6. Lime

6.1 This Section

This section covers the lime sector *("Contract J")*, as part of an overall project for DTI on *"EU Emissions Trading Scheme (ETS) Phase II – UK New Entrants Spreadsheet revisions"*.

The overall aim of this project is to validate and revise appropriately the existing New Entrants (NE) allocation spreadsheet. The following sub-sections present the findings for this sector.

6.2 Background and Sector Description

6.2.1 Background

The basic process of the lime industry is carried out in kilns of a number of different designs. The process is very energy intensive with fuel for combustion accounting for 40 % to 50% of the variable production costs. The main greenhouse gas emitted by the sector is carbon dioxide derived from the combustion of the fuel used to heat the kilns (combustion CO_2) and from the chemical reactions that liberate CO_2 from the carbonate aggregates (process CO_2).

The UK lime industry consists of fifteen lime production facilities owned by eight different companies. The sector can be divided into two types of operations:

- In house facilities that make lime for the sole use of their parent company; and
- Merchant lime facilities that make lime for sale to the market.

Of the in-house facilities seven are owned and operated by British Sugar and one is owned and operated by Corus. The merchant lime facilities are owned and operated by Buxton Lime Industries, Hanson, Singleton Birch, Specialty Minerals and Steetly Dolomite. The iron and steel sector represents the majority of demand, approximately 51%,[12] for the merchant sector with Hanson, Steetly Dolomite and Singleton being highly exposed to this sector's performance. The majority of the remaining demand is made up from the building / construction industry, the chemical and paper sector.

The type of lime is governed by the requirements of the application and specific processes in which it is used. The basic distinction can be made between calcium limes, which make up approximately 96% of the EU market[1]; dolomitic (magnesium-based) limes, with approximately 2.5% of the market and hydraulic lime at 1.5% of the market. The calcium limes are used in most sectors with applications ranging from a flux agent in steel making through to environmental protection (water and sewage treatment, neutralisation of acidic liquid and gaseous effluents). Calcium lime is also produced and used within the sugar industry as a bleaching agent. Dolomitic limes are a specialist product and the brands sold in the UK by Steetly Dolomite, namely Dolomet, Dolofrit and Dolopel, are used, respectively, as steelmaking fluxes, for kiln repairs and for the production of high quality refractory bricks. Hydraulic limes are used in specialist building products.

The three different basic types of lime are not substitutable for each other as they are chemically very different. It would not be possible to use a calcium lime where a magnesium (dolomitic) lime is required.

In theory all three types of lime can be made in either of the two basic types of lime kiln, the rotary design or the shaft design, but in practice this does not happen. The choice of kiln is dictated by the physical and chemical qualities of the raw material (e.g. size, tendency for the limestone or chalk to decrepitate (crackle and disintegrate) on heating) and market demand, as no one particular type of kiln is capable of producing the range of quicklime qualities demanded by the market.

There has been a trend in recent years for kiln types to become more standardised on the parallel-flow regenerative (PFR) shaft kiln that can be fired on gas, oil and, with the right preparation, solid fuel as well[13]. However, the PFR kiln is not suitable for feedstock types that decrepitate on heating as its design relies on the feedstock maintaining an efficient structure through which the combustion gas can pass. The type of dolomitic limestone found in the UK is subject to decrepitation and cannot be burned in a shaft kiln. Consequently the dolomitic lime products must be made in a rotary kiln.

The main restriction on the use of the PFR design is that it requires a feedstock in the size range 25 – 200 mm although the "finelime" version of the kiln can operate on 10 – 30 mm stone. There are a number of other kiln designs, based upon modern cement kiln technology that can handle the mixed streams of finely divided calcium carbonate and organic matter produced by the sugar and paper industries as well as surplus fine stone from limestone quarries[12].

6.2.2 Phase I incumbent and new entrant installations

Identification of how sector is covered under EU ETS

The emission of carbon dioxide from the lime sector is covered under EU ETS by the following clause in the directive[1]:

> *Installations for the production of … lime in rotary kilns with a production capacity exceeding 50 tonnes per day or in other furnaces with a production capacity exceeding 50 tonnes per day.*

CO_2 emissions from sector

Total CO_2 emissions from the lime sector in recent years are presented in Table 6.1.

Table 6.1 Total CO_2 emissions from the lime sector

Total emissions (tCO_2)			
2000	**2001**	**2002**	**2003**
2,525,482	2,341,685	2,173,324	2,262,804

Source: NAP database

Identification of Non-benchmarked incumbents, Benchmarked incumbents and New Entrants

The coverage of the lime facilities in the UK NAP allocation for Phase 1 [2] is somewhat fragmented with four sites owned by four companies, Steetly Dolomite (Thrislington site), Lhoist, Minteq and Corus included in Phase 1 and five sites owned by four companies Steetly Dolomite (Whitwell site), Buxton Lime (Tunstead and Hindlow sites), Hanson and Singleton Birch being listed as opted out via the CCA mechanism. As well as the seven companies specified above there is an eighth company, British Sugar, that has also opted out its six lime kilns from Phase 1 on the basis that it is a direct participant in the UK ETS [3]. The British Sugar lime production is somewhat unusual as the process emissions from the kilns are reabsorbed into the sugar product and not released to atmosphere.

Non-benchmarked Incumbents

The vast majority of the installations covered by Phase 1 of the EU ETS were given allocations, or in the case of those granted opt out via the CCA route had them calculated, based upon the assessment of their historical emissions over the years 1998 – 2003. This approach, often called "grandfathering", is not dependent upon any performance benchmark. The incumbents in the UK lime sector that have received this type of allocation in Phase 1 (together with sugar industry sites, for completeness) are listed in Table 6.2 below.

Table 6.2 Non-benchmarked Incumbents[2]

Company	Plant	Location	NAP ID	Capacity [4]tpd	Kiln Number and Type[4]
British Sugar (Note 1)	Allscott Sugar Factory	Allscott	2164	96	1 x Shaft
	Bury St Edmunds Sugar Factory	Bury St Edmonds	136	336	1 x Shaft
	Cantley Sugar Factory	Cantley	138	120	1 x Shaft
	British Sugar plc - Newark	Newark	140	768	1 x Shaft
	Wissington Sugar Factory	Wissington	135	508	1 x Shaft
	York Sugar Factory	York	142	144	1 x Shaft
Buxton Lime Industries Limited	Tunstead Lime	Tunstead	634	1480	8 x Maerz / PFR 2 x rotary
	Hindlow Lime	Hindlow	656	600	2 x Maerz / PFR
Corus UK Ltd	Shapfell Works	Shap	657	1200	4 x Maerz / PFR
Hanson Quarry Products Europe Ltd	Batts Combe Lime Kiln	Batts Combe	658	552	1 x rotary
Lhoist UK Ltd	Lhoist UK Limited Hindlow	Hindlow	661	300	2 x Maerz / PFR

Company	Plant	Location	NAP ID	Capacity [4]tpd	Kiln Number and Type[4]
MINTEQ UK LTD	Specialty Minerals Lifford	Lifford	663	100	1 x multi chamber vertical shaft
Singleton Birch Limited	Melton Ross Limeworks	Melton Ross	662	1200	4 x Maerz / PFR
Steetley Dolomite Limited	Whitwell Works Lime Kiln Plant	Whitwell	659	750 (Note 2)	2 x rotary
	Thrislington Works Lime Kiln Plant	Thrislington	660	900 (Note 2)	2 x rotary

Note

1. Installations in the sugar sector have applied to opt-out of EUETS
2. The kiln capacities for the Steetley sites have been provided by the BLA[5]

Benchmarked Incumbents

There are currently no benchmarked incumbents in Phase 1 in the lime sector.

New Entrants in Phase 1

Expected new entrants to EU-ETS during Phase 1 of the scheme are:

- Buxton Lime Industries' new lime kiln at the Tunstead lime works (NAP ID 634). This will be an extension to the capacity of the existing works.
- Singleton Birch's new kiln at Melton Ross (NAP ID 662). This will be an extension to the existing works.

Both of these new kilns are likely to be of the Maerz / PFR design and of similar capacity to the units already on the sites. It is possible that the development timetable for these two sites will result in them being classed as new entrants in Phase 2 rather than Phase 1.

6.2.3 Possible new entrant technologies in Phase II

Brief description of known or likely new entrants and market developments
Market developments have recently been investigated in a report by Oxford Economic Forecasting (OEF)[6]. The relevant section of the text is reproduced below.

The most significant single driver of lime sales is steel production, which is forecast to rebound by almost 45% in the period to 2005-2007 from the very depressed levels witnessed in 2002. Output of speciality chemicals as well as chemicals in general is also recovering, while continued growth is forecast for construction output. Demand for lime for environmental uses is difficult to assess, but there is no reason to expect the upward trend evident since the mid-1990s to cease. Export markets for lime can be expected to show growth of around 1% pa.

Given the available information on lime demand, i.e. that demand is dominated by the steel sector, OEF are in broad agreement with the BLA's version A forecasts. Note. They consider, however, that the version B forecasts are overly optimistic, particularly with regard to the assumption of 10% pa export growth, which would imply continuous increases in market share.

(A summary of growth estimates is given in Table 6.3.) *One caveat is that the BLA have only been able to supply historical data for the period 1995 to 2003, a period during which the fortunes of the main client sector have fluctuated significantly. Given the short time series of data, it is difficult to assess whether there is any trend change in the 'intensity' of lime use, i.e. the amount of lime demanded per unit of output in the client sectors.*

Table 6.3 Lime sector growth estimates

Source of forecast	Forecast growth (%)			
	2002-2005	2002-2006	2002-2007	2002-2012
BLA version A	17.8	23.8	26.2	n.a.
BLA version B	22.5	29.5	33.7	n.a.
OEF	17.6	22.8	24.9	31.0

Source: Oxford Economic Forecasting

Summary of possible types of New Entrants in Phase II

A summary of possible types of New Entrants in Phase II is given in Table 6.4. The dominant kiln technology is most likely to be the PFR design operated on natural gas. There is some potential to operate new kilns on biomass and other types of substitute fuel. This is discussed below. A PFR kiln can be considered to be a modern and sophisticated version of a shaft kiln. It is not beyond the bounds of possibility that a new gas powered rotary kiln may be built but the details of this are confidential.

Table 6.4 Summary of possible types of New Entrants in Phase II

Type of New Entrant	Is this type of New Entrant realistically possible in Phase II?	Technology type	Fuel type	Examples (known or likely)	Other relevant details
New installation	No new installations are envisaged, although new kilns at existing sites are likely (see below)				
New piece of equipment to increase capacity at existing installation	Yes	MAERZ / PFR	Gas	Two possible	Not clear if these will be in Phase 1 of Phase 2
Extension to existing piece of equipment to increase capacity at existing installation	No				

6.3 Review of relevant data

6.3.1 Data sources

The British Lime Association

Entec has held detailed discussions with the BLA on the revision of the NE spreadsheet. The BLA provided Entec with a revised version of the original emission factors that were put into the Phase 1 spreadsheet. There was discussion on the need to establish a higher degree of transparency in the way in which the benchmark factors in the spreadsheet are derived.

European Lime Association (EuLA)

No information was received from EuLA in response to Entec's request for information.

Individual lime companies

Individual companies have provided very useful background information on the new entrant process and have commented on the likelihood of types of new entrants in Phase 2. Some data on individual lime companies (e.g. capacity, technology, fuels etc) is already held in-house from previous research.

The Environment Agency

Entec held detailed discussions with the EA's sector expert for lime on the issues of allocation to new entrants in Phase 2. Their views were very similar to those of the DTI discussed below.

DTI

Entec held a discussion with the DTI sector expert for the lime industry. They were of the opinion that there would not be any significant changes in the technology base and energy efficiency of the UK lime sector between now and Phase 2. This opinion can be reinforced by the fact that CCA target for the sector is to achieve a 2% improvement in energy efficiency between 2002 and 2010 [7]. They were also of the opinion that the sector has little potential to use substitute fuels or feedstock materials. The DTI anticipate some production growth but it is difficult to predict and only knew of one potential NE in Phase 2.

6.3.2 Data from literature

The key source of information for the sector is the BREF Note[12]. A literature search was undertaken to identify other sources of information but this did not identify other key literature sources of best operating practice data for lime kilns.

6.3.3 Benchmarks used in other contexts, including other Member States

Investigations have been undertaken to try to identify benchmarking approaches for new entrants in other Member States. Overall, the extent of information available within the tight timescales of this study has been limited. Furthermore, information will tend to relate to Phase I approaches, and hence may not be indicative of approaches in Phase II, which this study is focussed on. Notwithstanding this, it is useful to consider these approaches, as briefly summarised below.

Denmark

The Danish NAP assumes an efficiency factor of 0.9 for new entrants but no distinction is made between sectors for this factor. No discussion of new entrant benchmarks or formula.

Germany

New entrants are granted allocation on BAT benchmarks. These benchmarks are established for installations with comparable products, and derived from BAT for new installations in that class. Also, each product category will have a benchmark. New entrants that don't have defined benchmarks will be granted allowance based on BAT.

New entrant formula (industry non-specific);

$$Allocation_i = C_i \cdot U_i^P \cdot BAT,$$

where

i	is an index for the installation;
C_i	is the installation-specific output capacity in MW;
U_i^P	is the projected utilisation or load factor by installation; and
BAT	BAT benchmark for emissions per output unit, here CO_2/MW.

Netherlands

$$A_i = E_v \cdot P \cdot \beta \cdot C$$

Where

A_i = Allocation (tCO_2/year);

E_v = Emissions from combustion averaged for 2001 to 2002 (tCO_2/year), information not readily available on the specific approach for new entrants operational after that time;

P = Production growth as a factor for the total of the years 2003-2006 (relative index);

β = energy consumption of the world's best divided by the installation's actual energy consumption in the benchmark year 1999 (relative index);

C = Allocation factor (relative index).

Sweden

$Allocation_{05\text{-}07} = k$ x Projected $output_{05\text{-}07}$ x BM / BAT

Where

k = Scale factor applied to fuel-related emissions from combustion installations in the energy sector. For non energy sector sites, $k = 1.0$;

Projected $output_{05\text{-}07}$ = emissions in accordance with projected produced quantity of installation-specific product 2005-2007. Only production based on fossil fuels is meant for electricity and heat production;

BM = Benchmark emission factor;

BAT = Corresponds to estimated specific emissions at installation (tCO_2/t product).

Other Member States

For a number of other Member States, the readily available information simply indicates that new entrant allocations are to be based on BAT levels of performance. This applies to Czech Republic, Ireland, Malta, Portugal (explicitly stating BAT Reference Documents), Slovenia (also referencing BAT Reference Documents), and Spain.

The fact that many of the MSs have cited BAT and the BREF as the main reference upon which a NE allocation will be based should allow for potential harmonisation of the process across the EU. The BREF note does not specify emission factors as such but it does specify a range of energy use in MJ / tonne lime for all the different kiln technologies in use. The EuLA have published a table of emission factors [8] for the main lime kiln technologies and these emission factors have been based upon the BREF energy values and standard emission factor for different fuels. It is anticipated that this would be a standard reference for all EU MSs.

6.4 Review of Phase I benchmarks

6.4.1 Characterisation of existing New Entrant allocation benchmarks

A characterisation of the existing New Entrant allocation spreadsheet is given in Table 6.5.

Table 6.5 Characterisation of the existing New Entrant allocation spreadsheet

Item	Parameter value / details	Justification for choice of parameter value / details given by FES	Source of data
Coverage of activities *(how does the coverage of activities included in the spreadsheet compare to the activities in the sector that are covered by EU ETS)*	Covers lime production not any of the associated milling and blending	The associated activities are usually electrically driven and therefore outside the scope of the EU ETS	EU ETS Directive
Level of sector differentiation *(Is there one set of formulae / parameter values for the whole sector, or are there separate formulae / parameter values for different technologies, fuels, products etc)*	There are different predetermined emission parameter values for kiln fuel, product types and kiln technologies.	The main elements have been justified by FES' analysis of the industry [9]	FES Report [9]
Degree of standardisation of formulae *(i.e. what types of input parameters are required in the formulae?)*	Standard formula requiring one (and for one type of kiln two) input parameters, although requires selection of applicable technology, product and fuel.	The main elements have been justified by FES' analysis of the industry	FES Report [9]

Item	Parameter value / details	Justification for choice of parameter value / details given by FES	Source of data
Technology / process types *(What types of technologies / processes are used as the basis for the parameter values?)*	Five different types of technology and four different types of product have been included.	The main elements have been justified by FES' analysis of the industry and by data submitted by the BLA.	FES Report [9]
Fuels assumed *(What types of fuels are used as the basis for the parameter values?)*	Three different types of fuel have been included. Waste derived liquid fuels, known to be used by the sector are not included.	Data submission made to FES by BLA.	FES Report [9]
Emission factors *(What are the fuel CO_2 and Process CO_2 emission factors?)*	Predetermined fuel and process emission factors selected for kiln, fuel and product type. No process emission for kilns at sugar plants.	The analysis of real energy data from EuLA based upon the BREF SEC figures.	EuLA Data submission.
Capacity utilisation factors / load factors *(What are the values for these factors?)*	Standard load factors with user defined design capacity. 330 days operation per year and 95% load factor	Justified by FES' analysis of the industry	FES Report [9]
Moisture content of feedstock	User input of moisture for one type of kiln (PFR) only	Applies to a single incumbent site in the UK	

The existing NE spreadsheet contains a number of input and calculation steps that allow applicants to the NER to calculate the number of allowances they can claim as part of the overall application process. The allocation amount, A, for a year in t CO_2 is given by the sum of:

Combustion emissions:

A	=	P	*	EF
Allocation	=	Annual Production	*	Emissions Factor
tCO_2		Tonnes of lime per year		tCO_2 / tonne lime

and Process emissions:

A	=	P	*	EF
Allocation	=	Annual Production	*	Emissions Factor
tCO_2		Tonnes of lime per year		tCO_2 / tonne of lime

Where the annual production is defined by:

P	=	C	*	D	*	U
Annual production	=	Design capacity of kiln	*	Days of planned production per year	*	Utilisation of production days
Tonnes of lime per year		Tonnes of lime per day		Days		%

Where:

Parameter / Variable	Value
EF	Emission Factor - See text below and Table 6.6
P	Annual production
C	Stated design capacity of kiln, tonnes per day
D	330 days per year
U	95% utilisation

The lime kilns that operate in the sugar industry only release combustion based emissions as the process emissions are recarbonated at a later point in the sugar refining process.

The Phase 1 NE spreadsheet has predetermined values for the process and combustion emission factor for different types of kiln, product and fuel. The values used in the Phase 1 NE spreadsheet are shown in Table 6.6 below along with the notes from the FES report [10]. These values were provided to FES by the BLA and are very similar to those in the EuLA Lime Activity Emission Table[8]. The spreadsheet user selects the type of kiln product and fuel from a dropdown menu.

Table 6.6 Lime kiln / product / fuel combustion factors

Kiln Type	Lime Product	Process CO2 (t CO2 / t lime)	Fuel (a)	Combustion CO2 (b) Range (t / t)	Total CO2 (b) Range (t / t)
Long Rotary	High Calcium	0.785	Gas	0.53 - 0.58	1.31 - 1.37
		0.785	Petcoke	0.80 - 0.90	1.58 - 1.68
	Light burnt Dolomitic (Dolomet)	0.913	Gas	0.58 - 0.63	1.50 - 1.54
		0.913	Petcoke	0.90 - 1.00	1.81 - 1.91
	Dead burnt Dolomitic (Dolofrit) (c)	0.913	Petcoke	1.00 - 1.10	1.91 - 2.01
	Dead burnt	0 (g)	Petcoke	0.55 - 0.65	0.55 - 0.65 (h)

Kiln Type	Lime Product	Process CO2 (t CO2 / t lime)	Fuel (a)	Combustion CO2 (b) Range (t / t)	Total CO2 (b) Range (t / t)
	Dolomitic (Dolopel) (d)				
Preheater Rotary	High Calcium (e)	0.785	Gas	0.30 - 0.35	1.09 - 1.14
	Light burnt	0.913	Gas	0.41 - 0.47	1.33 - 1.38
	Dolomitic (f)	0.913	Petcoke	0.67 - 0.75	1.58 - 1.66
Mixed Feed	High Calcium	0.785	Coke	0.49 - 0.65	1.28 - 1.43
PFR	High Calcium	0.785	Gas	0.21 - 0.25	1.00 - 1.04
Other Shaft	High Calcium	0.785	Gas	0.28 - 0.30	1.06 - 1.09

Notes:

(a) When it is technically possible to use either natural gas or solid fuel, ranges have been quoted for both, although the use of gas is not generally ‘All Cost Effective’ *(a term used in the CCA to describe the economics of emission reduction potential).* When a product cannot be made using gas, the appropriate solid fuel has been taken.

(b) Ranges are based on performance of UK kilns

(c) "Dolofrit" is produced by pelletising fine dolomet with iron oxide, calcining and sintering at 1400 degrees C

(d) "Dolopel" is produced by sintering light burnt dolomitic lime at 1900 degrees C

(e) With a shaft preheater

(f) With a grate preheater - chosen because of the low limestone and lime strength & abrasion resistance

(g) As this is a second calcination of light burnt dolomitic lime, the process CO2 is zero.

(h) The CO2 from the production of the light burnt dolomitic lime must be added to these values

(i) The production of Dolopel requires that Dolomet must be made first

6.4.2 Validation of existing New Entrant allocation spreadsheet

The results of the validation exercise as conducted on all the UK lime plants included in the EU ETS are presented in the tables below, with data on the British Sugar kilns presented separately. The first comparison is between the Phase 1 allocations as stated in the UK NAP (final version May 2005) and the allocations that would be derived using the existing NE spreadsheet, and the most recent input data that are available for the incumbent sites. This information is shown in Table 6.7 below. The second comparison, in Table 6.8, is between actual emissions data, in this case the average emissions over the years 2000 – 2003 (excl lowest year) as stated in the UK NAP (final version May 2005), and the allocations that would be derived using the existing NE spreadsheet, and the most recent input data that are available for the incumbent sites.

The Phase I NE spreadsheet contains a number of input variables that can be used to allow for site specific adjustment to a range of factors such as kiln type, fuel type and, in the case of certain types of kiln, feedstock moisture as well. In order to fully test the NE spreadsheet it is necessary to obtain all of these values for the incumbents for their recent performance i.e. the years 2003 - 2005. However, at the time of writing this report this information was not available. The ability of the current NE spreadsheet to calculate an allocation was tested therefore using the published[4,5] kiln type and capacity data for the UK lime sites as the sole input variables (a moisture level was used for one site where it was known). Unless there have been major modifications at a site level this kiln capacity data will be a constant for any given site and it is reasonable to expect that the data from the reference in 2001 reflects the position in 2005.

Table 6.7 Comparison of UK NAP Allocation with NE Spreadsheet Allocation

Site	Phase I NE Spreadsheet Input Assumptions	Phase 1 NE Spreadsheet Allocation/ UK Phase 1 NAP Annual Allocation
1	Dolofrit and pet coke	142%
2	High calcium and gas	158%
3	High calcium and gas	53%
4	High calcium and gas	88%
5	High calcium and gas	123%
6	High calcium and gas	97%
7	High calcium and gas	149%
8	Dolofrit and pet coke	120%
9	High calcium and gas, 10% moisture	143%
Weighted average		120%

Note: The under allocation in Site 3 may be due to an error in the original reference source[4].

The comparison made between the UK NAP annual allocation for Phase 1 and annual allocation calculated using the Phase 1 NE Spreadsheet shows that for the majority of sites the NE produces an over allocation. We believe that a key factor leading to this result is that the capacity for existing sites typically incorporates old kilns that are used less intensively e.g. in standby mode.

The lime industry, particularly companies who use Maerz / PFR kilns, tend to operate the units as a battery where by kilns are brought online and taken off-line in rotation as dictated by demand. The kilns at Site 4 and Site 9 are typical examples of sites where this strategy is used. The input of the total site capacity should therefore give an over allocation when compared to the actual emissions.

Despite the similarity of the strategies that we believe are used at these two sites, the validation exercise above yields results for these sites that differ significantly from each other. In particular, Site 9 would receive a benchmarked allocation that is 43% higher than its actual allocation, whereas Site 4 would receive a benchmarked allocation that is 12% *lower* than its actual allocation. The reason for this difference is not clear. The Site 9 result seems to be consistent with the battery strategy described above as the emission from the 3 on-line kilns will be approximately ¾ of the NE allocation for the total site capacity of 4 kilns. However, the result for Site 4 does not seem to be consistent with this and the NAP allocation based upon historical emissions seem to be greater than the NE allocation result even when all the kilns are assumed to be on-line. The result may be due to the type of assumptions made for the input parameters but it cannot be explained at present without further information.

More meaningful results would be gained if the 'on-line' capacity was used in the calculations. This is the capacity that is actually used in normal operation, and this would equate more directly to operation of new entrant. However, 'on-line' capacity data has not been available to this study.

Table 6.8 Comparison of Annual Average Emissions for 2000 -2003 with existing New Entrant allocation spreadsheet

Site	Phase 1 NE Spreadsheet Input Assumptions	Phase 1 NE Spreadsheet Allocation/ Average Emissions 2000- 2003 (lowest omitted)
1	Dolofrit and pet coke	167%
2	High calcium and gas	168%
3	High calcium and gas	59%
4	High calcium and gas	94%
5	High calcium and gas	123%
6	High calcium and gas	98%
7	High calcium and gas	162%
8	Dolofrit and pet coke	113%
9	High calcium and gas, 10% moisture	147%
Weighted average		125%

Note: The under allocation in Site 3 may be due to an error in the original reference source[4].

The comparison made between the most recent emission data available, the NAP data for 2000 – 2003, and an annual allocation calculated using the Phase 1 NE Spreadsheet (version 23rd May 2005) shows a similar set of results as for Table 6.7, namely that there are substantial differences in the results using the Phase 1 NE spreadsheet and the actual emission from the kilns, with generally higher emissions using the Phase 1 NE spreadsheet.

6.4.3 British Sugar Kilns

The Phase 1 NE spreadsheet has a separate section for the lime operations carried out by British Sugar. As the process emissions from these kilns are reabsorbed into the product and not released to atmosphere allocation spreadsheet does not need to include the process emission contribution for these sites. These kilns received no allocation and have no emission data reported in the NAP therefore it has not been possible to evaluate the operation of the current NE spreadsheet against them.

6.5 Assessment of Phase I Benchmarks and Proposed Revisions to these Benchmarks

This section assesses the existing New Entrant allocation spreadsheet and, where appropriate, develops proposals for the revision of the spreadsheet. Proposals are justified against the agreed evaluation criteria in the next section.

There is the need to establish that all the input parameters required for the NER spreadsheet are consistent with the principles of the EU ETS and that they are scientifically and statistically valid. The origins of the emission factors and validity of them as applied to new entrants in Phase 2 needs to be transparent. The issues and data requirements for each of the main input parameters and standard factors for the existing NER spreadsheet are discussed below.

There are a number of potential revisions that can be made to the spreadsheet. These are discussed in turn below.

Emission Benchmarks

The emission benchmarks used in the current NE spreadsheet are shown in Table 6.6, are disaggregated on a number of elements including kiln type and fuel. The BLA have provided Entec with a revised version of these emission factors[11]. These are shown in Table 6.9 below. These emission factors combine the fuel and process emission into a single value.

Table 6.9 Revised Lime Kiln / Product / Fuel Combustion Factors

Kiln Group	Kiln Type	Number of Kilns in Sector	Product Specification	Emission Factor:Gas Fired t CO_2 / t lime	Emission Factor: Coke Fired t CO_2 / t lime
1a	PFR	12	High calcium, light burnt	1.04	1.26
1b	Counter-current shaft	9	High calcium, light burnt		
2a	Pre—heater rotary	1	High calcium, light burnt	1.11	1.34
2b	Mixed feed	7	High calcium, light burnt		
3a	Long rotary with internals	2	High calcium, light burnt	1.34	1.62
3b	Pre-heater rotary	1	Dolomitic (x % MgO), light burnt		
4	Long rotary with internals	2	Dolomitic (x % MgO), light burnt	1.52	1.84

Kiln Group	Kiln Type	Number of Kilns in Sector	Product Specification	Emission Factor:Gas Fired t CO_2 / t lime	Emission Factor: Coke Fired t CO_2 / t lime
5	Long rotary	1	Dolomitic (x % MgO) + iron oxided, dead burnt	n/a	1.96
6	Long rotary	1	Dolomitic (x % MgO), dead burnt with second burning	n/a	0.60 (no process CO_2 is emitted by this step)
7	Mixed-feed (British Sugar)		High calcium, light burnt	n/a	0.42*

*Emission factor based upon 2004- 2005 CCA Milestone data.

The comparison of the emission factors in Table 6.9 with the original version reveal that there has been very little change in the numbers although the categories have been simplified. The figures are very similar to those found in the EU Lime Association's table of emissions factors, Table 6.10, which themselves are based upon the BREF[12] note's ranking of technologies and carbon/energy intensity. One difficulty with the approach taken by the BLA is that combining the kiln types to get a single emission factor results in a factor that is above the lowest range value stated in the EuLA/ BAT reference for a type of kiln. For example the proposed emission value for PFR/ counter current shaft kilns of 1.04 t CO_2 / t lime is higher than the lowest value of 0.987 t CO_2 / t lime cited in the EuLA/ BREF values shown in Table 6.10 and higher than the emission factor used in the Phase 1 NE Spreadsheet of 1.00 t CO_2 / t lime, shown in Table 6.6. This same feature is observed with the value for the preheater rotary kilns where the of 1.11 t CO_2 / t lime is higher than the lowest value of 1.05 t CO_2 / t lime cited in the EuLA/ BREF values shown in Table 6.10 and higher than the emission factor used in the Phase 1 NE Spreadsheet of 1.09 t CO_2 / t lime, shown in Table 6.6.

Table 6.10 CO_2 emissions factors for different kiln types [8]

Kiln type (1)	Tonne of process CO_2 per tonne of lime (CaO) (2)	Tonne of process CO_2 per tonne of dolomitic limestone (CaO.MgO) (2)	Tonne of combustion CO_2 per tonne of Lime – dolomitic limestone(3)	Total Activity CO_2 emission factor
Parallel flow regenerative shaft kiln	0.785	0.913	0.202 to 0.425	Lime 0.987 to 1.210 Dolomitic lime 1.115 to 1.338
Annular shaft kiln	0.785	0.913	0.224 to 0.465	Lime 1.009 to 1.250 Dolomitic lime 1.137 to 1.378
Other shaft kiln	0.785	0.913	0.224 to 0.506	Lime 1.009 to 1.291 Dolomitic lime 1.137 to 1.419

Kiln type (1)	Tonne of process CO_2 per tonne of lime (CaO) (2)	Tonne of process CO_2 per tonne of dolomitic limestone (CaO.MgO) (2)	Tonne of combustion CO_2 per tonne of Lime – dolomitic limestone(3)	Total Activity CO_2 emission factor
Mixed feed shaft kiln	0.785	0.913	0.224 to 0.708	Lime 1.009 to 1.493 Dolomitic lime 1.137 to 1.621
Rotary with grate enshaft preheater kiln	0.785	0.913	0.269 to 0.617	Lime 1.054 to 1.402 Dolomitic lime 1.182 to 1.530
Long rotary kiln	0.785	0.913	0.365 to 1.062	Lime 1.150 to 1.847 Dolomitic lime 1.278 to 1.975

(1) the type of kiln is dependent on required quality and on limestone quality and granulometry input

(2) Process CO_2 emission factor defined by UNFCCC IPCCC guidelines

(2) Process CO_2 emission factor defined by UNFCCC IPCCC guidelines

(3) Combustion CO_2 Lime BREF March 2000 page 80 Table 2.8. Based upon heat use for calcium quicklime, light and hard burned dolomite

We propose revising the NE spreadsheet such that it is based upon a narrower number of kiln, fuel and product types than are used in the Phase 1 NE Spreadsheet. The proposed emission factors to be included in the final spreadsheet for Phase 2 are shown in Table 6.11. These are for gas only. The gas emission factor is based upon the lowest energy uses value given in the BREF Note[12] and the standard process emission factor of 0.785 t CO_2 / t lime and 0.913 t CO_2 / t dolomite as specified in the EuLA reference[8].

Table 6.11 Proposed Emission Factors for Revised NE Spreadsheet

Basic Kiln Type	Emission Source	Product Specification	Emission Factor (Gas Fired) t CO_2 / t lime
Shaft design	Fuel and process	High calcium	0.987
Shaft design	Fuel only (for beet sugar industry)	High calcium	0.202
Rotary design	Fuel and process	High calcium	1.05
Rotary design	Fuel and process	Dolomitic (x % MgO)	1.18

There are a number of reasons why it would seem necessary to retain the differentiation on kiln type. Firstly, there is the issue of the production of calcium or dolomitic lime. A rotary kiln is required to make dolomitic lime products as the magnesium limestone in the UK is known to decrepitate on heating and as such cannot be put into a shaft kiln, in addition, the two lime products are not substitutable i.e. it would not necessarily be possible to use a calcium lime where a dolomitic lime is required.

The second reason to retain the differentiation on kiln type is because a rotary kiln is able to make high calcium products of higher purity than can be made in a shaft kiln [5]. .Again the products are not substitutable. It would not necessarily be possible to use a lower purity calcium lime in the place of high purity lime.

In general, a rotary kiln can use raw material that cannot be calcined in shaft kilns due to their tendency to decrepitate[5] or due to the fact that they are relatively weak (e.g. Shell deposits and friable limestone[12]).

There are other types of lime kiln technology in use in the EU such as gas suspension calcinations design at Norsk Hydro's Porsgrunn site in Norway [12] that are able to handle pulverised raw material feeds but there is no evidence that any kilns of this type will be built in the UK in the foreseeable future.

We have considered revising the emission factors by using the actual recent performance of the newer kilns in the UK. However, as can be seen from the information presented on the actual number of kiln types in the UK in Table 6.9 it would be difficult to derive a meaningful data set from such a limited population. Information from a wider sample of kilns across the EU would allow an emission factor to be derived using this method.

Substitute Fuels

The operators of the majority of lime kilns in the UK have little potential to use substitute fuels, either from general bio mass or waste sources due to the required purity of the lime product. Entec know of at least one site equipped with long rotary kilns that make use of liquid fuel (SLF) made from waste solvents that are un-economic to recycle. The current NE spreadsheet makes no allowance for this as the only fuel options are gas, petcoke or coke. Given the lack of information available on this issue and the fact that it only impacts on one or possibly two companies and not the whole sector we propose that substitute fuels should not be included in the revision.

Moisture Value Input

The discussion with the BLA has suggested that the main factor that determines the moisture value is the geology of the aggregate extraction site. With closer examination of this issue it transpires that the issue of elevated levels of moisture in the feedstock due to geology only impacts upon a single site in the UK.

The possibility has been examined of using the geological parameters as the basis for moisture input value but this was considered to be un-necessary for the lime sector. The NE spreadsheet may be revised so as to require a specific statement of the mineral type of the feedstock in order to provide a mechanism to check the validity of any moisture value input by a future applicant.

One key concern for the existing moisture parameter is the potential for NE applicants to make a claim for additional allowances for the moisture content of other feedstock materials. However, this is unlikely to occur in the lime industry due to the technical constraints discussed above.

The moisture input value has a limited effect on the overall allocation calculation with an input of a value of 10% for moisture only resulting in a 2.7% increase in the overall allocation. More detailed analysis of the Phase 1 NE spreadsheet has revealed that the allocation calculated for the emission from combustion is directly proportional to the moisture value input, i.e. the relationship between the two factors is linear with every x % increase in the moisture value resulting in smaller but corresponding y % increase in the allocation.

The moisture input parameter does not appear to have a minimum or maximum value as it does in the cement allocation section. If a minimum input value of 8.5% for moisture (similar to that used in the cement allocation) were used in the lime sector allocation then the input of a moisture value of 10 % would only result in an increase of only 0.4% in the allocation.

We propose to remove the moisture input parameter from the lime allocation as including it does not contribute to the standardisation of the allocation process and introduces a level of differentiation by raw material.

Kiln Capacity

The kiln capacity is another key input parameter for the lime sector in the current NER allocation spreadsheet. The parameter seems to be well defined by kiln type for modern Maerz / PFR kilns with the stated kiln capacities provided by the kiln manufacturer[13] matching the capacity reported by the kiln operators. It would be possible to verify the accuracy of the input parameter further by cross referencing the production with the stated capacity for new and recent build kilns.

No revision is proposed for the NE spreadsheet in respect to the kiln capacity parameter.

Utilisation

The current proposal is to use 330 days for fuel based emissions rather than the 365 days reflected in the Phase I spreadsheet. This will be consistent with 330 days specified for process based emissions.

The validity of the 330 days operation at 95% utilisation was determined by FES in the development of the original spreadsheet. Entec have not received any updated information on this parameter. It is reasonable to expect that a new built kiln will be operated to a high level of utilisation as, once it has been fully commissioned, it will be more efficient than the older kilns on the same site. The BLA have stated [5] that once a shaft type kiln is up and running is it usually kept on line for years.

In order to fully understand this issue there would need to be significantly more analysis of the performance of recent new kilns and how their addition changed the utilisation rate of other older kilns on the same site. However, at the time of writing this information was not available.

Entec made contact with the kiln construction company Maerz Ofenbau AG in order to seek an opinion on the value of these parameters. A representative from Maerz confirmed that *"95% is common practice. Best practice would be 98% but in some instances it might be as low as 90% - but depends on the country conditions. 330 days at 95% is normal although 340 days would also be utilized at 95%"*. This strengthens the argument for retaining these parameters as their stated values.

Summary

The following table briefly considers the key elements of the existing NE allocation spreadsheet and summarises details of proposed revisions. The proposals are then justified against the agreed evaluation criteria in the following section.

Table 6.12 Summary assessment of key elements of existing New Entrant allocation spreadsheet and proposals for potential revision

Tests to be applied to existing NE allocation spreadsheet		Answer / Details of proposed revision	Source of data
Differentiation: should there be less or more differentiation within the sector (i.e. differentiating based on sub-product, raw materials, technology, fuel, efficiency etc)? If so, what should it be?		Less differentiation is proposed by removing some of the kiln and fuel types. See next section for more details.	
Level at which benchmark is set	Is the **emission factor** consistent with sector best practice[1]? If "No", what should it be?	The proposed emission factor is consistent with data in the BREF and data from EuLA. These figures are thought to be consistent with sector best practice.	BAT Reference Documents, EuLA documents
	Is the **load factor** realistic for new entrants in that sector? If "No", what should it be?	The use of the load factor of 95% of 330 days per year is considered realistic for new entrants.	Phase 1 NE Spreadsheet Report[9]

Overall, the proposals for potential revisions to the formulae to be used in the New Entrant allocation spreadsheet are that the two types of emission factors, combustion and process, be combined into one and that:

The annual allocation A, in t CO_2, is given by:

A	=	P	*	EF
Allocation	=	Annual Production	*	Emissions Factor
tCO_2		Tonnes of lime per year		tCO_2 / tonne lime

Where the annual production is defined by:

P	=	C	*	D	*	U
Annual Production	=	Stated design capacity of kiln	*	Days planned production per year	*	Utilisation of production days
Tonnes of lime per year		Tonnes of lime per day		Days		%

[1] Interpreted as 'Best Available Techniques' (BAT), as defined in the IPPC Directive. In practice, within the scope of this study it will only be possible to assess this in broad indicative terms at a sectoral level. It is clearly not within our scope to define BAT at the level of detail that would be required for a site specific PPC Permit.

Where:

Parameter / Variable	Value
EF	Emission Factor, see Table 6.11
P	Annual Production
C	Stated design capacity of kiln, tonnes per day
D	330 days per year
U	95 % utilisation

6.6 Evaluation of Proposed Benchmarks

Feasibility

- The benchmark factors proposed for the revision of the NE spreadsheet are the lowest emission factors taken directly from the emission factor ranges in the list of BREF/ EuLA lime activity factors. These factors represent best practice and, in so much that this information has been subject to the peer review process in the development of the BAT reference document and is not confidential, they would appear to be the best available.

- The proposed removal of the input parameter for moisture will minimise the use of unverified and non standard inputs and remove the differentiation due to raw materials.

- It proposed to maintain the use of standard values for utilisation and planned production days which are transparent and simple. The actual levels themselves (330 days planned use and 95% utilisation) do not seem unreasonable for new kilns.

- The plant capacity value should be the nameplate capacity of the new kiln unit and should be backed up with verifiable data. This key operator input is transparent, simple and verifiable. This parameter can be verified by reference to the design plans for a new kiln. The review of the literature received by Entec from Maerz Ofenbau AG [13], one of the worlds leading kiln construction companies, has confirmed that kilns can be operated between 50 and 100 % of their nominal capacity. Consequently the capacity of a 200 tpd Maerz kiln will be 200 tpd.

Incentives for clean technology

- It is proposed to maintain the choice between a shaft kiln and a rotary kiln both of BAT design. The number of kiln types has been reduced by removing some of the more energy inefficient types such as the long rotary kiln. Though the possibility for operator specified choice of technology to some degree limits the incentive for clean technology, it is necessary for reasons of competitiveness and consistency with incumbents (the two different types of kiln are used to make different types of products and certain types of rock cannot be calcined in shaft kilns) to maintain the option for a rotary design kiln. The difference in emission factors is not vast, being about 6% for the same product / fuel type.

- It is proposed to remove the differentiation for fuel type. This will increase the degree of incentives given by the benchmark as there is approximately 20% difference between the total (process and combustion) emissions factors for gas (the proposed benchmark fuel) and coke firing. There are some technical reasons why gas may not be the first choice fuel for rotary kilns as it does not have the same flame radiance properties as a high carbon fuel (coal). However, gas powered rotary kilns are in use in both the UK and EU lime and in the cement industry so this suggests that the issue can be dealt with at a site engineering level when required. In addition it is anticipated that New Entrants in Phase 2 will be gas fired.
- It is proposed to maintain the choice between calcium limes and dolomitic limes. The two raw materials are converted into different products and this justifies the differentiation as it is needed to limit negative impacts on competitiveness and secure consistency with incumbents, see next section. These two product types have different process emission factors (by approximately 15%).

Competitiveness and impact on investment

- The lime industry competes nationally and internationally. It has significant energy costs and therefore may be exposed to a potentially significant effect of the EU ETS on costs and profit margins. The proposed allocation methodology based on best practice should not prevent the further development of the industry as new capacity can be based on best practice. In particular, typical new kilns are generally expected to be of the ‘PFR’ type due to their lower operating costs through greater energy efficiency.
- Early estimates by DTI suggest that total emissions costs to the cement, lime, and plaster sectors combined could be as high as 8% of the value of these industries’ sales—assuming all CO_2 needed to be paid for and also including effects on electricity prices[14]. Therefore, if there would be a large deviation between site needs and the free allocation it could have significant impacts on a site’s competitiveness. However, variations in benchmarked allocations would be substantially lower than the total impact represented by this analysis. The proposed benchmark is close to site needs if best available modern kilns are used.
- The differentiations and operator choices included in the benchmark equation allow for taking important technical constraints into account. Having both the shaft and the rotary kiln types included take into account that certain types of rock cannot be calcined in shaft kilns. The dolomitic limestone used to produce the product dolomitic lime requires rotary kilns.
- For new gas fired units using the most efficient kiln designs, the benchmark will provide more or less the need. For coke fired units there could be a shortfall of free allowances up to 20% of the total emissions. We are not aware of any proposals for new coke fired kilns and given that there only a limited technical constraint (providing there is availability of gas supply) on using gas this potential shortfall is the incentive for the operator to use gas.

- Only for a site that would want to use a long rotary kiln there could be a shortfall of free allowances of about 30%. Technically there seems to be no argument for using that type compared to the rotary kiln option included in list of technologies.
- If later during the consultations any technical constraints on fuel or kiln type would be identified, these issues should be reconsidered and it will be up to DTI to decide on this matter.
- There is furthermore little difference between the average allocations from the proposed revised benchmark and the Phase I NE benchmark, for sites with modern kilns fuelled by gas.

Consistency with incumbent allocations

- The consideration of what non-BM incumbents would receive if the proposed new benchmark were applied to them is a key test for the Phase 2 NE spreadsheet. The allocations calculated using the proposed values as specified in Table 6.11 are compared to the Phase I allocation received by these sites in Table 6.13 and to the 2000-2003 "relevant emissions" (i.e. excl lowest year) by these sites in Table 6.14 below.

Table 6.13 Comparison of UK NAP Allocation with Proposed Phase 2 NE Spreadsheet Allocation

Site	Phase 2 NE Spreadsheet Input Assumptions	Proposed Phase 2 NE Spreadsheet Allocation / UK Phase 1 NAP Annual Allocation
1	Rotary, dolomite, gas	81%
2	Shaft, high calcium , gas	142%
3	Shaft, high calcium , gas	51%
4	Shaft, high calcium , gas	84%
5	Shaft, high calcium , gas	118%
6	Shaft, high calcium , gas	93%
7	Rotary, high calcium, gas	114%
8	Rotary, dolomite, gas	69%
9	Shaft, high calcium , gas	133%
Weighted average		95%

Table 6.14 Comparison of Annual Average Emissions for 2000 -2003 with lowest dropped with Proposed Phase 2 NE Spreadsheet Allocation

Site	Phase 2 NE Spreadsheet Input Assumptions	Proposed Phase 2 NE Spreadsheet Allocation / Average Emissions 2000-2003 (lowest omitted)
1	Rotary, dolomite, gas	96%
2	Shaft, high calcium , gas	151%
3	Shaft, high calcium , gas	57%
4	Shaft, high calcium , gas	89%
5	Shaft, high calcium , gas	118%
6	Shaft, high calcium , gas	93%
7	Rotary, high calcium, gas	125%
8	Rotary, dolomite, gas	65%
9	Shaft, high calcium , gas	137%
Weighted average		100%

- The comparisons show the same degree of variability in the ratios as was seen with the comparison of the allocation calculated using Phase 1 NE spreadsheet. This is due to the fact that the installed kiln capacity at incumbent sites is not fully utilized at any one time [5]. The difference between installed and on line capacity is dictated by market conditions. The comparison has also been made between the allocation under the Phase 1 NE spreadsheet and the proposed Phase 2 NE spreadsheet.

Table 6.15 Comparison of Phase 1 and Phase 2 NE Allocations

Site	Proposed Phase 2 NE Spreadsheet Allocation / Phase 1 NE Spreadsheet
1	57%
2	90%
3	96%
4	96%
5	96%
6	96%
7	77%
8	57%
9	93%
Weighted average	80%

- The comparison shows that for the sites with modern kilns powered by gas such as Corus and Singleton Birch the proposed changes have only a small effect. The impacts of the proposed changes are greatest at the sites that currently use coke or pet coke for fuel, or use relatively inefficient rotary kilns for reasons of geology and product purity.

6.7 References

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