Category		Title
NFR:	**2 A 1**	**cement production**
SNAP:	**040612**	**Processes with Contact, Cement, Cement (decarbonizing)**
NOSE:	**104.11.02** **105.11.21**	**<<to be completed>>**
ISIC:	**2394**	**<<to be completed>>**
Version	**3 (draft 2)**	**Guidebook Revision, 2007/2008**
Major change since earlier versions		○ This chapter implements the decisions of the Thessaloniki TFEIP meeting on the "Tiers" ○ This chapter now clearly separates process emissions for combustion emissions. The latter are treated in chapter 1.A.2.f ○ All emission factors have been revised to reflect this split.

Comment:
I propose ti nclude the category name for all code lists here

Comment:
The version number is one of the document properties. To be set in "File | properties | Custom". Select the property "version" and set its value

To refer to the version number use the field DocProperty
I propose to use for all new chapters the version number **3** and as long as we are drafting the addition (draft #)

This draft chapter is to be a trial version of a chapter of the Revised EMEP Corinair Guidebook.

Contents

1 Overview

Cement production is a process in which the hot flue gases from a combustion process are directly injected into the reactor where the chemistry and physics take place converting the raw materials into the so-called clinker (a combustion "process with contact"). The split of combustion emissions from process emissions in this case is not always easy for several reasons:

- Emissions might be due to both the occurrence of specific chemicals or elements in both the fuel and the raw materials feed into the process
- The reactor might act as a filter, absorbing some pollutants emitted from the combustion of fuels

This chapter covers process emissions from

- the materials handling caused by feedstocks (raw meal)
- chemical and physical processes in the reactor (both the kiln and the mill) used to produce cement.
- materials handling of finished products (cement)

IPPC BREF document (EUROPEAN COMMISSION, 2001) reports a specific heat demand for clinker production of approximately 3500 to 5000 MJ/tonne clinker, depending on fuel type and kiln operation (wet or dry). The emissions due to the combustion of these fuels are covered in Chapter 1.A.2.f.

The most important pollutant emitted from the processes in the cement production is dust (particulate matter). The emitted dust may contain heavy metals, particularly so when wastes are burnt as fuel, see Baart et al. (1995).

2 Description of sources

2.1 Process description

Cement production consists of four fundamental stages (Figure 2-1):

- Quarrying:

  The raw materials are first brought to site; some will normally be conveyed from nearby quarries or open pits. The materials are then mixed, crushed and ground to produce a raw mix (raw meal) of the correct particle size and chemical properties.

  Emissions due to the operation of limestone quarrying are treated in chapter 1.B.#

- Preparation of the raw mixture ("Raw Meal")

  The raw materials for cement production are a mixture of minerals containing calcium oxide, silicon oxide, aluminium oxide, ferric oxide, and magnesium oxide. The raw materials are usually quarried from local rock, which in some places is already practically the desired composition and in other places requires the addition of clay and limestone, as well as iron ore, bauxite or recycled materials. The raw mix is formulated to a very tight chemical specification. Typically, the content of individual components in the raw mix must be controlled within 0.1% or better. Calcium and silicon are present in order to form the strength-producing calcium silicates. Aluminium and iron are used in order to produce liquid ("flux")

Comment: We need to set the scene very clearly at the start of each chapter!

This section should answer the question: "**Is this source category important for my inventory?**"
The section should be brief and explanatory, not an ecyclopedia.

Comment: Asfar as we can see this term is only used in the Guidebook. It should be explained in the glossary

Comment: This statement should refer to a "crosses" table of source categories" versus pollutants to be available in the cross curtting issues.
Such a table could be developed from the NFR reporting table, where in principle crosses could occur wherever not a N.A. is prefilled. We could also use a bold type to indicsate major pollutants.
The table could be derived from the most detailed dataset on WEBDAB

Comment: This section should provide enough detail to understand the emission estimation methods described below. Again it should be brief and concise.

Comment: We propose to include graphical process schemes in all chapters where relevant

Comment: The text below is adapted from Wikipedia (http://en.wikipedia.org/wiki/Portland_cement) on February 10th, 2007. More detail is available on this location

Comment: Terminology to be checked with the industry.
The slide included as an alternative is from a presentation by Ole Restad. Copyrights must be checked!

in the kiln burning zone. The liquid acts as a solvent for the silicate-forming reactions, and allows these to occur at an economically low temperature.

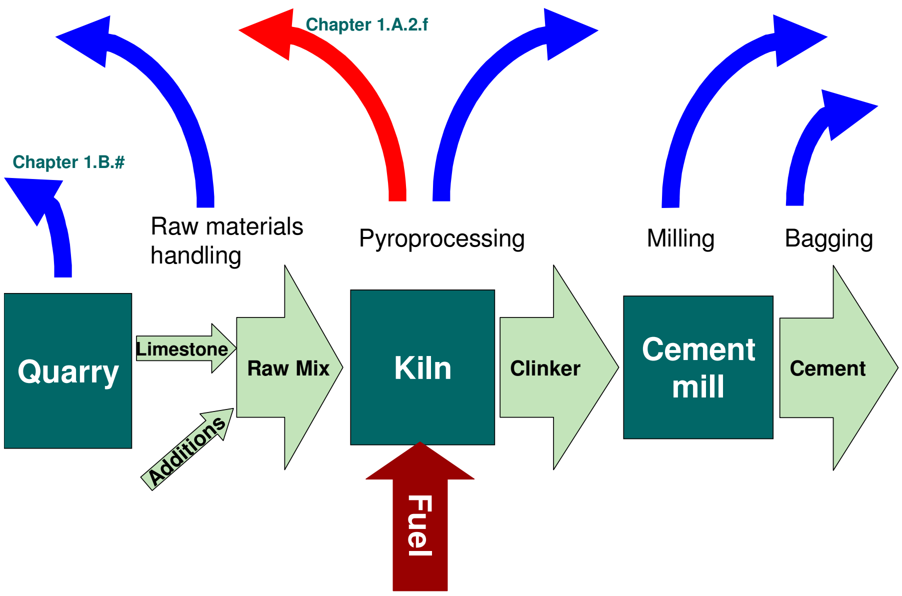

Figure 2-1 Production of cement; combustion emissions are indicated in red, process emissions are indicated in blue; emissions from quarrying are treated in chapter 1.B.# and those of combustion in chapter 1.A.2.f

Comment: Quarrying now is in source category 1.B, which is "energy". Is this what we want?

Comment: Each chapter should contain a graphical presentation of the source category, specifying the emissions. We propose to adopt a convention to mark combustion emissions in red and process emissions ion blue.

- Production of the clinker: pyroprocessing

The raw mixture is heated in a cement kiln, a gigantic slowly rotating and sloped cylinder, with temperatures increasing over the length of the cylinder up to ~1480 °C. The temperature is regulated so that the product contains sintered but not fused lumps. Too low a temperature causes insufficient sintering, but too high a temperature results in a molten mass or glass. In the lower-temperature part of the kiln, calcium carbonate (limestone) turns into calcium oxide (lime) and carbon dioxide. In the high-temperature part, calcium oxides and silicates react to form dicalcium and tricalcium silicates (C_2S C_3S). The resulting material is clinker, and can be stored for a number of years before use.

The energy required to produce clinker is ~1.7 MJ/kg. However, because of heat loss during production, actual values can be a factor of two to three higher. IPPC BREF document (EUROPEAN COMMISSION, 2001) reports a specific heat demand for clinker production of approximately 3500 to 5000 MJ/tonne clinker, depending on fuel type and kiln operation (wet or dry).

Comment: Check this value. This might be the thermodynamic value. IPPC BREF indicated about twice to three times this value.
In this text I assume that both values indeed are correct.

Types of fuels used vary across the industry. Cement kilns are highly energy-intensive and fuel costs have a critical effect on profitability. Historically, some combination of coal, oil, and natural gas was used, but over the last 15 years, most plants have switched to coal. However, in recent years a number of plants have switched to systems that burn a combination of coal and waste fuel.

The choice of fuel is influenced by the fact that part of the combustion products is incorporated into the clinker and hence influences product quality. Ashes (from coal and solid wastes) become a part of the clinker and determine the quality of the product. A change in fuel mix therefore generally will also influence the input of additional chemicals to obtain the same product quality.

- Preparation of the cement: milling

  In order to achieve the desired setting qualities in the finished product, a quantity (2-8%, but typically 5%) of calcium sulphate (usually gypsum or anhydrite) is added to the clinker and the mixture is finely pulverized. The powder is now ready for use, and will react with the addition of water.

- Product handling: storage, handling, bagging

  The end of the production process is handling, packaging and storage of the cement products.

2.2 Techniques

Comment: This section should briefly identify different techniques as far as these are relevant to understand the emissions.

Cement can be produced either by dry or wet milling. In the case of wet milling the raw cement clinker is first mixed with water; this mixture is fired into a rotary kiln and finally milled. In the dry process the mixing with water is omitted. The dry process requires less energy than the wet process. Most cement kilns now use the dry process, in which raw material is fed into the rotary kiln dry.

Before passing into the kiln the material may be preheated in a vertically arrayed multi-cyclonic preheater, in which the rising hot gases exiting the kiln contact the downward flowing raw materials. Some dry processes also employ a precalciner stage beneath the preheater, just before the raw material enters the kiln. Preheaters and precalciners often have an alkali bypass between the feed end of the rotary kiln and the preheater to remove undesirable volatile components.

The use of the wet process, where the ground meal is mixed with water and fed into the kiln as a slurry, is now less common. The wet process uses about 40% more energy than the dry process.

The last stage involves cooling the clinker. As the hot clinker comes off the lower end of the kiln it is rapidly cooled by ambient air in a clinker cooler. There are many different designs of cooler, the most common of which is a travelling grate with under-grate fans that blow cool air through the clinker. Some of this air can be used for combustion, but some is vented to atmosphere or used for drying solid fuels and raw materials.

Finally, the cooled clinker is then mixed with gypsum and, for composite cements, other materials such as blast furnace slag, and ground to a fine homogeneous powder to produce the final product, which is then stored in silos prior to bulk transportation or bagging.

2.3 Emissions

Comment: This section should describe the main pollutants and the sub-processes where they occur.

The largest emission sources are the three units of kiln operation: the feed system, the fuel firing system, and the clinker cooling and handling system. Nitrogen oxides (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO) emissions are primarily due to the combustion of fuels, providing the heat needed for the pyroprocessing. Because some facilities burn waste fuels, particularly spent solvents, in the kiln, these systems also may emit small quantities of additional hazardous organic pollutants (IPCC, 1995). Methods to estimate the emissions from the combustion of the fuels, including waste fuels, are provided in source category 1.A.2.f.

As in most combustion processes with contact the split between combustion and process emissions from the cement kiln is relatively arbitrary and artificial:

- In the Tier 1 and Tier 2 approaches, described below, all emissions from the fuel firing system are estimated using the methods as described in the specific combustion chapter 1.A.2.f. All other emissions are estimated using the methods described in this chapter.
- In a Tier 3 approach, it might occur that some emission measurements are available that do not allow to separate combustion emissions from process emissions. In these cases it is good practice to report the emissions in the source category where the majority of the pollutant would occur and report an "included elsewhere" in the other source category.

Comment: My feeling is that this could be a general pragmatic approach to be used wherever there is confusion or unclarities in the combustion/non-combustion splits

This chapter treats methods to estimate the process emissions from cement manufacturing:

- Dust emissions result from activities such as handling raw materials, on site transportation, milling and shipment.
- Carbon dioxide (CO_2) emissions also occur as a result of the chemical reactions in the kiln. Methods to estimate these CO_2 emissions are provided in the IPCC 2006 Guidelines
- Sulphur dioxide may be generated both from the sulphur compounds in the raw materials and from sulphur in the fuel. The latter should be reported in 1.A.2.f. The sulphur content of raw materials varies from plant to plant and with geographic location. Sulphur is normally present in the form of metal sulphide and sulphates. The amount of sulphur present will vary widely according to the nature of the deposits used. During the calcining operation, sulphur dioxide is released.

  In cases where the SO_2 emissions are determined by (continuous) measurement and hence the split between combustion and process emissions is not easily obtained emissions can be reported in either source category 1.A.2.f or in 2.A.1 and reporting IE (included elsewhere) in the other. The preferred option could be chosen on the basis of an assessment of the sulphur contents in both the fuels and the raw materials. It is good practice to report in the source category where expectedly the major part of the emissions would occur if the split was made.

  Comment: This is an example of the pragmatic approach on splitting combustion and process emissions.
  This text might serve as a model for all other cases.

  For practical purposes sulphur in the kiln exhaust may be assumed to be emitted as sulphur dioxide, although there is usually some sulphur trioxide formed. Where this sulphur dioxide is formed at temperatures lower than the calcium carbonate calcination, it will be emitted from the kiln and preheater system to a significant extent. Some absorption may take place in the precipitator or raw mill. In most circumstances, only a small fraction of the sulphur dioxide generated within the kiln from the fuel is released to atmosphere, since it is mainly incorporated into the cement clinker by chemical combination. (IPCC, 1995; EPA, 1995). The kiln in this way acts as a SO_2 abatement technology to the combustion emissions.
- Emissions may also include residual materials from the fuel and raw materials or products of incomplete combustion that are considered to be hazardous. A similar approach as for SO_2 should be used here.

2.4 Controls

Emission reduction is usually obtained by reducing the dust emissions. Electrostatic precipitators (ESPs) and fabric filters (FFs) are most widely used on both kilns and clinker coolers. For electrostatic precipitation dust concentrations of 30 - 40 mg/m^3 can be achieved. For fabric filters a value of 20 to 50 mg/m^3 is common. A few gravel bed filters have also been used to control clinker cooler emissions. Fugitive emission sources are normally captured by a ventilation system and fabric filters used to collect the dust. The most desirable method of disposing of the collected dust is injection into the kiln burning zone and production of clinker from the dust. If the alkali content of raw materials is too high, however, some of the dust is discarded and leached before returning to the kiln. In many instances, the maximum allowable cement alkali content of 0.6 % (calculated as sodium oxide) restricts the amount of dust that can be recycled.

A portion of heavy metals in the flue gas will also be removed with particles. However, the most volatile heavy metals are present on very fine particles, often penetrating both ESPs and FFs. It is proposed that further reduction of dust concentrations in the flue gas to 10 mg/m^3 should be achieved in order to obtain reasonable reduction of heavy metals.

Emissions of sulphur dioxide are best reduced by use of low sulphur raw materials. Removal of sulphur dioxide from the exhaust gases is possible using injection of calcium hydroxide into the air stream - after the preheater for minor reductions, or by a separate fluid bed absorber for significant reductions. However, the alkaline nature of the cement provides for direct absorption of SO_2 into the product, thereby mitigating the quantity of SO_2 emissions in the exhaust stream. Depending on the process and the source of the sulphur, SO_2 absorption ranges from about 70 percent to more than 95 percent. However, in systems that have sulphide sulphur (pyrites) in the kiln feed, the sulphur absorption rate may be as low as 70 percent without unique design considerations or changes in raw materials. Fabric filters on cement kilns are also reported to absorb SO_2 (IPCC, 1995; EPA, 1995).

Flue gas desulphurisation equipment also reduces the concentration of gaseous mercury present in the flue gas. This reduction can be as high as 50 %. Further reduction of up to 85 % can be achieved through the application of very expensive measures such as injection of activated carbon or application of activated carbon beds.

3 Methods

Comment:
This section is the core of each chapter.
Its structure is:
1.Decision tree
2. Tier 1 default approach
3. Tier 2 technology specific approach
4. Tier 3: anything beyond the above

Emission factors and activity data guidance is provided withine these sub-sections of this methods section

3.1 Choice of method

Figure 3-1 presents the procedure to select the methods for estimating process emissions from the Cement Industry. The basic idea is:

- If detailed information is available: use it
- If the source category is a key source, a Tier 2 or better method must be applied and detailed input data must be collected. The Decision Tree directs the user in such cases to the Tier 2 method, since it is expected that it is more easy to obtain the necessary input data for this approach than to collect facility level data needed for a Tier 3 estimate
- The alternative of applying a Tier 3 method, using detailed process modelling is not explicitly included in this decision tree. However, detailed modelling will always be done at facility level and results of such modelling could be seen as “Facility data” in the decision tree.

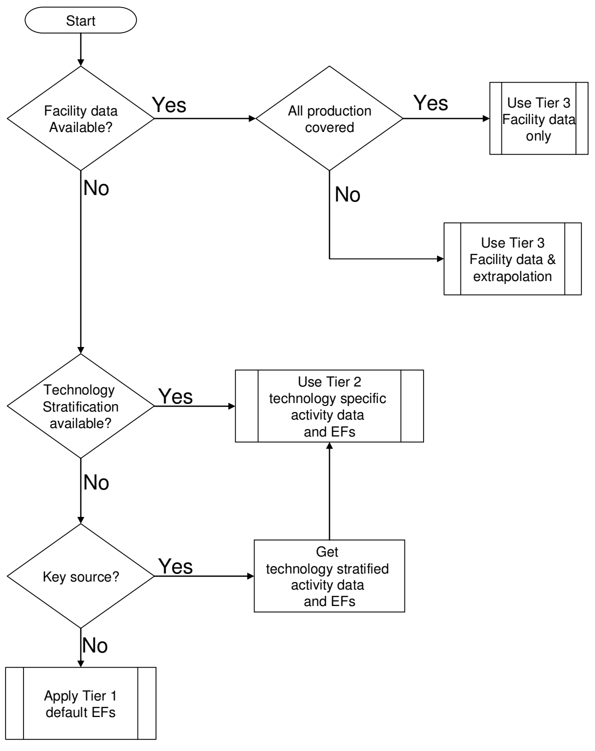

Figure 3-1 Decision tree for source category 2.A.1 Cement Production

3.2 Tier 1 Default Approach

3.2.1 Algorithm

The Tier 1 approach for process emissions from cement uses the general equation;

$$E_{pollutant} = AR_{production} \times EF_{pollutant} \quad (1)$$

This equation is applied at the national level, using annual national total cement production. Information on the production of cement, suitable for estimating emissions using of the simpler estimation methodology (Tier 1 and 2), is widely available from UN statistical yearbooks or national statistics.

The Tier 1 emission factors assume an averaged or typical technology and abatement implementation in the country and integrate all different sub-processes in the cement production between feeding the raw material into the process and the final shipment off the facilities.

In cases where specific abatement options are to be taken into account a Tier 1 method is not applicable and a Tier 2 ort Tier 3 approach must be used.

3.2.2 Default Emission Factors

The Tier 1 approach needs emission factors for all relevant pollutants, that integrate all sub-processes within the industry from the feed of raw material to the final shipment of the products off site. The default emission factors as given in Table 3-1 have been derived from all available

Comment:
We propose the simplest method here as Tier 1: use cement production and apply an integrated and averaged or typical default emission factor.
We propose to not talk about clinker and cement based estimation methods in Tier 1.

Comment:
We need to add parameter and variable definitions

Comment:
This sentence indeed means that specific technologies and techniques must be treated in a Tier 2 or higher approach. Abatement is by definition a technology specific approach!
This sentence here is needed to avoid any confusion.

data and information, taking into account the results of an assessment of emissions factors included in the earlier version of the guidebook.

Comment: (Jeroen) Since we don't have many emission factors available for processes in cement industry, it might be better to take the simpler methodology factors from the 2006 Guidebook as Tier 1 default emission factors here (as described in comment below).
For Tier 1, not a single lower/upper confidence interval is from the Guidebook. All ranges are a first guess by us!

Table 3-1 Tier 1 emission factors for source category 2.A.1 Cement production

Tier 1 default emission factors				
	Code	Name		
NFR Source Category	2.A.1	Cement production		
Fuel	NA	not applicable		
			95% confidence interval	
Pollutant	**Value**	**Unit**	Lower	Upper
Particulates				
TSP	600	kg/tonne cement	300	1200
PM10	510	kg/tonne cement	250	1000
PM2.5	180	kg/tonne cement	90	360
Heavy Metals				
Arsenic	IE			
Cadmium	IE			
Chromium	IE			
Copper	IE			
Mercury	IE			
Nickel	[illegible]			
Lead	IE			
Selenium	IE			
Zinc	IE			
POPs				
Dioxins and furans	IE			
Hexachlorobenzene	IE			
Poly-aromatic hydrocarbons	IE			
Polychlorinated biphenyls	IE			

Comment:
These are basically the default emission factors from the tables 8.1a and 8.1b of the 2006 Guidebook, including only those that are provided on a production basis.

Where no information on ranges of emission factors is available, we used an more or less arbitrary value of plus or minus a factor of two or three to calculate the upper and lower boundaries of the 95% confidence interval!

All these numbers need consideration! They might be underestimated in these tables.

NOx, SOx emissions are assumed to originate from combustion and are treated in chapter 1.A.2.f

Emission factors in Table 3-1 are provided for particulate fractions only. The emissions of heavy metals and POPs are assumed to be mainly due to the combustion of the solid and waste fuels. In the Tier 1 approach they will, as far as they originate from the chemical composition of the raw meal, be reported as "Included Elsewhere" (IE) here.

3.2.3 Activity Data

Information on the production of cement, suitable for estimating emissions using of the simpler estimation methodology (Tier 1 and 2), is widely available from UN statistical yearbooks or national statistics.

Further guidance is provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 3 on Industrial Processes and Product Use (IPPU), chapter 2.2.1.3 " Choice of activity statistics".

3.3 Tier 2 Technology Specific Approach

Comment:
The Tier 2 approach is very similar to the Tier 1, but now includes more detail in terms of techniques used. In this case it might become possible to use the activity data in terms of clinker and to take into account the different cement production techniques that might occur.

3.3.1 Algorithm

The Tier 2 approach is similar to the Tier 1 approach. To apply the Tier 2 approach, both the activity data and the emission factors need to be stratified according to the different techniques that may occur in the country. These techniques may include:

- Different end products with different clinker contents

  The IPCC 2006 Guidelines require collection of production data for different types of cement and on the clinker content of these cement types. For the emissions of CO2, this is probably more important than for the emissions of air pollutants. Nevertheless, if these data are available for the reporting of greenhouse gases, it is good practice to also use this data for the estimation of air pollutant emissions. The IPCC 2006 Guidelines provide default clinker fractions for different types of cement in table 2.2 in Chapter 2 of Volume 3.

- Wet or dry milling processes (see above)
- Dust capture
- Any other emission abatement technologies implemented in the country.

Comment: This is an example on how we propose to refer to the IPCC Guidelines. It indicates what we can use and why.

There are two approaches possible:

1. Stratify the cement production in the country to model the different product and process types occurring in the national cement industry into the inventory by

   a) defining the production using each of the separate product and/or process types (together called "technologies" in the formulae below) separately and
   b) applying technology specific emission factors for each process type:

$$E_{pollutant} = \sum_{technologies} AR_{production,technology} \times EF_{technology,pollutant} \qquad (2)$$

2. Develop country specific emission factors from the understanding of the relative contributions of the different technologies within the national cement industry and apply this country specific emission factor for the total national cement production.

$$EF_{country,pollutant} = \sum_{technologies} Penetration_{technology} \times EF_{technology,pollutant}$$
$$E_{pollutant} = AR_{production} \times EF_{country,pollutant} \qquad (3)$$

Both approaches are mathematically very similar or even identical. Using one or the other approach depends mainly on the availability of data. If the activity data are indeed available, the first approach seems to be more appropriate. If however not direct activity data are available, penetration of different technologies within the industry could be estimated from data on capacities, number of employees or other data that reflect relative sizes of facilities using the different technologies.

A country where only one technology is implemented basically is a special case of the above approaches. The penetration of this technology in such a case is 100 % and the algorithm in equation (3) reduces to:

$$E_{pollutant} = AR_{production} \times EF_{technology,pollutant} \qquad (4)$$

The emission factors in this approach still will include all sub-processes within the industry between the feeding of raw materials until the produced cement is shipped to the customers.

3.3.2 Technology Specific Emission Factors

Comment: We must make a distinction between process techniques and add-on abatement techniques. The latter are typically aimed at one specific pollutant and could be treated by means of an abatement efficiency factor.

The first type should be treated in a way that provides a full set of technology specific emission factors. We propose to have these ones in separate sub-sections (level 4) within this section

Abatement then is treated in a separate section (level 3).

Applying a Tier 2 approach for the process emissions from cement production, technology specific emission factors are needed. These are provided in this section. A so-called BREF document for this industry is available at http://eippcb.jrc.es/pages/FActivities.htm. In section 4.3.1 emission factors derived from the emission limit values (ELVs) as defined in the BREF document are provided for comparison.

This section provides a series of technology specific process emission factors for the cement production. In cement production the most important techniques that influence non-combustion emissions are the choice of a wet versus a dry kiln process and the implementation of dust abatement equipment.

3.3.2.1 Wet kiln process

In the wet kiln process, the raw meal is fed into the kiln as wet slurry. Apart from the effect of this on the energy requirement of the process, this also might result in lower emissions of dust from the feed system, resulting in the emission factors as presented in Table 3-2.

Comment:
Needs to be checked. Does the BREF document provide information on this? We are not sure whether Cement Production is a good example for this section.

<<to be completed>>

Table 3-2 Tier 2 emission factors for source category 2.A.1 Cement production, wet process kiln

Tier 2 emission factors				
	Code	Name		
NFR Source Category	2.A.1	Cement production		
Fuel	NA	not applicable		
SNAP (if applicable)	040612			
Technologies/Practices	Wet Kiln process: the raw meal is mixed with water, before feeding it into the kiln			
Region or regional conditions	All			
Abatement technologies	None			
Other	None			
Pollutant	**Value**	**Unit**	**95% confidence interval**	
			Lower	**Upper**
Particulates				
TSP	60[illegible]	kg/tonne cement	300	1200
PM10	[illegible]	kg/tonne cement	250	1000
PM2.5	180	kg/tonne cement	90	360

Comment:
The values in this table now are equal to the ones in the Tier 1

3.3.2.2 Dry kiln process

In the dry kiln process the raw meal is fed into the kiln dry. The main reason for this is the energy efficiency. Typically the dry process uses 30 to 40 % less energy as compared to the wet process. The feeding of dry material into the kiln will however typically result in higher emissions of dust as compared to the wet kiln process.

Comment:
This is my guts feeling. So far we did not find any data on it.

Must be checked…

Since most cement kilns now use the dry process, the emission factors for this process are the same ones as the Tier 1 default values, provided in Table 3-1.

<<to be completed>>

Table 3-3 Tier 2 emission factors for source category 2.A.1 Cement production, dry process kiln

Tier 2 emission factors				
	Code	Name		
NFR Source Category	2.A.1	Cement production		
Fuel	NA	not applicable		
SNAP (if applicable)	040612			
Technologies/Practices	Dry Kiln process: the raw meal is mixed with water, before feeding it into the kiln			
Region or regional conditions	All			
Abatement technologies	None			
Other	None			
Pollutant	**Value**	**Unit**	**95% confidence interval**	
			Lower	**Upper**
Particulates				
TSP	[illegible]	kg/tonne cement	300	1200
PM10	[illegible]	kg/tonne cement	250	1000
PM2.5	180	kg/tonne cement	90	360

Comment:
The values in this table now are equal to the ones in the Tier

3.3.3 Abatement

Comment:
We must make a distinction between process techniques and add-on abatement techniques. The latter are typically aimed at one specific pollutant and could be treated by means of an abatement efficiency factor.

Abatement is treated in a separate section (level 3; this section) with different abatement options as subsections at level 4.

A number of add on technologies exist that are aimed at reducing the emissions of specific pollutants. The resulting emission can be calculated by replacing the technology specific emission factor with an abated emission factor as given in the formula:

$$EF_{technology,abated} = \eta_{abatement} \times EF_{technology,unabated} \qquad (5)$$

This section presents default abatement efficiencies for a number of abatement options, applicable in the cement industry.

3.3.3.1 Dust capture

Comment:
If ESPs are standard then this should be included in the defaults.. If abatement is not standard then it should be presented as a control technique and not a default factor.. Alternatively we could have a series of default factors assuming different abatement/controls.

If however ESPs are standard we might need to include here guidance for estimates of cement works where such standard abatement equipment is **not** installed

Discuss with EP!

<<to be completed>>

Table 3-4 Abatement efficiencies ($\eta_{abatement}$) for source category 2.A.1 Cement production

Tier 2 Abatement efficiencies				
	Code	Name		
NFR Source Category	2.A.1	Cement production		
Fuel	NA	not applicable		
SNAP (if applicable)	040612			
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence interval**	
		Default Value	**Lower**	**Upper**
Electrostatic precipitators	TSP	98%		
	PM10	98%		
	PM2.5	98%		
…				

3.3.4 Activity data

Information on the production of cement, suitable for estimating emissions using of the simpler estimation methodology (Tier 1 and 2), is widely available from UN statistical yearbooks or national statistics.

For a Tier 2 approach these data need to be stratified according to technologies applied. Typical sources for this data might be industrial branch organisations within the country or from specific questionnaires to the individual cement works.

Further guidance is provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 3 on Industrial Processes and Product Use (IPPU), chapter 2.2.1.3 " Choice of activity statistics".

3.4 Tier 3 Emission modelling and use of facility data

3.4.1 Algorithm

There are two different methods to apply emission estimation methods that go beyond the technology specific approach described above:

1. Detailed modelling of the cement production process
2. Using facility level emission reports.

3.4.1.1 Detailed process modelling

A Tier 3 emission estimate, using process details will make separate estimates for the consecutive steps in the cement production process:

1. The handling of raw materials
2. The pyroelectric processing
3. The final steps top produce the products as they leave the facility (“bagging”).

3.4.1.2 Facility level data

Where facility level emission data of sufficient quality (see Chapter ### in part A) are available, it is good practice to indeed use these data. There are two possibilities:

Comment: Quality criteria for facility level data should be defined and explained in the QA/QC cross cutting issues chapter!

- the facility reports cover all cement production in the country
- facility level emission reports are not available for all cement plants in the country.

If facility level data are covering all cement production in the country, the implied emission factors (reported emissions divided by the national cement production) should be compared with the default emission factor values or technology specific emission factors. If the implied emission factors are outside the 95 % confidence intervals for the values given below, it is good practice to explain the reasons for this in the inventory report

If the total annual cement production in the country is not included in the total of the facility reports, the missing part of the national total emissions from the source category should be estimated, using extrapolation by applying:

$$E_{Total,pollutant} = \sum_{Facilities} E_{Facility,pollutant} + \left(\frac{National\ Production}{\sum_{Facilities} Production_{Facility}} - 1 \right) \times EF \qquad (6)$$

Depending on the specific national circumstances and the coverage of the facility level reports as compared to the total national cement production, the emission factor (*EF*) in this equation should be chosen from the following possibilities, in decreasing order of preference:

- Technology specific emission factors, based on knowledge of the types of technologies implemented at the facilities where facility level emission reports are not available
- The implied emission factor derived from the available emission reports:

$$EF = \sum_{Facilities} E_{Facility,pollutant} \Big/ \sum_{Facilities} Production_{Facility} \qquad (7)$$

- The default Tier 1 emission factor. This option should only be chosen if the facility level emission reports cover more than 90 % of the total national production

Comment: My choice at this moment; should be discussed with EPs and TFEIP!

3.4.2 Tier 3: Emission modelling and use of facility data

Cement kilns are major industrial facilities and emission data for individual plants might be available through a pollutant release and transfer registry (PRTR) or another emission reporting scheme. When the quality of such data is assured by a well developed QA/QC system and the emission reports have been verified by an independent auditing scheme, it is good practice to use such data. If extrapolation is needed to cover all cement production in the country either the implied emission factors for the facilities that did report, or the emission factors as provided above could be used (see section 3.3.2).

No generally accepted emission models are available for the cement industry. Such models however could be developed and used in national inventories. If this happens, it is good practice to compare the results of the model with a Tier 1 or Tier 2 estimate to assess the credibility of the model. If the model provides implied emission factors that lay outside the 95 % confidence intervals indicated in the tables above, an explanation for this should be included in the documentation with the inventory and preferably reflected in the Informative Inventory Report.

3.4.3 Activity data

Since PRTR generally do not report activity data, such data in relation to the reported facility level emissions are sometimes difficult to find. A possible source of facility level activity might be the registries of emission trading systems.

In many countries national statistics offices collect production data on facility level, but these are in many cases confidential. However in several countries, national statistics offices are part of the national emission inventory systems and the extrapolation, if needed, could be performed at the statistics office, ensuring that confidentiality of production data is maintained.

4 Data quality

Cement production is a process in which the hot flue gases from a combustion process are directly injected into the reactor where the chemistry and physics take place. This makes the split of the emissions between combustion and non-combustion not always simple. If such a split indeed is difficult to obtain, emissions could be reported at either this process emissions source category 2.A.1 or at the industrial combustion source category 1.A.2.f.

4.1 Completeness

In cases where attempts are made to indeed split the emissions from cement manufacturing in combustion emissions and non-emission combustions, care must be taken to include all emissions.

It is good practice to check, whether the emissions, reported as IE in 2.C.1 are indeed included in the emission reported under combustion in source category 1.A.2.f.

4.2 Avoiding double counting with other sectors

In cases where it is possible to split these emissions, it is good practice to do so. However care must be taken that the emissions are not double counted.

It is good practice to check, whether the emissions, reported in 2.C.1 are not included in the emission reported under combustion in source category 1.A.2.f.

4.3 Verification

4.3.1 Best Available Technology emission factors

<<to be completed>>

Table 4-1 BAT compliant emission factors for source category 2.A.1 Cement production

BAT compliant emission factors				
	Code	Name		
NFR Source Category	2.A.1	Cement production		
Fuel	NA	not applicable		
Pollutant	**Value**	**Unit**	**95% confidence interval**	
			Lower	**Upper**
Particulates				
dust (TSP)	24	mg/m3	20	30
(equivalent to)	0.049	kg/tonne clinker	0.04	0.06

Comment: Only BAT emission factors for dust, NOx and SOx could be found in the BREF document on cement production. For other pollutants, the Tier 1 estimate should be used (to be added).

4.4 Developing a consistent time series and recalculation

No specific issues for Tier 1 and 2

For Tier 3 using facility level data, it might occur that a different selection of facility level data is included in different years. This can lead to time series inconsistencies. Moreover, PRTR data generally are available for specific years only. Splicing such recent reported data under EPRTR/EPER with historical data could be used to get consistent time series. Splicing could be used for both the activity data and the country specific emission factors.

Unexpected discontinuities in time series can occur when specific cement works come into operation or are closed in specific years. If this happens, it is good practice to clearly document such explanations in the inventory archives.

4.5 Uncertainty Assessment

It is rather difficult to assess current uncertainties of emission estimates for pollutants emitted during the cement production. The uncertainties of sulphur dioxide emission estimates can be assessed in a similar way as the uncertainties of the estimates for the fossil fuel combustion (see chapter 1.A.2.f).

Recently it was concluded that up to 50% of uncertainties may be assigned to the emission estimates of most of the trace elements emitted from major point sources in Europe (Pacyna, 1994). Similar uncertainty can be assigned for emission estimates of these compounds from the cement production.

4.5.1 Emission factor uncertainties

No specific issues

4.5.2 Activity data uncertainties

No specific issues

4.6 Inventory Quality Assurance/Quality Control QA/QC

Emissions from cement production as discussed in this chapter only include the emissions due to other causes than the combustion of fuels. The emissions of fuel combustion are to be reported under source category 1.A.2.f in the industrial combustion sector. It is good practice to check whether the cement production data, used in this chapter, are consistent with the associated fuel use as reported in the industrial combustion sector. As indicated above (section 2.1) the energy required to produce clinker is 3.5 to 5 GJ/ton. However, because of heat loss during production, actual values can be much higher.

4.7 Gridding

Cement production plants should be considered as point sources if plant specific data are available. Otherwise national emissions should be disaggregated on the basis of plant capacity, employment or population statistics.

4.8 Reporting and documentation

No specific issues

5 Glossary

ESP	Electrostatic Precipitator: dust emissions abatement equipment
FF	Fabric Filters: dust emissions abatement equipment
combustion process with contact	is a process in which the hot flue gases from a combustion process are directly injected into the reactor where the chemistry and physics take place converting the raw materials into the product. Examples are ✓ primary iron and steel ✓ cement ✓ …

Comment: Asfar as we can see this term is only used in the Guidebook. It should be explained in the glossary

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Comment: Refer to CEPMEIP