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The use of renewable and alternative Fuel in the Heavy Clay Industry

An overview

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Abstract

The heavy clay industry brick is in many countries a very important economic factor with far reaching financial and environmental impacts.

In the industrialized countries the use of alternative fuels in the heavy clay industry is rather limited. The European brick industries common current research activity is mainly focused on synthgas from waste streams. In-house research activity by single brick companies does, at least in Europe, not take place at the moment.

The situation in the developing and industrializing countries is far different: The use of alternative, fossil and renewable, fuels in these countries is still wide spread. The use of such fuels does sometimes have severe negative impacts on the environment.

This paper gives an overview of the use of various renewable and alternative fuels in the heavy clay industry in several countries and the environmental and financial impacts these fuels have or might have on the operation of a typical installation in various parts of the world (Maghreb, Europe, USA, Australia, India, Vietnam). Two examples in which alternative fuels have been or are used, one in an industrializing and one in an industrialized country, are briefly presented.

A comparative product life cycle analysis, LCA, is presented.

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heavy clay, brick, alternative fuels, renewable fuels, alternative fuels, LCA.

1. Introduction

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Any fuel used in a brick kiln must not only generate the process heat required but must further fulfill a series of requirements: among them are low green house gas emissions and low release of possible air contaminants.

Another question to be dressed is timely availability of any fuels. Brick plants usually experience, sometimes very extended, standstill due to market conditions or for maintenance. Such standstills might be a problem, for example, when using biogas as a fuel as other uses for the gas generated during standstills must be searched for.

Renewable or alternative fuels might be considered in many cases to be an integration of fossil fuels rather than a complete substitution.

2. The Gasser project in Italy – rendering fat and biogas

When this project was started, the plant produced about 80 t/day of brick with a material, i.e. brick body, density of about 1.68 kg/l. At conclusion the plant manufactured 120 t/day of brick with a material density that had ben reduced to 1.35 kg/l on the average. Taking as example a standard 38 cm wall thickness brick, the daily number of brick per day had increased from about 6,300 brick/day to about 10,000 brick/day. Such an increase in the produced quantity, about 40%, had a substantial impact on the turnover of the company.

The first tests with alternative fuels began in 2002. From 2003 on, the previously used boiler oil was substituted, first in part and then in full, with rendering fat. The fuel switch was completed in 2004.

The technical difficulties encountered in the course of the project required substantial modifications to the firing system and the development of new burners. Such burners had to be purpose built by the brick plant itself, as they were not been available on the market.

The project resulted in a substantial reduction of the overall production costs due to the much lesser cost of the rendering fat compared to the boiler oil. The use of biogas further reduced costs as the substrate used, mainly fruit processing waste and organic matter resulting from differentiated refuse collection, did either not generate any costs or was delivered at a gate fee (i.e. the brick plant received a dumping fee).

By the end of 2003 trials with a containerized biogas plant had begun with very good results. It was hence decided to build a pilot plant that would be sufficient in size to supply up to 15% of the energy required for firing the bricks manufactured. As new burners, a substantial investment, had to be installed, it was decided to build dual fuel gaseous/liquid burners. These burners would allow using biogas as in integration for the rendering fat. The basic design of the firing system is high λ-value, high bypass medium pressure common rail system for the liquid fuel and a high-pressure system for the biogas.

The problem of carbon built-up at the nozzle of the burner has been solved using high temperature materials for the nozzles and a pulsating combustion of both fuels.

Emissions into air of potentially polluting substances have been greatly reduced. The release of dioxins has been reduced to almost non-measureable levels. The same applies to fluorides and chlorides.

Specific energy consumptions have not changed significantly with the use of the substitutive fuels. The shown differences are to be attributed to a more homogenous and uniform heat distribution in the kiln and hence apparently lower overall firing temperatures.

Table 2: Effects of kiln modifications and alterations and utilization of substitute fuels on specific fuel consumption and emissions into air

	2000	2001	2002	2003	2004	2005	2006
Firing temperature °C	940	940	760	820	820	860	860
Average production per day in t/day	80		95	105	120		
Average material density in kg/l	1.68			1.55	1.50	1.40	1.35
Fuel used	#6 boiler oil		#6 boiler oil rendering fat		rendering fat biogas		rendering fat recycled frying oil biogas
				Flue gas recirculation system			
			Purpose built burners				
						Higher firing temperatures for better mechanical strength	
Specific energy consumption kJ/kg brick	2,326.18	2,156.65	1,752.66	1,686.06	1,446.52	1,749.46	1,936.22
Dust	48.00		5.00		2.63	< 0.05	2.63
NO_x as NO_2			no data		22.0	< 1	< 1
SO_x as SO_2	24.00		200.00		4.53	8	8
Fluoride as HF	7.70		20.00		0.28	< 0.02	< 0.05
Chloride as HCl	32.30		50.00		4.04	< 0.05	< 0.02
TOC			no data		< analytical threshold values		
Ethanol average					< 0.1		
Benzyl					< 0.1		
Methanol average					< 0.1		
Phenol					< 0.1		
Formaldehyde					< 0.1		
Aldehyde					< 0.1		
Carbon monoxide					78.52	< 1	8
Dioxin and Furan			0,1		0.004 -> < 0.0005		

All emission data are reported at a reference oxygen concentration of 18%([1]) in mg/Nm^3 except for dioxin and furan that are indicated as I-TEQ in ηg/Nm^3.

This example shows, that for a medium sized brick plant a full conversion to alternative fuels is feasible and can have very interesting results both financially and technically.

[1] European legislation concerning emissions in brick plants fixes the oxygen reference value at 18%.

2. The SBBC Societè Briqueterie Bati Chouia project in Morocco – lampante oil and olive processing wastes

In Morocco both rural and industrial brick making co-exists. The rural kilns are fired with briquetted or blot coal and biomass, the industrial kilns mostly with boiler oil and petcoke. Emissions into air of all kilns are a major problem as is the use of biomass, mainly wood, by the rural brick plants.

The SBBC project is a partial fuel switch project:

Table 3: Timeline of the project

	2004	2005	2006	2007	2008
Firing temperature °C	860	860	860	860	860
Specific energy consumption kJ/kg brick	1,536.19	1,544.15	1,621.44	1,453.98	n.a.
Boiler oil	Brick kilns and dryers				Preheating zone of the kiln Emergency heating of dryers
Lampante oil				Mixed to boiler oil in varying percentages	
Coal			Body fuel		
Petcoke				Main fuel kiln	
Biomass					Main fuel brick dryers
% non fossil				5 – 20%	10 – 40%

Lampante (olive) oil is obtained either from bad fruit or by chemical extraction, mostly with Hexane, from the pulp, i.e. from the residues of the first mechanical extraction process. Processing errors can also result in oils not suitable for human use. This oil is intended, due to it's high acidity and residual traces of the extracting agent, for industrial uses ranging from soap to cosmetics. The lampante oil in this specific case is mixed to the fuel in varying percentages depending on availability and price. Coal and petcoke are sourced locally either from small local pits or from local refinieries. The petcoke used features a sulfur concentration of up to 12% in mass. The biomass is either wood that cannot be used as firewood, i.e. roots, and olive oil processing waste (olive oil cake).

Albeit legislation in Morocco imposes verification of emissions into air of brick plants such verification is commonly not carried out. Hence no emission data are available. The switch to petcoke as the main fuel in the kiln had a substantial negative impact on the emissions into air.

The switch from boiler oil as the sole fuel to a mix of fuels has had substantial impact on the energy costs of the plant. Taking into consideration the lower energy requirement achieved with better management of the raw material mixes and introduction of body fuels and the lower costs of the fuels now in use a substantial reduction of the production cost has been achieved.

Table 4: Relative cost of fuels

	Relative cost
Boiler oil	100 %
Coal	90 %
Petcoke	65 – 75%
Biomass	55 – 60%

These data are based on net calorific values.

This project must be, in conclusion, deemed a partial failure: the envisaged results, energy consumption <1.250 kJ/kg brick has been almost achieved but the environmental impact has substantially worsened due to the use of petcoke as main fuel. In 2008 the owners of the brick plant stopped the project as apparently their financial goals had been met.

3. Comparative environmental impacts

Environmental impacts of a any energy intensive production process such as brick plant depend mainly on the type and source of energy used. The following tables might hence be an example for any energy intensive production process.

The impact of a brick plant, the below data are averaged from a substantial number of plants, is:

Table 4: Environmental impacts of a brick plant using fossil fuels

Impact category	Unit	Production	Use
Global Warming Potential GWP100[2]	kg CO2 eq. /t	120.700	20,000
Stratospheric ozone depletion	kg CFC11 eq./t	304.500	
Acidification	kmol H+ eq./t	0.107	
Photochemical ozone creation	kg C2H4 eq./t	0.085	0.047
Eutrophication	kg O2 eq. /t	18.710	1.310

For a plant running on renewable fuels like the Gasser plant the impact data are:

Table 5:Environmental impacts of a brick plant using renewable fuels

Impact category	Unit	Production	Use
Global Warming Potential GWP_{100}	kg CO_2 eq. /t	64.83	16.890
Stratospheric ozone depletion	kg CFC_{11} eq. /t	not considered	
Acidification	Kmol1 H^+ eq. /t	0.040	0.01

[2] The DACH GBC Green Building Challenge study [1] indicates a GWP100 of 194.00 g CO_2 eq./$_{tProduction}$.

Photochemical ozone creation	kg C_2H_4 eq. /t	0.8	0.08
Eutrophication	kg O_2 eq. /t	26.70	0.96

The impacts of a brick plant running on renewable fuels are considerably lower. GWP is halved. Stratospheric ozone depletion is reduced to zero. All other impacts, except for Eutrophication caused by NO_x emissions from renewable fuels, are lower.

When comparing these data one might come to the conclusion that a rural plant running on alternative fuels does have a lesser impact on the environment than an industrial plant running on fossil fuels. This is only in part true. In the environmental impact calculation not all impact factors, such for example dust, are taken into account. Other important factors not taken into consideration are the use of land for mining, social factors such as labor conditions and product characteristics. A high environmental impact low density thermal insulation brick might in the end have a lesser overall impact than a low impact high density brick manufactured in a rural plant. In order to assess exact impacts a complete life cycle analysis might be needed.

One needs also to consider the environmental impact of the production of the fuel that in an impact assessment of the sole operation of the plant is not made.

3. Fuels used in brick plants in various regions – an overview

In general it might be more appropriate to use the term "substitutive fuels" rather than alternative or renewable. In many cases, take for example palm oil and biodiesel, fuels deemed renewable have turned out to be anything else but renewable.

The use of alternative and renewable fuels in the rural brick industry is still widespread. However, no technology transfer from rural to industrial installation or vice versa can take place due to different kiln technologies. In industrial plants the use of tunnel kilns, first patented by York in 1871, is common today. In the rural brick industry a number of different kiln designs are used with trench and Hoffman style kilns most probably the most common. Other types of kiln, such as vertical shaft and bottle kilns just to name two, are in many cases geographically limited. Some of these rural type kilns are surprisingly energy efficient operations when compared to modern tunnel kilns, especially when comparing to tunnel kilns in operation in developing or industrializing countries by local companies lacking the necessary technical skills..

The successful use of alternative and renewable fuels in industrial brick plants in the industrialized world is limited to a few examples: the Olfry brick company in Vechta in Germany [2] runs on landfill gas. In the United States the Boral Brick plants in Terres Hautes [3] in Illinois, Union City [4] in Oklahoma and the Jenkins brick plant in Moody [5] in Illinois run on landfill gas as well. Some plants running partially on landfill gas exist in Spain and the UK. Only one plant has been running on rendering fat and biogas [6]. A few plants have been running on waste motor or hydraulic oil (albeit these have not given authorization to be cited by name). A single plant in the north of France uses sawdust obtained from nearby furniture manufacturers as main fuel. In the wood rich countries of South America the use of sawdust as a fuel is widespread in both industrial and rural kilns.

Some wood chip syngas trials are made in the south of the US. The European Brick Association TBE has been active in getting a European Research Project under way aimed at the use of syngas from various wastes. Until now, the project started in 2010, no results have been obtained. None of the syngas plant suppliers taking part in the project has come up with a working system.

In Asia the use of clod coal, food processing wastes such as nutshells and wood is common.

A particular fuel used in a number of brick plants in South Africa is a waste generated by coal gasification that has been stored in lagoons and is now recovered, processed and sold a cheap fuel. The fuel however does have a

Fuels that could be used in a brick plant, rural or industrial are [7]:

Table 1: Potential fuels

Solid			Liquid			Gaseous		
Fossil	Renewable	Alternative	Fossil	Renewable	Alternative	Fossil	Renewable	Alternative
Petcoke	Wood	Household-waste	Light boiler oil	Rendering fat	Motor oil Hydraulic oil	LNG	Biogas	Biogas
Anthracite	Dried waste water treat-ment sludge cake	Industrial waste	Heavy boiler oil	Waste fat's and oils	Synthetic hydrocar-bons	NG	Landfill gas Sewage gas	Syngas
Coke	Dried organ-ic sludge	Food pro-cessing waste	Fuels ob-tained as waste from coal gasifi-cation		Pyrolysis oil			Hydrogen
Coal					Bio diesel and waste glycerin			Pyrolysis gas
					Alcohol (methanol, ethanol)			
					Edible oil and fat			

Wood and similar when used as fuel might not be considered to be renewable a priori for obvious reasons (deforestation). The same applies to fuels and fuel wastes derived from edible oils. Waste fat's and oils, such as recycled frying oil, might be considered renewable fuels whereas edible oils, including their derivatives such as biodiesel or ethanol, are certainly not to be considered renewable. Pyrolysis oil and gas might be considered renewable if the raw material used in the process fulfills the renewable criteria (as, for example, set forth in the UNFCCC United Nations Framework Convention on Climate Change guidelines).

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