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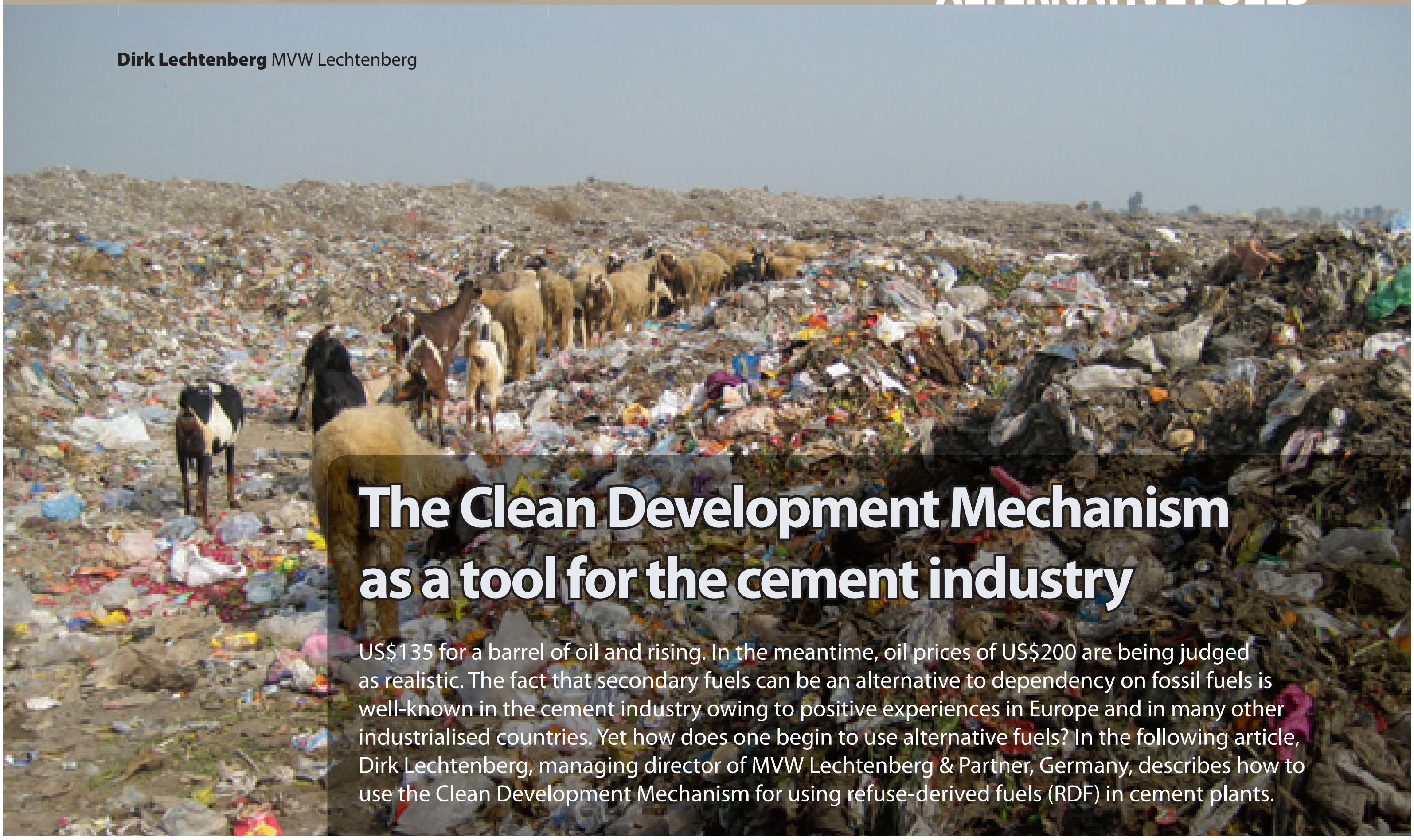

The Clean Development Mechanism as a tool for the cement industry

US$135 for a barrel of oil and rising. In the meantime, oil prices of US$200 are being judged as realistic. The fact that secondary fuels can be an alternative to dependency on fossil fuels is well-known in the cement industry owing to positive experiences in Europe and in many other industrialised countries. Yet how does one begin to use alternative fuels? In the following article, Dirk Lechtenberg, managing director of MVW Lechtenberg & Partner, Germany, describes how to use the Clean Development Mechanism for using refuse-derived fuels (RDF) in cement plants.

Over a decade ago, most countries joined an international treaty – the United Nations Framework Convention on Climate Change (UNFCCC) – to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. More recently, a number of nations have approved an addition to the treaty: the Kyoto Protocol, which has more powerful (and legally binding) measures. The Clean Development Mechanism (CDM) developed by the United Nations can be used as a tool for the cement industry in developing countries to finance investments for the introduction of RDF.

The Clean Development Mechanism (CDM), defined in Article 12 of the Kyoto Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to 1t of CO_2, which can be counted towards meeting Kyoto targets. The mechanism is seen by many as a trailblaser. It is the first environmental investment and credit scheme of its kind on a global scale, providing standardised emissions offset instrument, CERs. A CDM project activity might involve, for example, the reduction of methane gas on landfills or the substitution of RDF with a certain biogenic content (e.g. biomass such as paper/wood) in a cement plant.

The mechanism stimulates sustainable development and emission reductions, while giving industrialised countries some flexibility in how they meet their emission reduction and limitation targets.

To implement secondary fuels successfully, the same process steps are always necessary. Therefore MVW Lechtenberg has developed a 3-stage plan, which allows the cement plants to be on the safe side while starting up the use of RDF. Phase I is the basic evaluation on the technical concept and the effects on clinker and economics.

Phase I

- Verification and classification of existing waste types available at source;
- Suitability of available wastes as RDF, and recommended feeding points;
- Calculation of Carbon Credits / biogenic content in RDF;
- Quality requirements of secondary fuels;
- Impact of RDF utilisation on clinker chemistry and production process;
- Impact on air quality (emissions);
- Thermal energy substitution, and economical benefits;
- Project capital investment cost evaluation and return on investment.

In this article we concentrate on the basis for waste evaluation within the framework of a CDM project, but basically the most varied points have to be considered when evaluating waste.

How to evaluate possible waste streams for the production of RDF

To employ secondary fuels in a cement plant, the evaluation of the basic data are absolutely vital. The

available waste volumes and types must be painstakingly examined. Key questions include: Where do they come from? Who currently disposes of the waste? Are there waste disposal structures and waste disposal companies available? What costs arise currently for disposal/landfilling of the waste etc?

There are three groups of waste that might be burned:

a) Solid waste;
b) Liquid waste;
c) Pasty waste.

The chemical composition of the wastes, i.e., the content of Cl, S, Ca, Si, Al, Fe and other heavy metals, and their calorific values are of primary interest for the replacement of fossil fuels. The calorific values should be as high as necessary for the heat input for the cement production process. The chemical composition (Cl, S, heavy metals) must be compatible with the cement. The grain size must be as small as necessary for complete burn out.

For CDM projects, municipal solid wastes are available in developing countries. In most of the developing countries, waste is disposed on landfill sites that are generally not suited for protecting the environment. This means the landfill sites have no bottom sealing to protect soil and groundwater against contamination of hazardous materials like oil, heavy metals and toxic organic compounds. On the other hand, there is no protection of the air, so waste will decompose or burn at the landfills without cleaning the exit gases or volatile components.

Most of the landfills are located close to roads or residential areas. There isn't any regulation for the operation of such sites, so waste is delivered by citizens or industry without a regular treatment on the sites themselves. Waste is often blown off by the wind or eaten by animals. Running landfill sites in this way will cause contamination of soil, groundwater and air by hazardous materials. Methane (CH_4) is a relatively potent greenhouse gas with a high global warming potential. Methane in the atmosphere is oxidised to produce carbon dioxide. The use of high calorific value fractions from municipal solid wastes will reduce methane gas emissions and is therefore recognised as a means of limiting greenhouse gas emissions.

According to the CDM Executive Board, in order to calculate the methane emissions from solid waste disposal sites (SWDS), the UNFCCC classified the kind of SWDS with their associated methane correction factors (MCF).

The methane correction factor accounts for the fact that unmanaged SWDS produce less methane from a given amount of waste than managed SWDS, because a larger fraction of waste decomposes aerobically in the top layers of unmanaged SWDS.

The amount of methane that would - in the absence of the project activity - be generated from disposal of waste at the solid waste disposal site (BE_{CH_4}, SWDS, y) is calculated with a multi-phase model. The calculation is based on a first order decay model. The model differentiates between the different types of waste (j) with respectively different decay rates (k_j) and different fractions of degradable organic carbon (DOC j).

The model calculates the methane generation based on the actual waste streams ($W_{j,x}$) disposed in each year x, starting with the first year after the start of the project activity until the end of the year y, for which baseline emissions are calculated (years x with x = 1 to x = y). The amount of methane produced in the year y (BE_{CH_4}, SWDS, y) is calculated as follows:

$$BE_{CH_4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH_4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j (y-x)} \cdot (1-e^{-k_j}) \quad (1)$$

In developing countries without well managed landfill sites, the amount of methane avoidance is especially high.

A cement plant which will implement only 5t of RDF from high calorific value fractions out of municipal solid waste will save around 33,000t of CO_2 from methane gas avoidance on the landfill site:

Emissions Reductions Calculation for RDF Usage in Cement Plants

Assumptions		
Crediting period	yrs	10
RDF output per hour	t/hr	5
RDF output per day	t/day	120
Operating hours per year	hr/d	7.000
RDF-amount per year	t/yr	35.000
Baseline emissions		
CH4 avoidance		
Fresh waste total	t/day	300
Fresh waste total	t/year	105.000
Emission reductions from avoided methane em. of fresh waste	**t CO2/yr**	**33.502**
Old waste used for RDF production	t/day	-
Old waste used for RDF production	t/year	-
Emission reduction from waste older than 15 yrs	**t CO2/yr**	**-**
Equivalent CO2 emissions	**t CO2/yr**	**33.502**

Table: CO² savings from methane gas avoidance on landfill

CO_2 savings in the cement plant

Within the CDM Project, there is a second CO_2 reducing factor: Fossil fuels such as oil, coal and others are replaced by RDF with a high, so called 'biogenic' content consisting of materials which are biomass based, such as paper, cardboard, wood and so on. Depending on the emission factor of the replaced fossil fuels, the CO_2 savings are calculated.

CO2 Emission Factors of Kiln Fuels (per lower heating value)			
Conventional fossil fuels			
	coal + anthracite + waste coal	[kg CO2/GJ]	96,0
	Petrol coke	[kg CO2/GJ]	92,8
	(Ultra) heavy fuel	[kg CO2/GJ]	77,3
	diesel oil	[kg CO2/GJ]	74,0
	natural gas	[kg CO2/GJ]	56,1
	shale	[kg CO2/GJ]	107,0
	Lignite	[kg CO2/GJ]	101,0
Alternative fossil fuels			
	waste oil	[kg CO2/GJ]	74,0
	tyres	[kg CO2/GJ]	85,0
	Plastics	[kg CO2/GJ]	75,0
	solvents	[kg CO2/GJ]	74,0
	impregnated saw dust	[kg CO2/GJ]	75,0
	mixed industrial waste	[kg CO2/GJ]	83,0
	other fossil based wastes	[kg CO2/GJ]	80,0
Biomass fuels			
	sewage sludge	[kg CO2/GJ]	110
	wood, non impregnated saw dust	[kg CO2/GJ]	110
	Paper, carton	[kg CO2/GJ]	110
	animal meal	[kg CO2/GJ]	89
	animal bone meal	[kg CO2/GJ]	89
	animal fat	[kg CO2/GJ]	89
	agricultural, organic, diaper waste,	[kg CO2/GJ]	110
	other Biomass	[kg CO2/GJ]	110
	RDF	[kg CO2/GJ]	27*

* variation on biogenic content

Table: Emission factor of various fuels

A cement plant which is using 5t of RDF with a biogenic content of approximately 40% will save the following CO_2 emissions:

Kiln Operation	Kiln operated with coal (anthracite)	
NCV anthracite	TJ/t	0,0267
CO2 emission factor anthracite	t CO2/TJ	98,3
NCV ratio		0,55
Needed coal amount for equal energy output	t	19.270
Total energy	TJ	515
CO2 emissions	**t CO2/yr**	**50.575**

Table: CO² emission savings while using RDF

To produce RDF from municipal solid wastes, certain energy is needed. The energy is (mainly) produced with fossil fuels. Also the transportation of the RDF fraction or RDF from the landfill site to the cement plant causes CO_2 emissions from gasoline/diesel from the trucks. These project CO_2 emissions have to be considered as project emissions that must be deducted from the overall CO_2 savings. The UNFCC has developed certain tools to calculate exactly these project emissions.

Project emissions		
Kiln Operation	**Kiln operated with RDF**	
NCV RDF	TJ/t	0,0147
CO2 emission factor RDF	t CO2/TJ	27,2
Incinerated RDF amount	t	35.000
Total energy	TJ	515
CO2 emissions	**t CO2/yr**	**14.015**

Table: CO² project emissions

Emissions reductions	**t CO2/yr**	**70.062**

Assuming a substitution rate of 5t RDF (35,000t/year) from a landfill site in a cement plant, the cement plant will save in total 70,000t CO_2 emissions. Current value of these emissions savings is approximately US$23 per CER (Certified Emission Reduction Certificate), therefore US$1.6m/year.

The needed investment for such a small plant for separation of high calorific value fraction and processing of RDF will be approximately US$3m. MVW Lechtenberg is currently developing approximately 15 such projects especially in developing countries. This will save approximately 1Mt/year of CO_2 emissions!

Summary

The Clean Development Mechanism helps cement plants in developing countries to build a sustainable strategy for the reduction of CO_2 emissions.