	Fineness Blaine
10% FA	64	4	10	6	16	4827
15% FA	64	4	15	6	11	4857
20% FA	64	4	20	6	6	4801
25% FA	65	4	25	6	0	4816
30% FA	60	4	30	6	0	4827
OPC	**91**	**4**	**0**	**5**	**0**	**3850**

- **The content of clinker was reduced to and below the minimum acceptable clinker content (65 %) for PLC cement according to SNI (Indonesian Standard) and is far below the OPC clinker proportion.**

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EXAMPLE: OPC VS FLY ASH CEMENT
QUALITY PROPERTIES OF PCC AND OPC (3/3)

- **Often the quality of compressive strength, setting time, water demand, etc. of OPC vs high additive cement (= composite cements) is used to justify OPC production and sales. Is this still true?**

PCC Composition	1st setting	2nd setting	Water demand	3D	7D	14D	28D
	min	min	%	Mpa	Mpa	Mpa	Mpa
10% FA	145	265	26.76	15.2	20.6	26.4	31.2
15% FA	142	266	26.76	15.3	19.5	26.4	33.6
20% FA	148	300	26.46	16.9	25.0	31.2	39.0
25% FA	148	301	26.15	17.5	23.8	29.4	41.3
30% FA	154	313	25.84	16.4	23.1	31.3	40.0
OPC	156	286	NA	24.0	34.0	NA	42.5

- **The initial setting time of the cements is comparable. The final setting time the OPC is slightly faster but the PCC's are still within the acceptable range. The water demand of the cements is comparable.**

- **Only the compressive strength of the OPC is significantly higher compared to the PCC's but the cements achieve a comparable final strength. Further improvement of the strength development of the PCC's can be achieved by addition of grinding aid. The OPC was produced utilizing grinding aid.**

- **Resumé: Similar cement quality of OPC and FLY ASH cement can be achieved.**

EXAMPLE: OPC VS PORTLAND LIMESTONE CEMENT

COMPOSITION AND FINENESS OF CEMENTS (1/2)

- **The composition of the OPC and various PLC's tested and compared are given below. The fineness of the OPC is approximately 1000 Blaine lower compared to PLC.**

PLC Composition	Clinker %	Gypsum %	FA %	Limestone %	Pozzolan %	Fineness Blaine
15% LS	76	4	5	15	0	4815
20% LS	71	4	5	20	0	4871
25% LS	66	4	5	25	0	4900
30% LS	61	4	5	30	0	4886
35% LS	56	4	5	35	0	4919
OPC	**91**	**4**	**0**	**5**	**0**	**3850**

- **The content of clinker was reduced to and below the minimum acceptable clinker content (65 %) for PLC cement according to SNI (Indonesian Standard) and is far below the OPC clinker proportion.**

EXAMPLE: OPC VS PORTLAND LIMESTONE CEMENT

QUALITY PROPERTIES OF PLC AND OPC (2/2)

- **The results listed in the table below are as expected:**

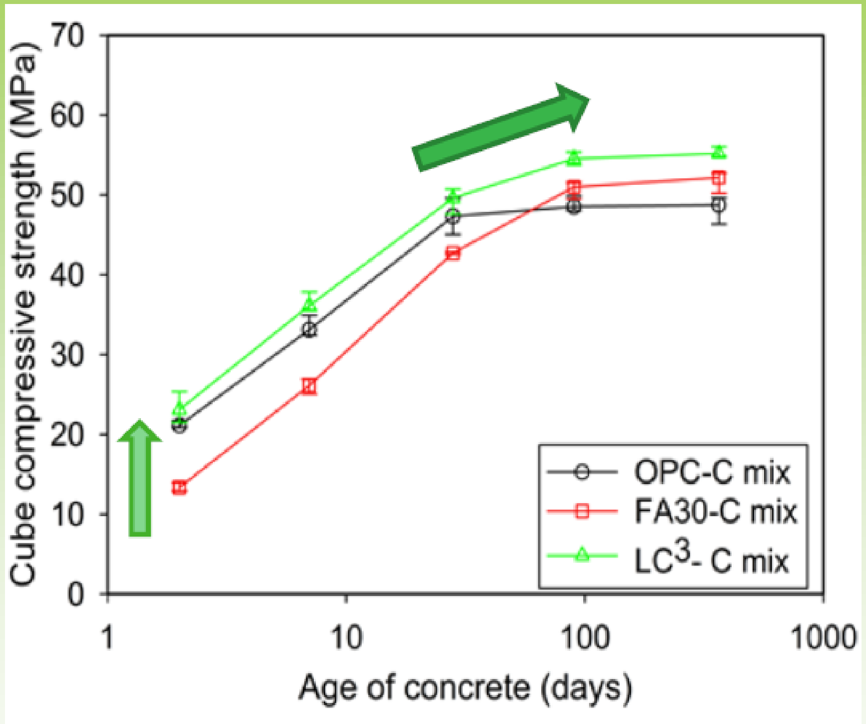
PLC Composition	1st setting	2nd setting	Water demand	3D	7D	14D	28D
	min	min	%	Mpa	Mpa	Mpa	Mpa
15% LS	155	295	25.53	18.2	24.6	27.5	35.4
20% LS	135	288	25.63	15.4	21.1	26.0	30.2
25% LS	117	287	25.08	13.9	16.5	21.7	26.9
30% LS	106	252	24.92	10.2	13.5	17.5	20.8
35% LS	98	255	25.08	8.4	12.6	14.9	18.1
OPC	156	285	NA	24.0	34.0	NA	42.5

- **Limestone is an inert filler which does not contribute to the strength development. However, the workability and the setting time is improved and reaches shorter values compared to the OPC.**
- **As expected the strength development is significantly lower in case of the PLC. Partially the lower strength development of the PLC compared to the OPC can be compensated by a higher fineness of 1000 Blaine. Further improvement of the strength development of the PLC's can be achieved by addition of grinding aid. The OPC was produced utilizing grinding aid.**
- **Resumé: Even with inert fillers acceptable cements with significant lower clinker content can be achieved.**

EXAMPLE: OPC VS LC3 CEMENT

QUALITY PROPERTIES OF LC3 CEMENT AND OPC

- LC3 means calcined clay, which is available in significant quantities as laterite in ASEAN.
- The calcination of clay requires much less thermal energy and does almost eliminate the CO_2 emissions by decarbonation.
- Strengths development of LC3 cement with almost 50 % substitution of clinker is comparable to OPC.
- It has a faster rate of strength and durability development compared to fly ash concrete and a less sensitivity to curing.
- The Chloride resistance significantly better than of OPC made concrete.
- The Carbonation resistance is lower than OPC concrete.



SUMMARY: QUALITY OF OPC VS OTHER COMPOSITE CEMENTS

- It is well known that Blast Furnace Slag based cements are achieving comparable or even identical properties compared to OPC.

- Even Trass (or Pozzolana) cements can achieve acceptable properties compared to OPC. In this case, like in the case of Fly Ash Cements and Limestone Portland Cements a lack of original strength development need to be compensated by higher fineness and/or utilization of grinding aid.
- LC3 cements achieve similar and even better properties compared to OPC.

- Fly ash cements (based on suitable quality of the fly ash) can substitute clinker basically without compromising the cement quality.

- In case of PLC, an inert filler, the strength development of the OPC cannot be reached even with higher fineness and utilization of grinding aid. However this cement is still suitable for most application.

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AVAILABILITY OF ADDITIVES IN ASIA

Country	Available Additives					
	Pozzolana	Blast furnace slag	Fly ash	Limestone	Basalt/Andesite	Calcined clay
India		X	X	X	X	X
Sri Lanka			X	X		X
Bangla Desh			X			X
Thailand		X	X	X		X
Indonesia	X	X	X	X	X	X
Philippines	X		X	X	X	X
Vietnam		X	X	X		X
Malaysia		X	X	X		X

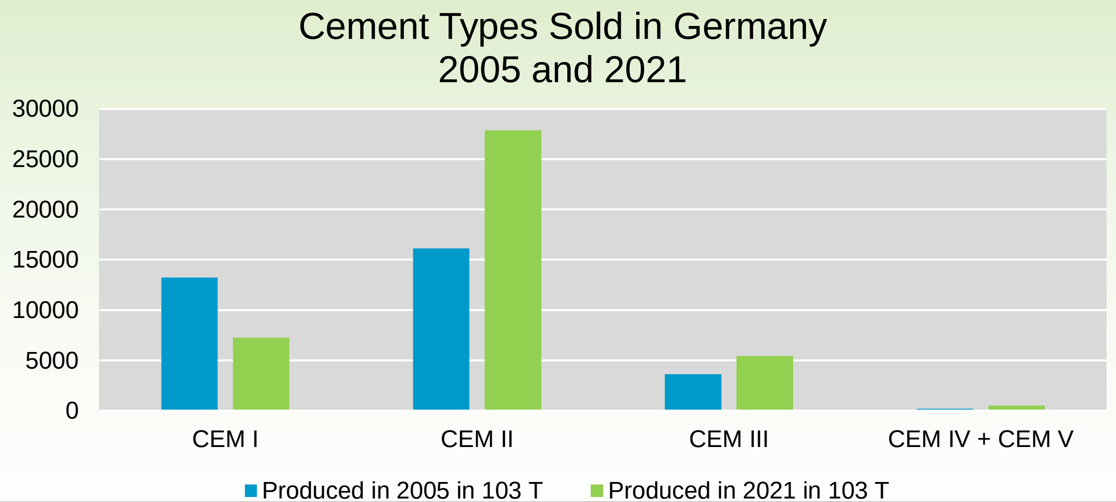
- **Additives like blast furnace slag (e.g. India, Vietnam), pozzolana (e.g. Indonesia, Philippines) are available in huge quantities. In other countries/areas fly ash or limestone as additives are available. In cases none of the above additives are available, calcined clay (LC3) is an alternative.**

CHANGE OF CEMENT TYPES AND SALES

EXAMPLE: GERMANY

- **In Germany a significant change in production and sales of cement types it to be observed between 2005 and 2021:**

Cement type	Produced in 2005	Produced in 2005	Produced in 2021	Produced in 2021
	in 10^3 T	%	in 10^3 T	%
CEM I	**13226**	**39.9**	**7262**	**17.7**
CEM II	16110	48.6	27858	67.8
CEM III	3621	10.9	5426	13.2
CEM IV + CEM V	193	0.6	515	1.3
Total	33150		41061	



OBSTACLES: EXAMPLE CEMENT STANDARDS

EXAMPLE: EUROPEAN (EN) VS INDONESIAN (SNI) STANDARD

The European Cement Standard EN196 specifies 5 cement types, which are splitting up into 23 subtypes. As usual each cement type has to achieve certain properties.
However, the essence is, that cement types with lower quality and high quantity of additives are specified. Clinker can be substituted by huge proportions.

Cement Types EN 196		
Cement type	Description	Max additives incl. minors
		%
CEM I	Portland cement	5
CEM II	Portland composite cement	35
CEM III	Blast furnace slag cement	95
CEM IV	Pozzolanic cement	55
CEM V	Composite cement	50

In the national standard of Indonesia (SNI), the major cement market in ASEAN specification and acceptance of cements with high quantity of additive materials are missing. This in spite of the fact that additives, e.g. pozzolana, fly ash, limestone and blast furnace slag is available in the country in significant quantities.

Cement Types SNI*		
Cement type	Description	Max additives incl. minors
		%
OPC	Portland cement	5
MPC	Mixed portland cement	
PCC	Portland composite cement	35
	Blast furnace slag cement	not existing
	Pozzolanic cement	not existing
	Composit cement	not existing

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PROPOSED ACTIONS AND RECOMMENDATIONS

- **Reduction and within medium times complete or almost complete replacement of production of OPC is the only suitable way to reduce CO_2 emissions in cement industry significantly. All other measures, e.g. technical improvements are marginal.**

- **For many applications low grade cements are sufficient.**

- **With additive cements a similar or almost comparable cement quality to OPC can be achieved. Quality protection of customers, as often used by politicians, standard committees and cement manufacturers and is not considered a valuable argument anymore.**

- **There are sufficient and various cement additives available in Asia. The availability differs regionally. Every cement plant has to develop its own maximized composite cement.**

- **Sales and marketing has to convince customers on replacement of OPC. In some regions, e.g. Sri Lanka this was already successfully achieved.**

- **To do so, national standards have to be adjusted, new composite cement types with higher additive proportion to be accepted.**

- **By the above measures the cement industry can significantly reduce CO_2 emissions, contribute positively to countermeasure climate change and particularly will shine in a positive public light as an environmental friendly industry.**

THANK YOU FOR YOUR KIND ATTENTION

I AM LOOKING FORWARD TO ANSWER YOUR QUESTIONS