IMPEL PROJECT: "*ENERGY EFFICIENCY IN PERMITTING AND INSPECTION*", EXCHANGE OF EXPERIENCES ON HOW THE ISSUES OF ENERGY EFFICIENCY AND REDUCTION OF GREENHOUSE GASES ARE DEALT WITH IN PERMIT PROCEDURES AND INSPECTIONS IN THE MEMBER STATES – DEVELOPMENT OF A TEMPLATE FOR DOCUMENTS AND DATA REQUIRED REGARDING ENERGY EFFICIENCY IN THE PERMIT APPLICATION (2011/2012)

CEMENT, LIME AND MAGNESIUM OXIDE

SUMMARY OF ENERGY-RELATED INFORMATION FOR THE CEMENT, LIME AND MAGNESIUM OXIDE INDUSTRY AND PROPOSAL FOR THE SECTOR SPECIFIC ANNEX TO THE DRAFT APPLICATION FORM FOR ENERGY EFFICIENCY

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Beratungsgesellschaft für integrierte Problemlösungen

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1 Summary of energy-related Information – CLM

In the following, energy (efficiency)-related information has been extracted from the **BREF for** Cement, Lime and Magnesium Oxide Industry **[BREF CLM 2012]**, the **BAT Conclusions** as well as from an **expert presentation**. The collected information serves as a basis for the development of a proposal for the sector specific supplements to the Draft Application form for Energy Efficiency in Chapter 2.

1.1 Techniques to consider in the determination of BAT (Energy-related)

1.1.1 Reduction of thermal energy use (cement industry)

In this context, useful information can also be found in the Reference Document on Best Available Techniques for Energy Efficiency (ENE).

Thermal energy use can be reduced by considering and implementing different techniques, such as implementing thermal energy optimisation techniques in the kiln system. Several factors affect the energy consumption of modern cement kilns, such as raw material properties, e.g. moisture content, burnability, the use of fuels with different properties and varying parameters as well as the use of a gas bypass system. The techniques can be applied individually. However, all techniques have to be considered in context with each other. Furthermore, the production capacity of the kiln has an influence on the energy demand.

Kiln systems

Kiln systems with multistage (four to six stages) cyclone preheaters with an integral calciner and tertiary air duct are considered standard technique for new plants and major upgrades. In some cases of raw material with high moisture content, three stage cyclone plants are used. Under optimised circumstances such a configuration will use 2900 – 3300 MJ/tonne clinker.

Thermal energy optimisation techniques can be implemented at the different units of the plant including:

- **cooler:**
  - installation of a modern clinker cooler, e.g. stationary preliminary grate
  - use of cooler grate plates offering a greater flow resistance to provide a more uniform cooling air distribution
  - controlled cooling air supply to the individual grate sections
- **kiln:**
  - high capacity utilisation
  - optimised length: diameter ratio
  - optimised kiln design with regards to the fuel type which is inserted
  - optimised kiln firing systems
  - uniform and stable operating conditions
  - optimisation of process controls
  - tertiary air duct
  - near-stoichiometric, but oxidising kiln conditions
  - use of mineralisers
  - reducing air-in leakage
- **calciner:**
  - low pressure drop

  - uniform distribution of the hot meal in the kiln riser
  - minimal coating formation due to low circulation of alkalis
  - extensive precalcination of the raw meal
- **preheater:**
  - low pressure drop and a high degree of heat recuperation in the cyclones
  - high cyclone collection rate
  - uniform meal distribution over the gas duct cross-sections
  - uniform distribution of solid and gas streams in a two-string preheater
  - cyclone stages (three to six cyclones in total)
- **material handling:**
  - low moisture content of raw materials and fuels
  - easily combustible fuels with a high calorific value
  - homogenising and even feeding (precise metering) of kiln feed material
  - homogenising and even feeding of fuels
- **mills:**
  - compound operation of mills

Further information can be obtained from the **[BREF CLM 2012]**.

Raw material properties

The desired throughput and the moisture content of the raw materials influence the overall energy efficiency. These parameters determine the appropriate number of cyclone stages to be used, as the materials will have to be dried, preferably by the exhaust gas heat. The higher the moisture content, the higher the energy demand will be. It has to be noted that higher numbers of cyclones induces lower thermal losses which leave the preheater with the flue-gases.

For raw material input to the kiln which contains less than 8.5 % moisture, on a modern cement plant the drying can be completed using the exhaust gas from a four, five or six stage preheater. The sixth cyclone stage will save about 60 MJ/tonne clinker compared with a five stage preheater in the case of, where a reduced need for drying energy exists.

Calculated for the kiln preheater system alone, a four stage instead of a five stage cyclone preheater, requires an additional 90 MJ/tonne clinker approximately. With three cyclone stages the difference in energy demand rises further to above 250 MJ/tonne clinker. Three cyclone stages are only used in special cases with very wet material.

However, at raw material moisture content greater than 8.5 % and up to 10 – 11 %, fewer cyclone stages are preferable (e.g. four) so that the heat can be utilised in the drying process (raw mill).

Further information can be obtained from the **[BREF CLM 2012]**.

Fuel properties

Characteristics of the fuels used such as adequate calorific value, low moisture content, adequate content of sulphur, metals, halogen compounds and volatiles as well as air-entraining injection have positive influences on the specific energy consumption of the kiln.

Preparation of fossil fuels like coal or lignite partly or completely dried outside of the kiln system, even outside of the cement plant, lead to improved energy efficiency of the kiln system because it is one of the main impacts on energy consumption. Lignite, for example, can be extracted with a moisture content of above 50 % and needs to be dried before delivery to the cement plant. Furthermore, the use of excess heat for drying fuels leads to thermal energy savings. Replacing fuels containing higher levels of moisture by dried fuels results in a decrease of the energy consumption per tonne of clinker in the kiln system.

The practice to operate the calciner with a wide range of fuel grades, from highly reactive to extremely unreactive influences the energy efficiency. The use of a finely ground, dry and adequate calorific fuel compared to a low reactive or coarse fuel leads to an improved energy efficiency.

A comparison between identical kiln systems fired with hard coal on the one hand and lignite on the other hand, both of which commonly use fossil fuels, shows a difference of nearly 100 MJ/tonne clinker due to diverse fuel qualities.

The use of a finely ground coal compared to the use of a low reactive or coarse fuel can lower the energy demand of, e.g. more than 300 MJ/tonne clinker. Low thermal energy demand can be achieved (also for smaller plants) by using easily combustible fuels with a low moisture content.

In cases when plants are suitable and designed especially for the use of certain types of waste fuels, thermal energy consumption can still be as low as 3120 – 3400 MJ/t clinker. Parameters and properties of the waste fuels used, e.g. adequate calorific value, reactivity, coarseness, influence the energy efficiency. Furthermore, an energy consumption of 3473 kJ/kg has been reported for a five stage precalciner kiln.

Further information can be obtained from the **[BREF CLM 2012]**.

Gas bypass system

Raw material and fuels containing low levels of chlorine, sulphur and alkalis can minimise the enrichment cycle resulting from the internal circulation between the kiln and preheater. Furthermore, the deposit formation in the area of the kiln inlet, the calciner and the two bottom stages can be minimised which can be caused by higher concentrations. As a uniform kiln operation with minimised disturbances is the basis for energy efficient clinker production, shutdowns resulting from coating formation should be avoided. A low circulation of alkalis, chlorine and, to a lesser extent, sulphur can minimise the use of a gas bypass at the kiln inlet. By removing part of the process gas not only are chlorine, sulphur and alkalis discharged, but also other substances.

The removal of hot raw material and hot gas leads to a higher specific energy consumption of about 6 – 12 MJ/tonne clinker per cent of removed kiln inlet gas. Hence, minimising the use of gas bypass has a positive effect on the specific energy consumption.

Further information can be obtained from the **[BREF CLM 2012]**.

Reduction of the clinker content of cement products

A technique to reduce energy use and emissions from the cement industry, expressed per unit mass of cement product, is to reduce the clinker content of cement products. This can be done by adding fillers and additions, for example, sand, slag, limestone, fly ash and pozzolana, in the grinding step.

In Europe, the average clinker content in cement is 80 – 85 %. Many manufacturers of cement are working on techniques to lower the clinker content further. One reported technique claims to exchange 50 % of the clinker with maintained product quality/performance and without increasing production costs. Cement standards define some types of cement with less than 20 % clinker, the balance being made up of blast furnace slag. However, cement types with low clinker content are for special use only.

Further information can be obtained from the **[BREF CLM 2012]**.

1.1.2 Reduction of electrical energy use (cement industry)

Electrical energy use can be minimised through the installation of power management systems and the utilisation of energy efficient equipment such as high pressure grinding rolls for clinker comminution and variable speed drives for fans as well as, in some cases, replacing old raw material mills with new mills. By using improved monitoring systems and reducing air leaks into the system, the use of electricity can also be optimised. Some of the reduction techniques described in the next sections will also have a positive effect on energy use, for example, process control optimisation.

Further information can be obtained from the **[BREF CLM 2012]**.

1.1.3 Process selection (cement industry)

The selected process will affect the emissions of all pollutants, and will also have a significant effect on the energy use, as also shown from a study concerning energy technologies in the cement sector commissioned by the European Commission in 1993. A series of technical improvements or modifications along with corresponding energy saving potentials were identified, e.g. process modifications, improvements for the grinding process and raw meal preparation as well as development of energy management systems.

The thermal energy required for raw material drying and preheating mainly depends on the moisture content of the raw material. The lower the moisture content is, the lower the energy demand will be.

For new plants and major upgrades, a dry process kiln with multistage preheating and precalcination is considered to be state of the art. The wet process kilns operating in Europe are generally expected to convert to the dry process when renewed, and so are semi-dry and semi-wet processes.

On modern cement plants, if the raw material input is less than 8.5 % moisture, the drying can be completed using the exhaust gas from a four or five stage preheater and without supplementary heat. From an example, the strategy for having the most efficient plant required the closure of plants that were located on chalk-based raw materials with high moisture content; chalk contains over 20 % moisture.

Further information can be obtained from the **[BREF CLM 2012]**.

1.1.4 Energy recovery from kilns and coolers/cogeneration (cement industry)

The employment of cogeneration plants for steam and electricity or of combined heat and power plants is, in principle, applied in cement manufacturing. This is due to the simultaneous demand of heat and electric power which has for a long time been pursued. The Organic Rankine Cycle (ORC) process and conventional steam cycle processes are in operation. Furthermore, excess heat is recovered from clinker coolers or kiln off-gases for district heating. The essential feature of the cogeneration plant is the driving engine; however, generating power from low temperature exhaust gas is applied in two cement plants. Most commonly excess heat is recovered from the clinker cooler and, to a lesser extent, from the kiln off-gases.

Further information can be obtained from the **[BREF CLM 2012]**.

1.1.5 Reduction of energy consumption (lime industry)

An energy management system for monitoring the energy use of the kilns is applicable in the lime industry.

If only the energy efficiency and the CO_2 emissions are considered, the vertical kilns in general and the parallel flow regenerative kilns (PFRK) in particular are the most efficient kilns. However, even if energy and CO_2 considerations play a fundamental role, the other specifications have to be considered before making a decision on the choice of kiln or raw material. In some cases, the specifications can create a technical advantage to rotary kilns, especially with upgraded rotary kilns.

In most cases, new kilns replace old kilns, but some existing kilns have been modified to reduce fuel energy use. Such modifications range from minor modifications to major changes in the configuration of the kiln, depending on the technical feasibility, cost and actual need, as for example:

- the installation of heat exchangers for long rotary kilns to recover surplus heat from flue gases or to permit the use of a wider range of fuels
- the use of surplus heat from rotary kilns to dry limestone for other processes such as limestone milling
- in some cases, where shaft kilns have ceased to be economically viable, it has been feasible to convert them to modern designs, for example by converting a simple shaft kiln to the annular shaft design or by linking a pair of shaft kilns to create a parallel flow regenerative kiln. Conversion extends the life of expensive items of equipment, such as the kiln structure, the stone feed system and the lime handling/storage plant
- in exceptional cases, it may be economic to shorten long rotary kilns and to fit a preheater, thus reducing fuel use
- electrical energy use can be minimised through the utilisation of energy efficient equipment.

The energy efficient measure/techniques listed here have a positive effect on energy use:

- process control, e.g. excess of air combustion, fuel flowrate
- maintenance of the equipment, e.g. air tightness, erosion of refractory
- optimised grain size of stone.

Furthermore, the following table lists options for energy efficiency improvement in lime kilns sorted by kiln system components.

Kiln system component	Description	LRK	PRK	PFRK	ASK	MFSK, OK
Combustion system	Highly efficient and flexible burner technique to adapt the temperature profile to the product requirement	X	X	-	-	-
Combustion system	Online combustion monitoring and excess air reduction	X	X	-	-	-
Combustion system	Combustion control through flue-gas analysis	-	-	X	X	X
Combustion system	Highly flexible combustion system including possible fuel blends with waste fuels	X	X	X	X	X
Cooler	Efficient cooler with homogeneous air distribution and product discharge to minimise the quantity of cooling air which is required	X	X	X	X	X
Cooler	Reliable cooler level measurement device	X	X	-	-	-
Flue-gas circuit	Heat recovery system	X	-	-	-	-
Input control	Regular fuel and stone sampling and analysis as well as adaptation of the process accordingly	X	X	X	X	X
Input control	Stone re-screen before kiln feed to control stone gradation	X	X	X	X	X
Input control	Reliable weighing/metering devices to control fuel, stone and air flow rate	X	X	X	X	X
Kiln design (only new kilns)	Optimised length: diameter ratio	X	X	X	X	X
Kiln itself	Refractory internals inside the rotating part to promote heat exchange and minimise product segregation	X	X	-	-	-
Kiln itself	Efficient insulating lining to minimise the shell heat losses	X	X	X	X	X
Kiln itself	Air in-leakage reduction by installing seals at kiln hood and kiln feed	X	X	-	-	-
Kiln itself	Channel cleaning on a regular basis	-	-	X	X	X
Kiln and preheater	Air in-leakage reduction to control excess air	-	-	X	X	X
Kiln operation	Automatic control loops for hood draft, excess air, fuel rate, tonne/kiln revolution, adjustment, etc.	X	X	-	-	-
Kiln operation	PLC and supervision system with key parameter trends	X	X	X	X	X
Kiln operation	Uniform operating conditions	X	X	X	X	X
Kiln operation	Analysis of shutdown causes and repairs	X	X	X	X	X
Preheater	Optimise pressure drop versus heat exchange	-	X	-	-	-
Quality follow Up	Regular lime sampling and analysis as well as kiln adjustment	X	X	X	X	X

Table 1-1: Options for energy efficiency improvement in lime kilns [BREF CLM 2012, Table 2.34]

Further information can be obtained from the **[BREF CLM 2012]**.

1.1.6 Reduction of energy consumption (magnesium oxide industry)

An improved design of kilns, the optimisation of the process and the highest level of recovery and re-use of excess heat from kilns and coolers can reduce the consumption of energy and fuels. In addition, the use of oxygen (oxygen enriched combustion air) for the firing process can increase the efficiency of the firing process thus significantly improving the effectiveness of the kiln. This is coupled with a reduction in the air requirement and thus a reduction of the N_2 ballast in the kiln. The energy requirement can sustainably be reduced by this means.

Heat recovery from exhaust gases by the preliminary heating of the magnesite is used in order to minimise fuel energy use. Heat losses achieved from the kiln can be used for drying fuels, raw materials and some packaging materials.

Electrical energy use is minimised by utilisation of electricity based equipment with high energy efficiency. As an additional effect, CO_2 emissions resulting from fuels are reduced when the process becomes more efficient.

Further information can be obtained from the **[BREF CLM 2012]**.

1.2 BAT Conclusions for CLM (energy-related)

1.2.1 BAT Conclusions for the cement industry

BAT 3

In order to reduce emissions from the kiln and use energy efficiently, BAT is to achieve a smooth and stabile kiln process, operating close to the process parameter set points by using the following techniques:

a) Process control optimisation, including computer-based automatic control

b) Using modern, gravimetric solid fuel feed systems

BAT 6

In order to reduce energy consumption, BAT is to use a dry process kiln with multistage preheating and precalcination.

Description

In this type of kiln system, exhaust gases and recovered waste heat from the cooler can be used to preheat and pre-calcine the raw material feed before entering the kiln providing significant savings in energy consumption.

Applicability

Applicable to new plants and major upgrades, subject to raw materials moisture content.

BAT-associated energy consumption levels

Process	Unit	BAT-associated energy consumption levels (1)
Dry process with multistage preheating and precalcination	MJ/tonne clinker	2900 – 3300 (2)(3)
(1) Levels do not apply to plants producing special cement or white cement clinker that require significantly higher process temperatures due to product specifications. (2) Under normal (excluding, e.g. start-ups and shutdowns) and optimised operational conditions. (3) The production capacity has an influence on the energy demand, with higher capacities providing energy savings and smaller capacities requiring more energy. Energy consumption also depends on the number of cyclone preheater stages, with more cyclone preheater stages leading to lower energy consumption of the kiln process. The appropriate number of cyclone preheater stages is mainly determined by the moisture content of raw materials.		

Table 1-2: BAT associated energy consumption levels for new plants and major upgrades using dry process kiln with multistage preheating and precalcination [FD CLM 2012, Table 4.1]

BAT 7

In order to reduce/minimise thermal energy consumption, BAT is to use a combination of the following techniques

	Technique	Applicability
a	Applying improved and optimised kiln systems and a smooth and stable kiln process, operating close to the process parameter set points by applying: I. process control optimisation, including computer based automatic control systems II. modern, gravimetric solid fuel feed systems III. preheating and precalcination to the extent possible, considering the existing kiln system configuration	Generally applicable. For existing kilns, the applicability of preheating and precalcination is subject to the kiln system configuration
b	Recovering excess heat from kilns, especially from their cooling zone. In particular, the kiln excess heat from the cooling zone (hot air) or from the preheater can be used for drying raw materials	Generally applicable in the cement industry. Recovery of excess heat from the cooling zone is applicable when grate coolers are used. Limited recovery efficiency can be achieved on rotary coolers
c	Applying the appropriate number of cyclone stages related to the characteristics and properties of raw material and fuels used	Cyclone preheater stages are applicable to new plants and major upgrades.
d	Using fuels with characteristics which have a positive influence on the thermal energy consumption	The technique is generally applicable to the cement kilns subject to fuel availability and for existing kilns subject to the technical possibilities of injecting the fuel into the kiln
e	When replacing conventional fuels by waste fuels, using optimised and suitable cement kiln systems for burning wastes	Generally applicable to all cement kiln types
f	Minimising bypass flows	Generally applicable to the cement Industry

Description

Several factors affect the energy consumption of modern kiln systems such as raw materials properties (e.g. moisture content, burnability), the use of fuels with different properties as well as the use of a gas bypass system. Furthermore, the production capacity of the kiln has an influence on the energy demand.

Technique 7c: the appropriate number of cyclone stages for preheating is determined by the throughput and the moisture content of raw materials and fuels which have to be dried by the remaining flue-gas heat because local raw materials vary widely regarding moisture content or burnability

Technique 7d: conventional and waste fuels can be used in the cement industry. The characteristics of the fuels used such as adequate calorific value and low moisture content have a positive influence on the specific energy consumption of the kiln.

Technique 7f: the removal of hot raw material and hot gas leads to a higher specific energy consumption of about 6 – 12 MJ/tonne clinker per percentage point of removed kiln inlet gas. Hence, minimising the use of gas bypass has a positive effect on energy consumption.

BAT 8

In order to reduce primary energy consumption, BAT is to consider the reduction of the clinker content and cement of cement and cement products.

Description

The reduction of the clinker content of cement and cement products can be achieved by adding fillers and/or additions, such as blast furnace slag, limestone, fly ash and pozzolana in the grinding step in accordance with the relevant cement standards.

Applicability

Generally applicable to the cement industry, subject to (local) availability of fillers and/or additions and local market specificities.

BAT 9

In order to reduce primary energy consumption, BAT is to consider cogeneration/combined heat and power plants.

Description

The employment of cogeneration plants for the production of steam and electricity or of combined heat and power plants can be applied in the cement industry by recovering waste heat from the clinker cooler or kiln flue-gases using the conventional steam cycle processes or other techniques. Furthermore, excess heat can be recovered from the clinker cooler or kiln flue-gases for district heating or industrial applications.

Applicability

The technique is applicable in all cement kilns if sufficient excess heat is available, if appropriate process parameters can be met, and if economic viability is ensured.

BAT 10

In order to reduce/minimise electrical energy consumption, BAT is to use one or a combination of the following techniques:

	Technique
a	Using power management systems
b	Using grinding equipment and other electricity based equipment with high energy efficiency
c	Using improved monitoring systems
d	Reducing air leaks into the system
e	Process control optimisation

Further information can be obtained from the **[BREF CLM 2012]**.

1.2.2 BAT Conclusions for the lime industry

BAT 30

In order to reduce all kiln emissions and use energy efficiently, BAT is to achieve a smooth and stabile kiln process, operating close to the process parameter set points by using the following techniques:

a) Process control optimisation, including computer-based automatic control

b) Using modern, gravimetric solid fuel feed systems and/or gas flow meters

Applicability

Process control optimisation is applicable to all lime plants to varying degrees. Complete process automation is generally not achieved due to the uncontrollable variables, i.e. quality of the limestone.

BAT 33

In order to reduce/minimise thermal energy consumption, BAT is to use a combination of the following techniques:

	Technique	Description	Applicability
a	Applying improved and optimised kiln systems and a smooth and stable kiln process, operating close to the process parameter set points, through: I. process control optimisation II. heat recovery from flue-gases (e.g. use of surplus heat from rotary kilns to dry limestone for other processes such as limestone milling) III. modern, gravimetric solid fuel feed systems IV. maintenance of the equipment (e.g. air tightness, erosion of refractory) V. the use of optimised grain size of stone	Maintaining kiln control parameters close to their optimum values has the effect of reducing all consumption parameters due to, among other things, reduced numbers of shutdowns and upset conditions. The use of optimised grain size of stone is subject to raw material availability	Technique (a) II is only applicable to long rotary kilns (LRT)
b	Using fuels with characteristics which have a positive influence on thermal energy consumption	The characteristics of fuels, e.g. high calorific value and low moisture content can have a	The applicability depends on the technical possibility to feed the selected fuel into

		positive effect on the thermal energy consumption	the kiln and on the availability of suitable fuels (e.g. high calorific value and low humidity) which may be impacted by the energy policy of the Member State
c	Limiting excess air	A decrease of excess air used for combustion has a direct effect on fuel consumption since high percentages of air require more thermal energy to heat up the excess volume. Only in LRK and PRK the limitation of excess air has an impact on thermal energy consumption. The technique has a potential of increasing TOC and CO emission	Applicable to LRK and PRK within the limits of a potential overheating of some areas in the kiln with consequent deterioration of the refractory lifetime

BAT-associated consumption levels

Kiln type	Thermal energy consumption ([1]) GJ/tonne of product
Long rotary kilns (LRT)	6.0 – 9.2
Rotary kilns with preheater (PRK)	5.1 – 7.8
Parallel flow regenerative kilns (PFRK)	3.2 – 4.2
Annular shaft kilns (ASK)	3.3 – 4.9
Mixed feed shaft kilns (MFSK)	3.4 – 4.7
Other kilns (OK)	3.5 – 7.0
([1]) Energy consumption depends on the type of product, the product quality, the process conditions and the raw material	

BAT 34

In order to minimise electric energy consumption, BAT is to use one or a combination of the following techniques:

	Technique
a	Using power management systems
b	Using optimised grain size of limestone
c	Using grinding equipment and other electricity based equipment with high energy efficiency

Description – Technique (b)

Vertical kilns can usually burn only coarse limestone pebbles. However, rotary kilns with higher energy consumption can also valorise small fractions and new vertical kilns can burn small granules from 10 mm. The larger granules of kiln feed stone are used more in vertical kilns than in rotary kilns.

Further information can be obtained from the **[BREF CLM 2012]**.

1.2.3 BAT Conclusions for the magnesium oxide industry

BAT 56

In order to reduce thermal energy consumption, BAT is to use a combination of the following techniques:

	Technique	**Description**	**Applicability**
a	Applying improved and optimised kiln systems and a smooth and stable kiln process by applying: I. process control optimisation II. heat recovery from flue-gases from kiln and coolers	Heat recovery from flue-gases by the preliminary heating of the magnesite can be used in order to reduce fuel energy use. Heat recovered from the kiln can be used for drying fuels, raw materials and some packaging materials	Process control optimisation is applicable to all kiln types used in the magnesia industry.
b	Using fuels with characteristics which have a positive influence on thermal energy consumption	The characteristics of fuels, e.g. high calorific value and low moisture content have a positive effect on the thermal energy consumption	Generally applicable subject to availability of the fuels, the type of kilns used, the desired product qualities and the technical possibilities of injecting the fuels into the kiln.
c	Limiting excess air	The excess oxygen level to obtain the required quality of the products and for optimal combustion is usually in practice about 1 – 3 %	Generally applicable

BAT-associated consumption levels

The BAT-associated thermal energy consumption is 6 – 12 GJ/t, depending on the process and the products ([1]).

([1]) This range only reflects information provided for the magnesium oxide chapter of the BREF. More specific information about best performing techniques along with the products produced was not provided.

BAT 57

In order to minimise electrical energy consumption, BAT is to use one or a combination of the following techniques:

a) Using power management systems

b) Using grinding equipment and other electricity based equipment with high energy efficiency

Further information can be obtained from the **[BREF CLM 2012]**.

1.3 Expert contribution (cement industry)

During the **2nd Expert Group Meeting**, Mr. Hoenig from the Research Institute of the Cement Industry (Germany) introduced the cement manufacturing sector in general and presented energy-related information which can be utilised for the purpose of this document.

After a brief introduction of the cement industry and the presentation of key figures the main production processes were described in more detail.

The cement production process consists of 2 major process steps, the clinker burning process (incl. quarrying preparation) and the cement grinding process. The following specific consumption levels and shares of fuels and power consumption for the two main process steps were presented (see Figure 1-1).

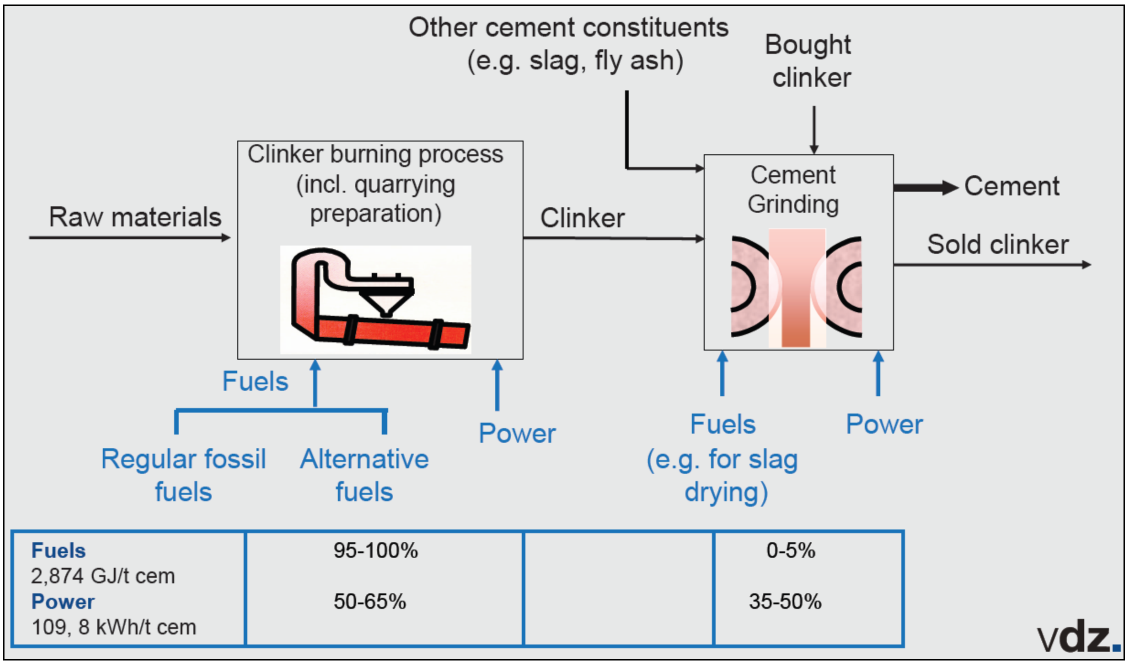

Figure 1-1: Consumption of fuels and power in the main cement production steps (Germany 2010), [VDZ 2012]

With regard to the energy saving agreements and management systems it was stated that the cement industry belongs to the energy intensive sectors and that energy costs (power and fuels) are the most significant cost factors (besides investment in assets). Therefore all cement companies have energy management systems for decades, but no certification is needed until now. It was further stated that in Germany energy management systems are currently being implemented in all cement companies to ensure tax refunds within renewable energies legislation.

From the expert's personal view the implementation of energy management systems cannot contribute to find additional 'big potentials', but it can contribute to improve the awareness and creativity of the personal staff with respect to energy issues and this may help to find additional 'small potentials'.

In connection to the definition of system boundaries it was stipulated that the definition of system boundaries is crucial, but it will be difficult to find simple assessment methodologies for all types of cement plants.

The main energy inputs and outputs (used energy) were summarised as follows:

Energy input	Used energy output
Fuels ▪ kiln fuels ▪ non-kiln fuels e.g. for slag or coal drying (depending on system boundaries)	▪ Reaction enthalpy of clinker ▪ Waste heat used for - Drying of raw materials - Drying of fuels - externally - process integrated - Drying of cement constituents (e.g. slay, limestone…) - Heat delivered externally - Power generation

Figure 1-2: Energy input/output for an integrated cement plant [VDZ 2012]

In relation to the electric energy demand it was concluded that it cannot be used for the efficiency assessment due to:

- the increasing requirements to performance of cement and concrete (e.g. higher strength by finer grinding)
- the increasing use of slag with a lower grindability and
- the increasing power demand for emission abatement (filters, DENOX) due to increased environmental requirements.

Finally, Mr. Hoenig concluded that the energy management system documentation will cover all required information (i.e. information requested in the application form for energy efficiency).

2 Proposal for the Sector Specific Supplement – CLM

2.1 Supplement to the Application Form for EE (cement industry)

Process selection *(Process selection is subject to raw material moisture content and only applicable to new plants and major upgrades)*

Is a dry process kiln with multistage preheating and precalcination used to reduce energy consumption (use of exhaust gases and recovered waste heat from the cooler to preheat and pre-calcine the raw material feed before entering the kiln)? Please provide further explanations/justifications.

Reduction of thermal energy consumption

Is a combination of the following techniques applied in order to reduce thermal energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
Use of **improved and optimised kiln systems** and a smooth and stable kiln process, operating close to the process parameter set points by applying: I. **process control optimisation**, including computer based automatic control systems II. **modern, gravimetric solid fuel feed systems** III. **preheating and precalcination** to the extent possible (considering the existing kiln system configuration)		
Recovering excess heat from kilns. In particular, the kiln excess heat from the cooling zone (hot air) or from the preheater can be used for drying raw materials (applicable when grate coolers are used).		
Applying the a**ppropriate number of cyclone stages** related to the characteristics and properties of raw material and fuels used (applicable to new plants and major upgrades)		
Using fuels with characteristics which have a **positive influence on the thermal energy consumption** (subject to fuel availability and for existing kilns to the technical possibilities of injection the fuel into the kiln)		
When replacing conventional fuels by waste fuels, **using optimised and suitable cement kiln systems for burning wastes**		
Minimising bypass flows		

Reduction of primary energy consumption

Have you considered reducing the clinker content of cement and cement products (e.g. by adding fillers and/or additions, such as blast furnace slag, limestone, fly ash etc. in the grinding step in accordance with the relevant cement standards)? Please provide further explanations/ justifications.

Have you considered employing of cogeneration plants for the production of steam and electricity or of combined heat and power plants in order to reduce primary energy consumption? Please provide further explanations/ justifications.

Reduction of electrical energy consumption

Is one or a combination of the following techniques applied in order to reduce electrical energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Using **power management systems**		
Using **grinding equipment and other electricity based equipment with high energy efficiency**		
Using **improved monitoring systems**		
Reducing air leaks into the system		
Process control optimisation		

2.2 Supplement to the Application Form for EE (lime industry)

Reduction of thermal energy consumption

Is a combination of the following techniques applied in order to reduce thermal energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Applying **improved and optimised kiln systems** and a smooth and stable kiln process, operating close to the process parameter set points, through: I. **process control optimisation** II. **heat recovery** from flue-gases (e.g. use of surplus heat from rotary kilns to dry limestone		

Is a combination of the following techniques applied in order to reduce thermal energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
for other processes such as limestone milling) III. **modern, gravimetric solid fuel feed systems** IV. **maintenance of the equipment** (e.g. air tightness, erosion of refractory) V. the **use of optimised grain size of stone** (subject to raw material availability)		
Using **fuels** with characteristics which have a **positive influence on thermal energy consumption** (subject to fuel availability and technical possibilities to feed the selected fuel into the kiln)		
Limiting excess air (only relevant for LRK an PRK within the limits of a potential overheating of some areas in the kiln)		

Reduction of electrical energy consumption

Is one or a combination of the following techniques applied in order to reduce electrical energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Using **power management systems**		
Using **optimised grain size of limestone**		
Using **grading equipment and other electricity based equipment with high energy efficiency**		

2.3 Supplement to the Application Form for EE (magnesium oxide industry)

Reduction of thermal energy consumption

Is a combination of the following techniques applied in order to reduce thermal energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** (*provide brief justification):*
Applying improved and **optimised kiln systems** and a smooth and stable kiln process by applying: **III. process control optimisation** IV. **heat recovery** from flue-gases from kiln and coolers		
Using **fuels with characteristics which have a positive influence on thermal energy** consumption (subject to availability of the fuels, the type of kilns used, the desired product quantities and the technical possibilities of injecting the fuel into the kiln)		
Limiting excess air (usually about 1-3 %)		

Reduction of electrical energy consumption

Is one or a combination of the following techniques applied in order to reduce electrical energy consumption? Please provide further explanations/justifications.		
Technique	**Yes** (*provide brief explanation*):	**No** *(provide brief justification):*
Using power management systems		
Using grinding equipment and other electricity based equipment with high energy efficiency		

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