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Alternative fuels - What about the environment? - Part 1

Alternative fuels are now a firmly-established reality in well-developed cement industries around the world and increasing amounts of alternative fuels are also being used in developing economies. Here, MVW Lechtenberg & Partner's Dirk Lechtenberg uncovers a wealth of information regarding the use of alternative fuels in the German cement industry, especially with reference to the relatively unexplored negative aspects of their use. Alternative fuels may mean lower CO_2 emissions, avoidance of landfill and decreased costs but they may also entail higher numbers of truck movements, higher dust emissions and higher specific energy consumption per tonne of cement. Part 2 of Dirk Lechtenberg's research will follow in the November 2013 issue of *Global Cement Magazine*.

When a cement plant announces to the public that secondary fuels from waste or biomass will be used, it's at this stage (at the very latest) that the question is posed as to whether such alternative fuels have a negative or harmful influence on the environment and the immediate environs of the cement plant. The possibility that all burning can have a negative effect on the environment should be obvious to everybody. In many cases this topic is discussed in an animated manner as it has a very emotional effect. It is, in many cases, understandably afflicted with residents' existential concerns.

When a cement plant announces a new fuel, the neighbouring vegetable grower, for example, is worried he will no longer be able to sell his vegetables. Residents may be concerned that alternative fuels will lead to dust or odour pollution. A classic example is the burning of tyres. Who hasn't seen the pictures of rising black clouds of smoke if a tyre storage depot catches fire?

Of course each cement plant operator will try to consider the topic of emissions scientifically. Often they will try, using data and figures, to prove to neighbours and in the worst case, opponents of such co-processing, that no such effects on mankind and the environment need to be feared.

No effects at all? Well, claiming that there will be no ill effects will surely be incorrect. Also the cement plant operator often has no suitable and independent data and facts at his disposal. The use of alternative fuels will always have an influence on the operational behaviour of a cement plant and, as a result, on the immediate environs of the plant. This begins with changed logistics for the fuels to be utilised. If previously a truck delivered 20t of coal to a cement plant with a calorific value of ~ 500GJ/t, in future maybe 30 trucks will be required to deliver the same calorific value of alternative fuels. These are direct consequences and effects that will surely be felt by immediate neighbours of a cement plant.

For the main part, the possible displeasure of the residents will not be focused on the immediate effects but on the indirect effects, such as altered emissions from a cement plant.

For the latter, every cement producer will of course immediately have worldwide cement association statistics or those of the Cement Sustainability Initiative or such to hand (and presented using nice photos) in order to emphasise the advantages of using alternative fuels to all possible critics. Emissions data prognoses are also presented, especially regarding saved fossil CO_2 emissions, in order to illustrate the advantages of the plant's intentions.

For many decades environmentalists have been struggling worldwide to publicise emissions data from industrial facilities, not only to pillory possible environmental contaminators but also to promote awareness of responsible behaviour among all industrial facilities. Remember - 20 or 30 years ago environmental protection in industrial complexes in many countries in Europe for example, was still being handled as an afterthought. Environmental protection was a 'necessary evil.'

Nowadays the situation is presented somewhat differently. Environmental protection and sustainability are *the* slogans that we encounter every day in industrial company statements. For 'sustainable' companies there is even an index of its own on the New York Stock Exchange. Only sustainably-run companies nowadays have a chance to attract new employees, to receive company loans or to sell their products. Everything is 'green,' 'light' or 'sustainable.' The fact that appearances often deceive is something that we witness more and more in the consumer or food industry. Egg boxes with pictures of hens running around in the open. Who wants to buy eggs laid by hens in cages? 'Light' butter, which is merely frothed up with nitrogen and as a result no longer weighs 500g but 340g and is hence 'light.'

What does this have to do with a cement plant which wants (and has to) use alternative fuels in order to remain competitive? A cement plant, even if it is highly modern, will always affect the environment. The truck which brings the fuels and raw materials; the quarry (which can bloom into a nature paradise and can often possess richer flora and fauna than the land which was previously there), the emissions from heat generation irrespective of the fuels that are used and the emissions from limestone calcining.

For a cement plant operator to announce to possible critics that the planned secondary fuel employment has 'no kind of effect,' especially in the internet age and with constant, globally-available information, is surely not the correct method.

In many guidelines on the topic of co-processing the theme of public relations regarding the use of alternative fuels is only discussed peripherally. It is pointed out that it is purposeful to 'enter dialogue' with the stakeholders while statistical data (published by the cement industry itself) is used to 'convince' the public.

In this article we want, for the first time, to make available to stakeholders and possible critics anonymised, real emissions data for *all* existing cement plants in the Federal Republic of Germany that use alternative fuels, as a basis for an independent dialogue between cement plant operators, in order to have an open discussion.

No 'light' butter, but data and facts that are compared with the latest findings on possible effects of emissions on man and nature. The latter in order to make available an independent basis for a dialogue which, owing to the uniform production methodology in the cement industry worldwide, can also be used worldwide.

The basis of these emissions data is the online measurements recorded by the monitoring authorities of 34 cement plants comprising 42 kiln lines in Germany performed with continuous measurement systems. All results are from 2008-2010.

As each cement plant has varying legal approval pre-conditions, as well as different technical and raw material-dependent prerequisites, we have made the effort to prepare this raw data independently and in such a way that a comparision is possible using different parameters. This data was prepared by:

- Conversion of the uniform measured variables;
- Adjustment of the 'start-up phases' in which no secondary fuels are utilised;
- Capture of day average values;
- Comparison of the substitution quotas and material volumes as well as the actual clinker production volumes;
- Evaluation of the specific CO_2 emissions and energy consumption per tonne of clinker;
- Comparison with European as well as other emission limit values;
- Comparison with 'best available technology' standards.

Furthermore we also give, after presentation of the evaluation results, a few suggestions on how these independent data, in an understandable form, can be used for approval processes and for communication with stakeholders.

Overview of the German cement industry

In the survey period, 2008-2010, the German cement industry was characterised by a clinker production capacity of 25.4Mt in 2008 and 23.0Mt in 2010 (See Table 1). Apart from the noticeable financial crisis in the country through stagnating building activity, the fall in clinker production is also attributed to a decreasing clinker factor.

During this time, the kiln types mainly consisted of simple preheater kilns as well as aged and energy-intensive Lepol and shaft kilns. The relative proportions of these are shown in Table 2.

Since carrying out initial trials with the alternative fuel 'BRAM' (Brennstoff aus Müll: 'fuel from waste') at Miebach & Söhne's Wittekind Zement plant in Erwitte, employment of alternative fuels has evolved into becoming the mainstay in fuel supply. The reasons behind using alternative fuels are manyfold:

- Reduction of fossil CO_2 emissions;
- Reduction of fossil raw materials and fuels;

	2008	2009	2010
Clinker production (Mt)	25.366	23.232	22.996

Above - Table 1: Clinker production in Germany, 2008-2010.

Below - Table 2: Type and capacity of cement kilns in Germany, 2008-2010.[1]

		As at: 1 January 2009			As at: 1 January 2010			As at: 1 January 2011		
		No.	Capacity (t/day)	% of capacity	No.	Capacity (t/day)	% of capacity	No.	Capacity (t/day)	% of capacity
Kilns with pre-heater		41	103,700	93.1	41	103,700	93.1	41	104,660	94.1
Lepol kilns		8	6500	5.8	8	6500	5.8	6	5350	4.8
Shaft kilns		8	1200	1.1	8	1200	1.1	8	1200	1.1
TOTAL		**57**	**111,400**	**100**	**57**	**111,400**	**100**	**55**	**111,010**	**100**
Average capacity	Rotary kilns	2249t/day			2249t/day			2336t/day		
	Shaft kilns	150t/day			150t/day			150t/day		

- Service performance in waste valorisation with accompanying benefits of environmentally compatible valorisation (avoidance of landfill space, utilisation of energy content, creation of waste valorisation structures for (almost) all types of waste material(s);

- Significant reduction in the import of fossil fuels, with resultant increase in GDP;

- Creation and preservation of workplaces;

- Increase in competitiveness;

- Cost savings in aspects of cement production.

MVW Lechtenberg & Partner has seen that in discussions between cement plant operators and stakeholders, mainly the 'green' arguments are referred to.

The German cement industry surely also designates these 'green' arguments to be seen as facts in the approval process, yet it will also present the arguments of workplace retention and securing production in Germany. As we will show in the following, the emission values and environmental standards of the Federal German cement industry that need to be complied with are regarded worldwide as exemplary, but with consequential and necessary investments as well as ongoing operational costs, cement production in the Federal Republic is also considerably more expensive than in many other countries. In order to avoid Germany's future cement needs being covered by cheap imports that stem from lower environmental requirements and production costs coupled with minimal logistics costs, a realistic consideration of the fundamental economics of cement production is vital.

Right - Table 3: Types and amounts of alternative fuels (in '000t) used by the German cement industry, 2008-2010.[1-3]

Fuel source	2008	2009	2010
Tyres	266	245	253
Used oil	80	73	61
Cellulose, paper, card	150	175	133
Plastic	460	556	527
Packaging	0	1	0
Textile waste	2	9	11
Meat and bone meal	231	204	182
Municipal waste	220	188	287
Used wood	12	13	8
Solvents	102	81	98
Sewage sludges	267	263	276
Oil sludges, distillation residues	175	78	146
Others	936	911	931
Total	**2901**	**2797**	**2913**
Million GJ/yr	**52.1**	**51.5**	**53.7**
Subst. rate (%)	**54**	**58**	**61**

Alternative fuels in Germany

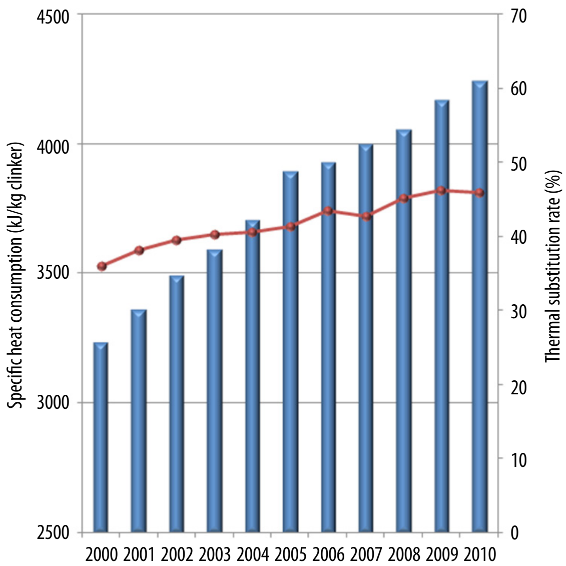
The German cement industry has been employing alternative fuels for some 25 years. Starting from around 4.1% substitution in 1987, the German cement industry achieved on average around 61% substitution rate in 2010. On the other hand, specific thermal energy consumption raised slightly, as can be seen by Figure 1. This rise can be explained by the increased energy requirement for evaporation of the water content in alternative fuels, as well as by heat losses owing to increased gas volumes. While fossil fuels are as a rule considered 'absolutely dry,' with a residual moisture content of 3-5%, alternative fuels as a rule have a higher water content, around 10-30%, which, with increased specific energy consumption, first needs to be vaporised/evaporated. Total energy consumption in the German cement industry for the period under review is shown in Table 4.

Right - Table 5: Total energy consumption in the German cement industry (million GJ/yr), 2008 - 2010.[1]

Fuel source	2008	2009	2010
Coal	13.9	10.3	9.3
Lignite	23.1	20.0	20.7
Petcoke	4.9	4.4	3.3
Heavy fuel oil	0.9	1.1	0.6
Light fuel oil	0.2	0.2	0.3
Gas	0.3	0.1	0.1
Other fossil fuels	0.4	0.6	0.4
Total fossil fuels	43.7	36.7	34.4
Total alternative fuels	52.1	51.5	53.7
Total thermal energy	95.8	88.2	88.1

In order to evaluate the increase in heat losses and hence the increase in specific energy consumption per kg of clinker all these aspects have to be taken into consideration. While the calculation of the heat losses is partly feasible (e.g. evaporation of moisture, heating of air), it is hard to gain respective results for other aspects, such as for the devaluation of the flame. Experience from cement plants using high substitution rates of alternative fuels provides some rules of thumb as an orientation. For instance, the specific energy consumption of a four-stage double string preheater kiln

Below - Figure 1: Specific heat consumption (kJ/kg clinker) (red line) and thermal heat substitution by alternative fuels (%) (blue columns) in the German cement industry, 2000-2010.



(~2800t/day) increased by up to 15% while raising the substitution rate from 0% to 75%. However, cement plants accept those increases because they are alleviated or compensated for by the economic benefits of the alternative fuels.[2]

The pneumatic feeding of alternative fuels also contributes to increased energy requirements. For instance, the installation of an additional pipe for alternative fuel feeding into the calciner causes heat losses due to the additional input of cold air. The heat losses can be easily calculated by multiplying the air flow rate by temperature difference, specific heat capacity and air density.[2]

Example: Heat loss/hr = 1000m^3/hr x (1000°C – 20°C) x 240Cal/°C kg x 1.3kg/m^3 = 305MCal/hr.

Alternative raw materials

The German cement industry has also been substituting fossil raw materials with so-called alternative raw materials for many years (See Table 6). These alternative raw materials are partially employed directly in the clinker production process and as such influence emissions. They may also be included for cement grinding.

The type and volume of the useable alternative raw materials largely depends on the quality of the available in-house (natural) resources, such as limestone and marl. In this way iron-, silica-, or aluminium-containing raw and additive materials are utilised in the form of alternative raw materials. On the other hand, usage also depends on the underlying economic parameters.

Right - Table 5: Raw materials consumed (in '000t) by the German cement industry, 2008-2010.[1-3]

Group	Raw material	2008	2009	2010
Ca	Limestone, marl	42,065	34,580	37,517
	Others such as: Lime residues from (waste) water treatment, lime hydrate, calcium fluoride	82	64	62
Si	Sand	1252	978	1187
	Used foundry sand	151	101	148
Si-Al	Marl	1149	802	436
	Bentonite/Kaolinite	35	47	41
Fe	Iron ore	111	106	132
	Others such as: Furnace slag, iron gravels, ferrous oxides / fly ash mixtures, foundry dusts, mill scale	149	110	92
Si-Al-Ca	Foundry sands	6430	4480	5365
	Fly ash	455	311	316
	Oil shale	227	230	263
	Trass	29	25	29
	Others such as: Paper residues, ash from other incinerators, mineral residues, oil-contaminated soil	3	50	39
S	Natural gypsum	635	587	620
	Natural anhydrite	528	418	439
	FGD	345	310	313
Al	Residues from aluminium industry, dross, aluminium hydroxide	51	47	55
	Total raw materials incl. natural materials	53,697	43,246	47,054
	Total natural raw materials	46,031	37,773	40,664
	Total alternative raw materials	7666	5473	6390

	Specific CO_2 emissions				
	Thermal-related	Electricity-related	Raw material-related	Total	Unit
2008	0.117	0.066	0.388	0.571	t/t (CO_2/cement)
2009	0.110	0.068	0.398	0.575	t/t (CO_2/cement)
2010	0.104	0.074	0.398	0.575	t/t (CO_2/cement)

Above - Table 7: Specific energy- and raw material-related carbon dioxide emissions by the German cement industry 2008-2010.[1]

In this manner, certain alternative raw materials are used (as a service made available by cement plants) in exchange for a valorisation fee, which is more economic than landfilling or other valorisation options, or are more economic than clinker production.

CO_2 emissions

Clinker replacement contributes to a significant reduction in the unavoidable clinker production-related CO_2 emissions. Nevertheless, specific electrical energy consumption per tonne of cement in cement production has risen in parallel over the last few years owing to market-related demands. This is attributed to the increase in demand for finely ground cement products in the building industry. For this reason the overall arising, specific CO_2 emissions have not fallen as shown in Table 7.

Part 2 of *'Alternative fuels - What about the environment?'* will be in the next issue of *Global Cement Magazine.*

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