Exploring Sector-Specific Baseline Setting:

Standardised Baselines with different levels of integration

– Case Study –

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at the Federal Environment Agency
Bismarckplatz 1
D-14193 Berlin
Phone: +49 (0) 30 89 03-50 50
Fax: +49 (0) 30 89 03-50 10
emissionstrading@dehst.de
Internet: www.dehst.de/EN

This report was written by

Lukas Hermwille, Christof Arens
Wuppertal Institut für Klima, Umwelt, Energie GmbH
Döppersberg 19
42103 Wuppertal

Martin Burian
GFA Consulting Group GmbH
Eulenkrugstraße 82
22359 Hamburg

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Content

Authors

Martin Burian is Senior Consultant at the Competence Centre for Climate and Energy of GFA Consulting Group. His work focuses on Joint Implementation & Clean Development Mechanism projects, especially on Energy Efficiency & Energy Saving, Forest-Climate, and Bioenergy projects; he has special regional expertise for Africa & Latin America.

Lukas Hermwille is Research Fellow at Wuppertal Institute for Climate, Environment and Energy. His research within the Research Group 2: Energy, Transport and Climate Policy focuses on market-based climate policy instruments, particularly flexible Kyoto mechanisms and EU emissions trading.

Christof Arens is Project Coordinator at the Wuppertal Institute for Climate, Environment and Energy. His work concentrates on international climate policy, with a special focus on market-based instruments, especially the flexible mechanisms of the Kyoto Protocol.

Preface

The cement sector is a key industrial emissions sector, accounting for roughly 5 per cent of current global CO_2 emissions. The sector also typically accounts for about one seventh of a country's industrial energy demand., Efficiency measures in the cement sector may set resources free for other parts of the country's economy, especially in countries hampered by an electricity supply gap while facing a rapidly increasing demand. Nonetheless, in developing countries, the cement market is growing substantially resulting in increasing emissions.

In light of this, greater incentives for mitigation are necessary to counteract the emissions connected with the increase in cement production. One option is to develop emission reduction projects under the Clean Development Mechanism (CDM). Various methodologies have been developed to make greenhouse gas mitigation measures in the cement industry suitable for CDM, and that has already led to nearly 200 registered projects. However, these methodologies are only targeted at individual mitigation measures, not at an integrated assessment of the cement sector as a whole. Hence, more emphasis on sectoral approaches is necessary to broaden the scope of mitigation activities towards a more comprehensive integrated approach. Utilising a broader approach, such as offering standardised approaches or default values for calculating the baseline emissions for an entire sector or parts thereof, unlocks much higher mitigation potentials than the project specific CDM. The project cycle would be streamlined, transaction costs decreased and the environmental integrity improved by, for instance, a more robust approach towards demonstrating additionality.

As the cement sector offers many opportunities to target each of its emission sources in the production process, it is an ideal candidate to test the (dis)integration of the various processes for a holistic, robust and conservative standardised baseline. If it can be proven that problems occurring in a process as integrated and complex as cement production can be solved, it will more likely be able to come to grips with other sectors.

Hence, it is the overall aim of this study to analyze different integration and aggregation options for developing a standardised baseline for the cement sector in Indonesia. Specifically to gain experience regarding environmental integrity, the general feasibility and to make recommendations for advancing standardised baselines further. Based on the findings, the research team evaluated the impact on New Market Mechanism/Nationally Appropriate Mitigation Action baseline setting and potentials for standardised baselines in the cement sector in African countries. In parallel, it developed a standardised baseline for the Ethiopian cement sector to support sectoral approaches and the evolution of mitigation activities in a developing country.

Whereas the methodology described considers the final product as cement in its global context of standardised baselines, it should be noted that the system boundary for benchmark allocation and monitoring in the EU Emissions Trading System focuses on the intermediate product, cement clinker. This is due to the need to limit the risk of carbon leakage, as clinker can be transported world-wide at relatively low cost in contrast to cement.

This study, although not necessarily reflecting the views of the German Emissions Trading Authority (DEHSt), provides valuable input to the development of standardised baselines.

Berlin, in January 2015

Dr. Hans-Jürgen Nantke

Head of the German Emissions Trading Authority

at the Federal Environment Agency

Abbreviations

ACM	Approved Consolidated Large Scale CDM Methodology
AFD	Agence Française de Développement
AMS	Approved Small Scale CDM Methodology
BAT	Best Available Technology
BAU	Business as Usual
CDM	Clean Development Mechanism
CDM EB	CDM Executive Board
CCR	Cement to Clinker Ratio
CER	Certified Emission Reduction
CMP	COP serving as Meeting to the Parties to the Kyoto Protocol
CSI	Cement Sustainability Initiative
EF	Emission Factor
GDP	Gross Domestic Product
GEF	Grid Emission Factor
GHG	Greenhouse Gas
GJ	Gigajoule
GNR	Getting the Numbers Right
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
LDC	Least Developed Country
MAC	Marginal Abatement Costs
MJ	Mega Joule
NAMA	Nationally Appropriate Mitigation Activities
NCV	Net Calorific Value
NMM	New Market Mechanisms
SB	Standardised Baseline
UNFCCC	United Nations Framework Convention on Climate Change
WBCSD	World Business Council on Sustainable Development

1 Introduction

1.1 Objective of the Study

The Clean Development Mechanism (CDM) offers a wide range of methodologies allowing to calculate and monitor emission reductions. Currently, there are 244 approved methodologies (94 small scale methodologies and 150 large scale methodologies) available. These methodologies underwent detailed assessment by UNFCCC prior to approval and are considered conservative approaches for the quantification of emission reductions. They offer a wealth of approaches which can be harnessed to design CDM projects and programmes as well as serve as a tool box for New Market Mechanisms (NMM) and Nationally Appropriate Mitigation Activities (NAMAs). Yet these methodologies are often case-specific, supposedly too specific to allow for the development of emission benchmarks for a whole sector at national scale.

Against this background, Standardised Baselines (SB) were introduced as a tool to broaden the scope of the CDM beyond a purely project-based mechanism towards a more comprehensive sectoral one, to streamline the project cycle as well as to decrease transaction costs and thus to improve accessibility for smaller scale projects that would otherwise not be able to recoup the up-front investment. Last but not least SBs can serve to improve environmental integrity by following a more standardised and thus more robust approach towards additionality demonstration.

Standardised Baselines establish national greenhouse gas (GHG) emission benchmarks which may e.g. serve as baseline emission factor for all CDM projects in one specific sector in a host country. However, in some sectors a wide range of mitigation options is available. The most prominent example is supposedly the cement sector, where emissions can be reduced e.g. by altering the clinker content (i.e. switching to alternative pozzolanic materials as a feedstock for cement production) in the final product, switching to alternative fuels for the heating process or improving energy efficiency in the process by various means (see Table 1 below).

The SB regulatory framework allows for establishing a benchmark for a sector as a whole comprising several combined mitigation activities. CDM EB64, Annex 23, §5 notes: *'This framework allows for setting baselines that are not necessarily specific to one type of project activity in a sector, but can be applicable to most of the possible project activities in a sector'*.

Yet experience with such types of integrated SBs is however largely non-existent. Most SBs to date are focusing on relatively straightforward cases with little combination/interaction of different mitigation measures. In a series of interviews, Hermwille et al. (2013) found that many stakeholders remain concerned with regard to the performance-penetration approach that is the core concept of the SB Guidelines (see Box 1). Especially the application of the concept in complex integrated production processes is seen to be difficult.

This study aims to explore this hitherto unacquainted terrain of a Standardised Baseline covering a combination of different mitigation activities within a sector. The specific case we are analysing is the cement industry of Indonesia. We will explore potential conflicts with the current SB rules and regulations as well as aspects where the current guidance is perceived insufficient. In such cases we will investigate different alternative approaches and compare them with regards to their environmental integrity (conservativeness) and feasibility.

BOX 1: The Performance Penetration Approach

The performance penetration approach (PP) stipulates a way to derive a positive list of technologies, fuels or feedstock in a sector. In this approach, technologies/ fuels/ feedstock are ranked in descending order of their emissions intensity. The least emission intensive technology/ fuel/feedstock needed to produce a certain percentage of the sector's output is selected as baseline technology/ fuel/ feedstock. All technologies/fuels/feedstock that feature lower emission intensities than the baseline technology are candidates for the inclusion in a positive list of technologies/ fuels/ feedstock that are automatically deemed additional. Moreover, the baseline technology is not only used to condition the additionality of projects, it is also used to determine the crediting baseline against which emission reductions are calculated. Figure 1 depicts an example: All technologies that contribute to the sector's output are ranked as described above. The result is the step function illustrated in the figure. Each step of the function represents one technology. In this example we chose 80% as the value that determines the baseline technology. The last, i.e. most efficient, technology that is needed to generate 80% of the sectors output is the baseline technology (blue step of the function). All technologies that are more efficient than the baseline technology (green steps of the function) are candidates for a positive list of the SB.

The CDM Executive Board has defined a preliminary additionality and crediting threshold, i.e. the percentage value that determines the baseline technology. The EB chose a value of 80% for priority sectors – energy in households, electricity generation in isolated systems and agriculture – and 90% in other sectors.

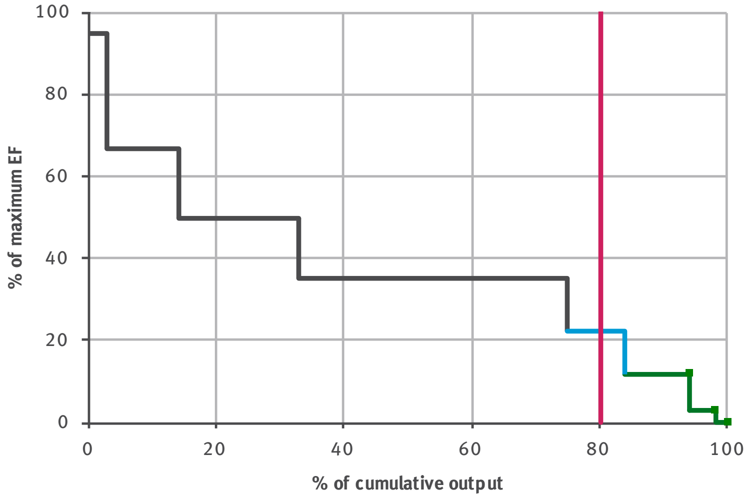


Figure 1: Illustration of the Performance Penetration Approach

1.2 Context of the Study

The decision to promote the development of SBs was taken at the sixth conference of the Parties to the Kyoto Protocol (CMP.6) in Cancún in 2010. Since then, a broad framework for the development of SBs has been elaborated (see Box 2).

Box 2: Documentation of the SB Framework

- Procedure for Submission and Consideration of Standardised Baselines, Version 2.0: CDM EB68, Annex 32;
- Guidelines for the Establishment of Sector-Specific Standardised Baselines, Version 2.0: CDM EB65, Annex 23;
- Guidelines for Quality Assurance and Quality Control of Data used in the Establishment of Standardised Baselines, Version 1.0: CDM EB66, Annex 49;
- Guidelines for the Consideration of Suppressed Demand in CDM Methodologies, Version 2.0: CDM EB68, Annex 2;
- Establishment of standardised baselines for afforestation and reforestation project activities under the CDM, Version 1.0: CDM EB70, Annex 10;

The SB framework allows for two alternative routes to develop an SB: [1] Establishing national GHG benchmarks following approved CDM methodologies and tools and [2] following the dedicated *'Guidelines for the Establishment of Sector-Specific Standardised Baselines'* (SB Guidelines).

Both approaches have been used so far. With eight proposed SB two of which have been approved, the most common type of SB proposed so far are national or regional grid emissions factors (GEFs). These GEFs are all following the first route and were developed using the *'Tool to calculate the emission factor for an electricity system'* (CDM EB63, Annex 19).

However, SBs following the second approach have also been proposed: To date (April 2014) four SBs have been proposed, two of which have been approved successfully.

It is this latter variation of SBs we are looking at in this study. The SB Guidelines allow for the development of standardised sectoral emission factors and automatic additionality demonstration through a positive list of technologies/ fuels/ feedstock We chose to explore the theoretical potential of the SB framework by investigating the case of the Indonesian cement sector for two reasons. First, the cement sector is a key emission sector accounting for roughly 5 per cent of current global CO_2 emissions (IEA 2009). Furthermore, the cement sector is a major source of industrial energy demand. Madlool et al. (2011) estimate that the cement sector typically accounts for 12-15 per cent of a country's industrial energy demand. Especially in countries which are hampered by an electricity supply gap while facing rapidly increasing demand, efficiency measures in the cement sector may free up resources to develop other parts of the country's economy.

Second, the case of the cement sector is a challenging one. The cement sector offers a large variety of mitigation options at the different steps of the production process. There are three different sources of CO_2 emissions in the cement production process:

1. Direct emissions from the chemical calcination process,
2. Direct emissions from fuel combustion to generate the heat required to start and maintain the calcination process;
3. Indirect emissions through the use of electricity at the various stages of the production process.

Each of these emission sources can be the targeted through a variety of mitigation measures. Some of these measures may reduce emissions from multiple emission sources (i.e. direct and indirect), while others are completely separate/isolated (see chapter 6 for a more detailed description of the production process and mitigation options). The variety of mitigation measures in this sector offers an ideal testing ground for investigating to what extent it is possible to integrate/dis-integrate the various process to develop a holistic, robust and conservative Standardised Baseline. It is against this background that the UNFCCC mentions the cement sector as an example for an SB which integrates several processes (CDM EB65, Annex 23, §46). If it is possible to solve occurring problems in a process as integrated and complex as cement production, it will likely be possible to solve similar problems in other sectors.

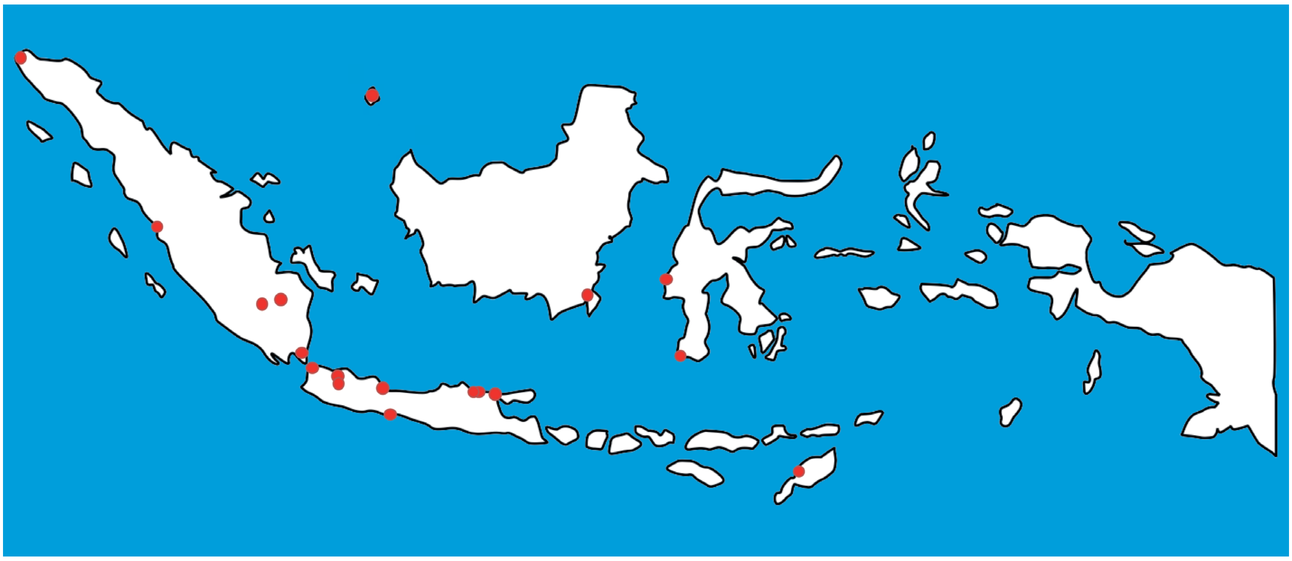
The study can comfortably build on previous research conducted as part of Indonesia's Ministry of Industry's efforts to develop and implement a NAMA in the cement sector. These efforts were supported by GIZ's programme for 'Policy Advice for Environment and Climate Change'. The programme had requested GFA Consulting Group to provide technical assistance for the development of the baseline for Indonesia's cement NAMA. The baseline study collected a complete data set for all cement companies operating in the country for the period 2009 to 2012 and considered the SB rules and procedures as framework for the development of a holistic, i.e. including emissions from all processes in the cement sector, baseline. This data set offers the ideal basis for testing various design options on a real data set deriving recommendations for the further development of the SB framework.

BOX 3: The Cement Sector in Indonesia

The Indonesian cement sector grew in average 6.67% per annum over the period 1999 to 2012 with a total production of 56.6 million tons cement in 2012. The future growth is difficult to predict, forecasts for the year 2020 range from 74.65 to 106.01 million tons cement produced (7 forecast models, mean: 88.54 million t cement).

In 2012 there were 9 companies active in the Indonesian cement sector. These companies operate a total of 36 production lines at 18 different plants (incl. grinding facilities). The facilities vary by their age. The oldest still operational production line was commissioned in 1980 while the bulk of the production capacity has been installed in the decade of 1990 and 2000. A list of companies, production sites and commissioning data may be found in Annex I.

Based on the current constructions of cement plants, it is possible to estimate future capacity additions and –considering the typical load factor for this capital intensive sector – to estimate future production. Such estimates are based on current investments instead of economy growth rates. Burian et al. (2013) estimate annual cement production to grow from 6.6 million tons cement in 2013 to 106.06 in 2020 (based on an average annual growth rate of 8.32%).



Source: Wuppertal Institute

Figure 2: Map of Cement Plants in Indonesia.

1.3 Structure of the Study

This study aims to explore the development of integrated SBs which covers a series of mitigation options. Using Indonesia's cement sector as example, various options are tested which allows for developing recommendations for the further development of the SB framework. These different options are reflected in three scenarios that form the core of this study.

Chapter 2 outlines the rationale for various scenarios used for road testing. Chapter 3 provides an introduction into the cement production process, summarizing mitigation potentials in the sector and reviewing CDM instruments (guidelines, tools, methodologies) that have been developed for the cement sector so far. Chapter 4 presents the development of a sectoral benchmark emission factor for the sector. We explore three different approaches based on the scenarios introduced in chapter 2. Chapter five tests the robustness of a cement sector SB by altering core input variables for investigating the impact of market concentration. By developing an alternative scenario of market concentration/fragmentation we analyse how sensitive the performance penetration approach is towards the number of market players and their respective production shares. Furthermore, we discuss whether or not it is reasonable to disaggregate the sector into sub-sectors (e.g. in governmental- and private companies). This may be necessary when the sector is very heterogeneous.

Additionality demonstration is a core requirement for CDM projects and has proven to be a great challenge. The SB Guidelines specify how a positive list of automatically additional technologies/fuels/feedstocks can be established. Chapter 6 elaborates why such an approach to automatic additionality may be problematic for highly integrated processes such as cement production.

Standardised Baselines receive attention not only as a tool to improve the CDM but also as a prospective component for NAMAs and a New Market Mechanism. In chapter 7 we discuss the potential of SBs in the development of BAU scenarios beyond the CDM. In chapter 8, we will investigate the potential for SBs in Africa and particularly African Least Developed Countries (LDCs) as Standardised Baselines are of particular importance for this region which is underrepresented in the CDM so far. Chapter 9 presents key findings and derives recommendations for the further development of the SB framework.

2 Methodological Approach

In this case study we will follow the stepwise approach as stipulated in the 'Guidelines for the Establishment of Sector-Specific Standardised Baselines' to develop an SB for the cement sector. The application of the SB Guidelines to the cement sector is not straightforward. As we go through the process we encounter aspects where the current SB Guidelines do not provide sufficient guidance. For each of these aspects we will describe the problems encountered, provide solutions where possible and/or discuss alternative ways to proceed.

In principle, the SB Guidelines allow for the combination of more than one mitigation measure into one combined SB. §46 of the Guideline reads:

When multiple measures are simultaneously applied in a sector or in a section of the sector it is necessary to derive a baseline emission factor that ***integrates*** *the combined effect of all the measures applied and other influencing factors e.g. fuel/feed stock and respective Net Calorific Values (NCV), baseline technology and its design features such as electricity/heat consumption/generation capacity, grid emission factor of electricity consumed. ."*

However, the Guidelines do not specify how such an integration may be carried out. To what extent should the performance of sub-processes be taken into account? How is 'integration' to be operationalized and what are the limits of its applications? These questions prepare the ground for developing sector-specific GHG benchmarks on national scale.

For the subsequent analysis, 'level of integration' is therefore defined as the degree to which the production chain of the sector's final product (i.e. cement) is broken down into sub-processes. A fully integrated approach conceives a complex production process as one black box. The benchmark emission factor is solely calculated on the basis of one indicator, i.e. the total emissions per final output. An approach with a low level of integration, on the other hand, specifies separate performance indicators for sub-processes (e.g. the Clinker to Cement Ratio and the emissions per tonne clinker production) and calculate a combined benchmark emission factor on the basis of these performance indicators.

Typically, the term 'integration' has a positive connotation. For this analysis we define 'integration' as a neutral concept. There are pros and cons to argue for or against integration. A low level of integration for example allows for a more differentiated perspective on the sector's performance, while a fully integrated approach may conceal mitigation potentials. We shall therefore demonstrate that while a fully integrated approach seems to be the simplest and therefore the most cost-effective way, an approach with low integration is likely to be more conservative than an integrated approach. This is because in an integrated approach, top performances in some sub-processes of the benchmark setting firm/plant are potentially offset by lesser performances in other sub-processes and hence 'averaged out'. On the other hand, for the disintegrated approach, a hypothetical combined emission factor needs to be calculated based on the performance indicators benchmarks of the set of sub-processes, each representing a top-performance in the respective sub-process. This may reflect theoretical production processes which in practice do not exist in this combination and hence may be considered as overly conservative.

To explore this trade-off between feasibility on the one hand and conservativeness and level of detail of the assessment on the other, this study will develop three scenarios. The scenarios will differ in their level of integration, i.e. they differ in the extent to which processes have been segregated:

- **Option A – Full Integration**
  Only the specific emissions from the cement production are considered.
- **Option B – Medium Level of Integration**
  The production process is dis-integrated into two sub-processes: clinker production and blending. The combined benchmark emission factor is calculated on the basis of the specific emissions of clinker production and the Clinker to Cement Ratio (CCR).
- **Option C – Low Level of Integration**
  This approach divides the cement production in various sub-processes. This is done as detailed as possible considering the available data. The combined benchmark performance factor is calculated on the basis of separate performance benchmarks for the use of alternative fossil fuels, use of biomass and biomass residues, specific heat consumption, specific power consumption and the CCR.

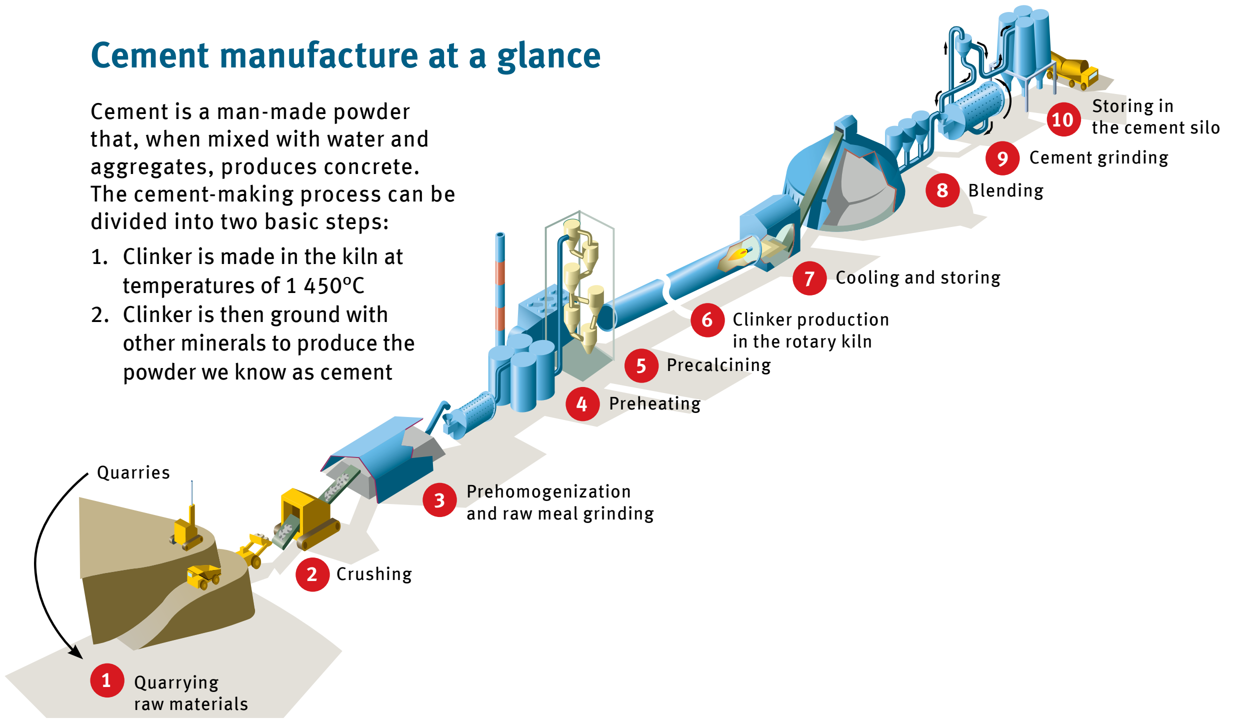
In the subsequent chapter 5 and we will test the robustness of the benchmark emission factors generated by means of the performance penetration approach in chapter 4 by altering some of the input data:

- **Does Size and Number of Companies impact the SB?**
  We will test the effect of different levels of market concentration by developing an alternative hypothetical market scenario with an increased (doubled) number of market players. This hypothetical market scenario will feature the identical output and average greenhouse gas emissions as the real sector.
- **What is a reasonable and justifiable to Division in Subsectors?**
  - The SB Guidelines define the level of aggregation of a sector as follows (CDM EB65, Annex 23, § 8):
    'The level of aggregation measures the extent to which consolidation of information from any parts or units to form a collective whole is undertaken. This consolidation is usually done within a common sector, to provide information at a broader level to that at which detailed observations are taken. Information on categories can be grouped or aggregated to provide a broader picture when this does not lead to misrepresentation. It can also be split or disaggregated when finer details are required by too much non-homogeneity'
  - The Guidelines, in § 16, further specify the level of aggregation:
    'The relevant region is the geographical area of the sector producing the output in a country or a group of countries. If there are fuels/feedstocks that are not available to some regions within the country, further disaggregation is needed and additionality and baseline fuels/feedstocks should be established for regions where the same set of fuels/feedstocks are available. Other levels of aggregation may be proposed to the Board if considered more appropriate.'
  - We will explore the effect of disaggregating the sector by calculating benchmark emission factors for private and state-owned cement plants separately and discuss the quantitative effects of this exercise.

3 A Standardised Baseline for the Cement Sector

3.1 The Cement Production Process

The cement production process can be summarized as follows: In a first step, limestone is mined and transported to a cement production site. After first mechanical treatment to homogenize the raw product, this limestone is heated to activate a chemical decomposition, calcination process of limestone ($CaCO_3$) to lime (CaO) and CO_2. This lime in turn reacts with silica, aluminium and iron containing materials to produce clinker, an intermediary product in the cement production (IPCC 2000: 176). This process happens in the so-called cement kiln. In a second step, clinker is milled and blended with gypsum to cement as final product (see Figure 3).



Cement manufacture at a glance

Cement is a man-made powder that, when mixed with water and aggregates, produces concrete. The cement-making process can be divided into two basic steps:

1. Clinker is made in the kiln at temperatures of 1 450°C
2. Clinker is then ground with other minerals to produce the powder we know as cement

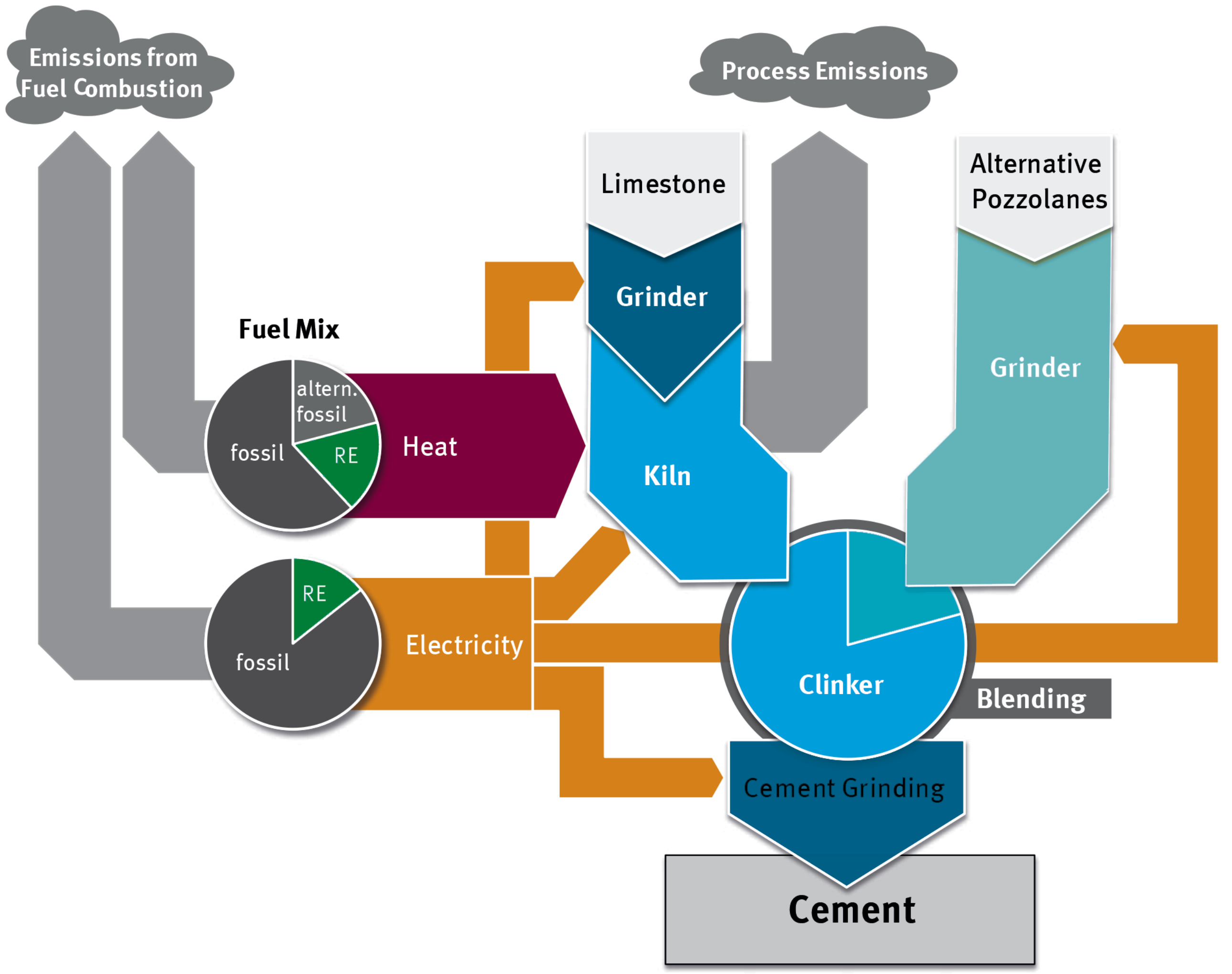
Source: IEA 2009, p4.

Figure 3: The Cement Production Process

The cement sector comprises several major emission sources:

- Process emissions from the calcination process in clinker production (accounting for ~60 per cent of total CO_2 emissions);
- Direct emissions from fuel combustion to provide heat to maintain the calcination process (30 per cent of total CO_2 emissions); and
- Indirect emissions through the use of electricity to power all sorts of mechanical treatment (~10 per cent of total CO_2 emissions, IEA 2009).

The process is represented as a basic flow chart in Figure 4.



Source: Wuppertal Institute

Figure 4: Flow Chart of the Cement Production Process and Associated CO_2 Emissions

3.2 Mitigation Measures

The cement sector offers a wide range of mitigation options characterized by different potentials and different marginal abatement costs. Some of these measures require substantial technical changes to facilities and related investment, others are bound to revisions of the policy framework and some require a mix of both.

Considering costs and potentials, the reduction of the CCR ratio (i.e. to substitute clinker in the final product) is considered as the most important mitigation measure (Madlool et al. 2011). Clinker can be partially substituted with e.g. fly ash from coal-fired power plants, blast furnace slag from the iron and steel industry or natural pozzolanic materials such as volcanic ash. Such substitutes do not only reduce emissions from the calcination process. They also save energy as heat treatment is not necessary, which in turn reduces direct emissions from fuel combustion. MoI and AFD (2010) estimate the increase of blending to feature slightly negative marginal abatement costs (i.e. an increase of blending is economically attractive). The substitution of clinker is therefore considered to be an effective mitigation option in the cement sector. It is however limited to the availability of suitable substitute materials. Furthermore, alternative cement blends may have different material properties and thus require special handling in the construction industry and/or may not be suitable for all purposes.

Emissions from fuel combustion may be addressed by two approaches: alternative and less emission intensive fuels and/or improved thermal efficiency of the installation. Typically fossil fuels are used to heat the cement kiln. In Indonesia this is usually coal. When coal is substituted with e.g. biomass residues, the amount of CO_2 emissions are reduced. This can also be achieved through the use of less CO_2 intensive fossil fuels such as natural gas or so-called ‘Alternative Fossil Fuels’ such as waste tires, or other type of waste that would have otherwise been landfilled.

Alternatively, emissions from fuel combustion can be avoided through improved thermal efficiency of the kiln. Modern kiln design can substantially reduce the demand for heat. However, for existing cement plants, the mitigation potential is limited as these require a fundamental reconfiguration of the plant. More feasible for existing plants may be measures to recover waste heat from the clinker production process. Waste heat is used to generate electricity and to pre-heat limestone.

Indirect emissions from electricity consumption are the third large source of CO_2 emissions in the cement industry. Mitigation options include energy efficiency measures: By far the largest share of electricity is consumed in the grinders that are used to treat the raw limestone before it enters the kiln and to mill the final cement blend. Efficiency measures in these grinders are possible, but usually require a fundamental overhaul and are thus mainly relevant for newly constructed cement plants. However, there are numerous smaller interventions such as the employment of flexible speed drives that may be implemented in existing facilities.

Last but not least, CO_2 emissions can be reduced if electricity is sourced from renewable energies or less emission intensive fossil fuels. One option is the before mentioned electricity generation from waste heat recovery.

The broad spectrum of available mitigation measures in the cement sector is summarized in Table 1below.

Table 1: Overview of Mitigation Measures in the Cement Industry

Measure	Type of Measure	Targeted Source of Emissions	Applicability in Existing Plants	Emission Reduction Effect
Reducing the clinker cement ratio	Feedstock switch	Process emissions and direct emissions from fuel combustion	Yes	Very high
Sustainably sourced renewable energy for heat generation	Fuel switch	Direct emissions from fuel combustion	Yes	High
Alternative fossil fuels for heat generation	Fuel switch	Direct emissions from fuel combustion	Yes	Medium/ high
Improved grinding media	Switch of technology	Indirect emissions from electricity consumption	Yes	Low
Efficient grinder/mill design	Switch of technology	Indirect emissions from electricity consumption	No	Medium
High efficiency classifier/ separator	Switch of technology	Indirect emissions from electricity consumption and reduced direct emissions from fuel combustion	Yes	Medium
Efficient kiln design	Switch of technology	Direct emissions from fuel combustion and indirect emissions from electricity consumption	No	High
Waste heat recovery for electricity generation	Switch of technology	Indirect emissions from electricity consumption	Yes	Medium
Waste heat recovery to pre-heat raw material	Switch of technology	Direct emissions from fuel combustion	Partly	Medium/ high
Sustainably sourced renewable energy for electricity generation	Fuel switch	Indirect emissions from electricity consumption	Yes	High
Alternative fossil fuels for electricity generation	Fuel switch	Indirect emissions from electricity consumption	Yes	Medium
Carbon capture and storage	Switch of technology	Direct emissions from fuel combustion	Unlikely	High

Source: Wuppertal Institute based on Madlool et al. (2011).

3.3 The Cement Sector and the CDM

Various methodologies have been developed to make GHG mitigation measures in the cement industry accountable under the CDM. However, these methodologies target the respective mitigation measure individually and do not allow for an integrated assessment. None of the methodologies allows quantifying the emission and emission reductions of cement sector as a whole, i.e. emissions related to fuel, blending and energy efficiency measures. The following methodologies are of relevance for the cement sector:

- AMS III.Q, Waste energy recovery (gas/heat/pressure) projects, Version 5.0, CDM EB69;
- ACM3, Emissions reduction through partial substitution of fossil fuels with alternative fuels or less carbon intensive fuels in cement or quicklime manufacture Version 4, EB66;
- ACM5 Increasing the blend in cement production, Version 7.1, EB67;
- ACM15 Consolidated baseline and monitoring methodology for project activities using alternative raw materials that do not contain carbonates for clinker production in cement kilns, Version3, EB53.

Standardised Baselines potentially may close this gap which is evaluated in the course of the subsequent chapters. This assessment will closely follow the approach stipulated in the SB guidelines. The SB Guidelines §15 stipulate a four step approach to develop a SB:

'The following steps should be applied to establish standardised baselines for each of the four measures:

a) *Step 1: Identify host country(ies), sectors, output(s) and measures;*
b) *Step 2: Establish additionality criteria for the identified measures (e.g. positive lists of fuels/feed stocks and technologies);*
c) *Step 3: Identify the baseline for the measures (e.g. baseline fuel, technology, level of GHG destruction);*
d) *Step 4: Determine the baseline emission factor where relevant.'*

The definition of the host country and the sector is straight forward. The geographical boundaries encompass the territory of the Republic of Indonesia. The sector scope is the cement sector and covers all nine cement companies, related plants and lines currently operating in the country.

The definition of the output deserves more attention. The definition of output is critical for the SB as according to the PP approach the different technologies have to be ranked according to their respective specific emissions in terms of tons of CO_2 per tonne of output. The analysis considers cement as output, as the measures to be covered by the activities may include the reduction of the clinker to cement ratio. However, the only proposed SB in the cement industry follows a different approach and considers clinker as the relevant output (Federal Republic of Ethiopia 2012). While emissions in the clinker production account for the largest share of emissions in the cement production process, it is still an intermediary product. Consequently we define the final product cement as relevant output for our case study.

For an integrated approach, the most difficult part is to unambiguously identify the mitigation measures that fall under the standardised baseline. The SB Guidelines define four different types of measures (§8.b):

*'**Measure** (for emission reduction activities) - a broad class of GHG emission reduction activities possessing common features. Four types of measures are currently covered in the framework:*

i) *Fuel and feedstock switch;*
ii) *Switch of technology with or without change of energy source (including energy efficiency improvement);*
iii) *Methane destruction;*
iv) *Methane formation avoidance'*

For the cement sector measures of type (i) and (ii) are relevant. Table 1 above indicatively lists mitigation measures that reduce CO_2 emissions in the cement sector.

For each of the above mentioned types of measures the SB Guidelines specify how to set an appropriate level of aggregation, to demonstrate additionality, to identify a baseline and to calculate the corresponding emission factor. However, these specifications seem to imply that an SB has to be developed for every measure separately. At a later stage, the Guidelines shortly discuss integrated measures:

'When multiple measures are simultaneously applied in a sector or in a section of the sector it is necessary to derive a baseline emission factor that integrates the combined effect of all the measures applied and other influencing factors [...]'. The question of whether or not separate benchmark emission factors should be determined is also contingent on the question on whether the measures are inherently linked to each other, i.e. one measure cannot be implemented without the other measure. An example would be fuel switch and technology switch in the power sector.

The sheer number of measures as listed Table 1 above reveals the problem that may be encountered when developing a combined SB. The problem is further exacerbated by the fact that some of the measures can be implemented individually, but others may be linked to other measures. In some cases mitigation measures might even exclude each other. For example efficient kiln designs typically inherently recover waste heat. Further options for waste heat recovery might not be available or be already incorporated in such an advanced design.

In the following chapter we present three different approaches to calculate a combined benchmark emission factor based on three different levels of integration.

4 What is an Appropriate Level of Integration?

As indicated above, there is no clear guidance available on how to calculate an emission benchmark for a complex production process within the CDM. There are a number of conceivable ways to do that. In this chapter we will explore some of these. We will do that by following three approaches that differ in their respective level of integration:

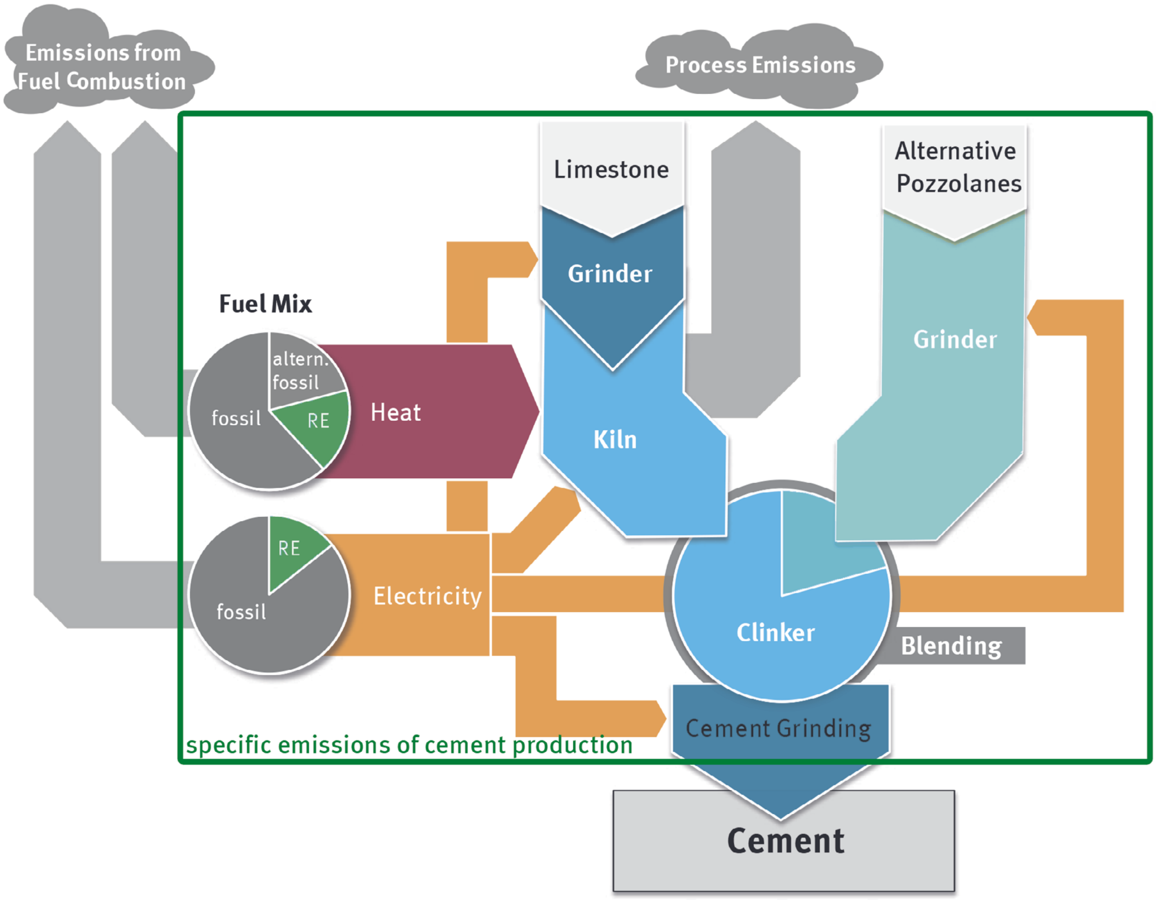
- **Option A – Full Integration**
  Only the specific emissions from the cement production are considered.
- **Option B – Medium Level of Integration**
  The production process is dis-integrated into two sub-processes: clinker production and blending. The combined benchmark emission factor is calculated on the basis of the specific emissions of clinker production (tCO_2 /t clinker) and the CCR.
- **Option C – Low Level of Integration**
  This approach subdivides the cement production process as detailed as possible with the available data. The combined benchmark performance factor is calculated on the basis of separate performance benchmarks for the use of alternative fossil fuels [in per cent of primary energy consumed], use of biomass and biomass residues [in per cent of primary energy consumed], specific heat consumption [in $TJ_{thermic}$ per t cement], specific power consumption [in $TJ_{electric}$ per t cement] and the CCR.

For each of the three options, we will calculate performance indicators and a combined benchmark emission factor. Finally, the three options are compared. Two questions are discussed: Which option results in the most conservative approach, i.e. does a lower level of integration lead to a realistic benchmark emission factor? To answer these questions, we compare and discuss the subsequently derived benchmark emission factors.

4.1 Option A – Full-Integration

Under this Option we do not look into the details of the cement production process. The complex is modelled as a 'black box' which does not concern itself with benchmark setting for relevant sub-processes. We only consider a one dimensional benchmark which is based on the average specific emissions of cement production of each company as specified in the World Business Council on Sustainable Development (WBCSD) Cement Sustainability Initiative (CSI)'s data template that was used to compile the data on which this report is based. Under this indicator all sub-processes are covered. Performance improvements in these sub-processes cannot be accounted for individually. The approach is illustrated schematically in Figure 5. The green box indicates which sub-processes are covered within the single indicator used to establish the baseline.

Please note, that emissions from external electricity generation are not included in the specific emissions of cement production. We have added these emissions, but for 4 of the 9 companies under consideration, external emissions from electricity generation had to be estimated on the basis of specific electricity consumption per tonne cement and the emission factor of the respective power grid (see box 4 below).



Source: Wuppertal Institute.

Figure 5: Schematic illustration of the measurement approach applied in Option A – full integration

The baseline is established following the SB which propose the following steps for baseline identification and establishment:

- In a first step the production shall be ranked by company according to their CO_2 intensity of production; from the most CO_2 production to the least CO_2 intensive production (CDM EB65, Annex 23, §20 – 21).
- The data used for baseline establishment shall be the average of the most recent three years (CDM EB65, Annex 23, Appendix 1, §1).
- For the identification of the baseline emission factor, the guideline requires the establishment of a threshold X_b (CDM EB65, Annex 23, §20). The CDM EB specifies a default threshold of 90% for the cement sector (compare CDM EB65, Annex 23, Appendix 1, §1). Consequently, the baseline emission factor is determined by the emission intensity of the company which represents the 90 percentile of the output, if the companies are arranged accord to their emission intensity.

After the companies had been ranked by their emission intensity of production, for each company the accumulated production share was determined by dividing the company's three year average cement production by the three year average of the national cement production. The company's share of the national production was added to the share of all other, more CO_2 intensive companies (e.g. the share of company 3 was added with the share of company 1 and 2).

Table 2 below presents the outcome of above work steps for the specific cement emissions. Company 9, the company with the lowest CO_2 intensity of production, produced in average 10.08 million tons cement per year, over the period 2010 to 2012. This equals 21.1 % of the national production. Hence the 90% threshold falls within the production of company 9 and the baseline emission factor is consequently determined by the specific CO_2 emissions of cement production of company 9. Consequently, the baseline emission factor is determined at 729.5 kg CO_2 per tonne clinker. The below Figure 6 illustrates the evolvement of the specific emission intensity over the accumulated production share.

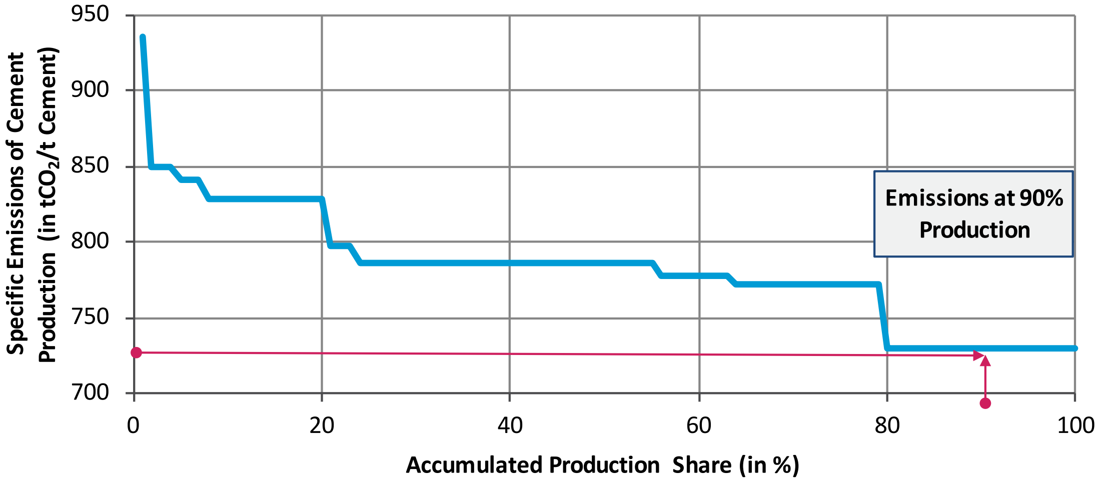


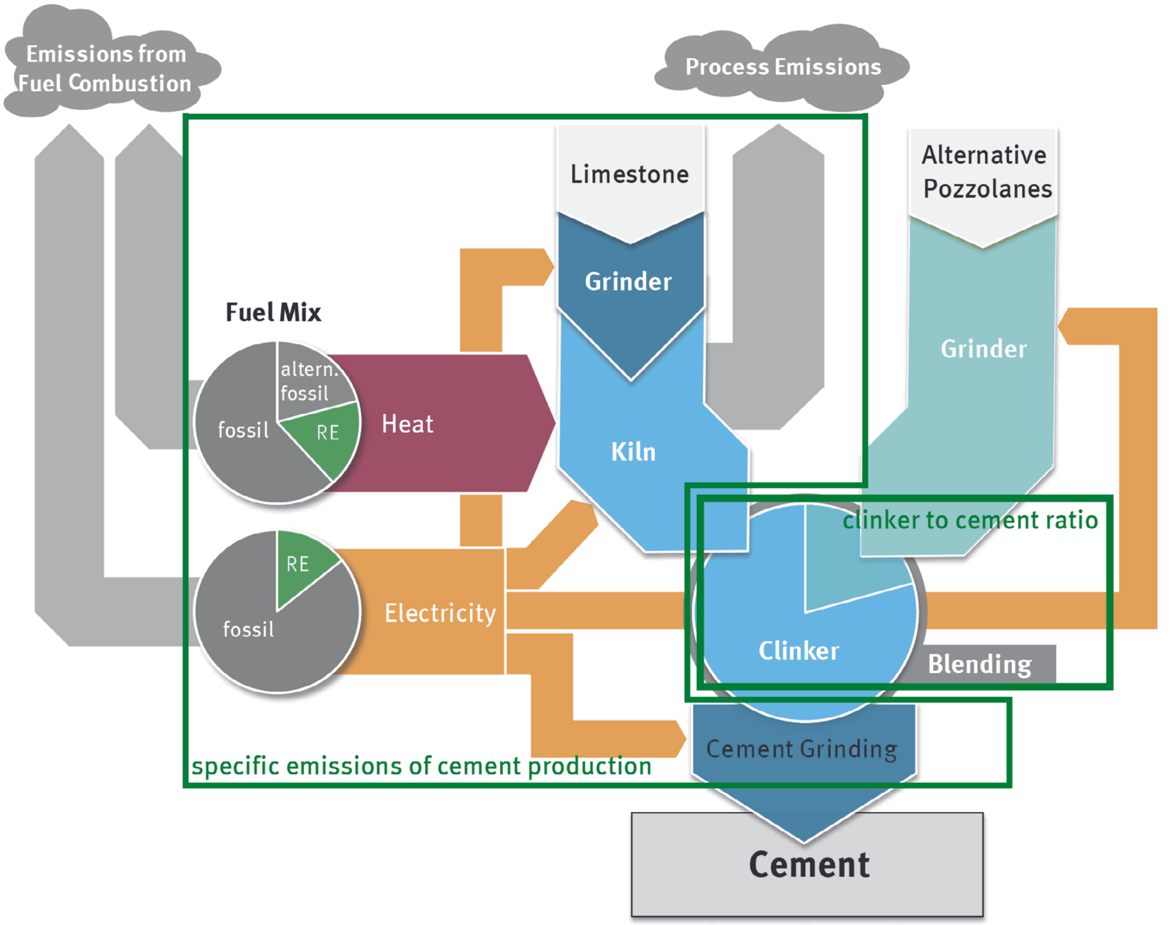
Figure 6: Specific Emissions from the Cement Production

Table 2: Standardised Baseline Assessment – Emissions from Cement Production

Company	1	2	3	4	5	6	7	8	9
Cement Emissions (in kg CO_2/t cement)	935.1	849	840.7	828.9	797.8	786.3	776.9	771.9	729.5
Cement Production (in 1000 t)	36.5	2,020.3	1,191.5	6,205.2	1,348.5	15,396.7	4,088.2	7,3579.9	10,080
Accumulated Production Share (in %)	0.08%	4.31%	6.81%	19.81%	22.63%	54.90%	63.46%	78.88%	100.00%

4.2 Option B – Medium Level of Integration

In the second scenario we follow the same technical approach as in Option A. However with the slight differentiation that we split the emissions of cement into the specific emissions for clinker production and into the CCR, which allows for developing two separate benchmarks. This approach is illustrated in Figure 7.



Source: Wuppertal Institute

Figure 7: Schematic illustration of the measurement approach applied in Option B – medium level of integration.

To arrive at a combined baseline emission factor for cement production we multiply the CCR benchmark with the clinker emission benchmark. Again, the companies were ranked by their emission intensity of production. The accumulated production share of each company was determined by dividing the company's three year average clinker production (and for CCR benchmark, cement production) by the three year average of the national clinker production (CCR: cement production). The company's share of the national production was added to the share of all other, more CO_2 intensive companies.

4.2.1 Specific Emissions of Clinker Production

Table 3 below presents the outcome of above work steps for the specific clinker emissions. Company 9, the company with the lowest CO_2 intensity of production, produced in average 7.94 million tons clinker per year, over the period 2010 to 2012. This equals 17 % of the national production. Hence the 90% threshold falls within the production of company 9 and baseline emission factor is consequently determined by the specific CO_2 emissions of clinker production of company 9. Consequently, the baseline emission factor is determined at 894.2 kg CO_2/t clinker. The below figure illustrates the evolvement of the specific emission intensity over the accumulated production share.

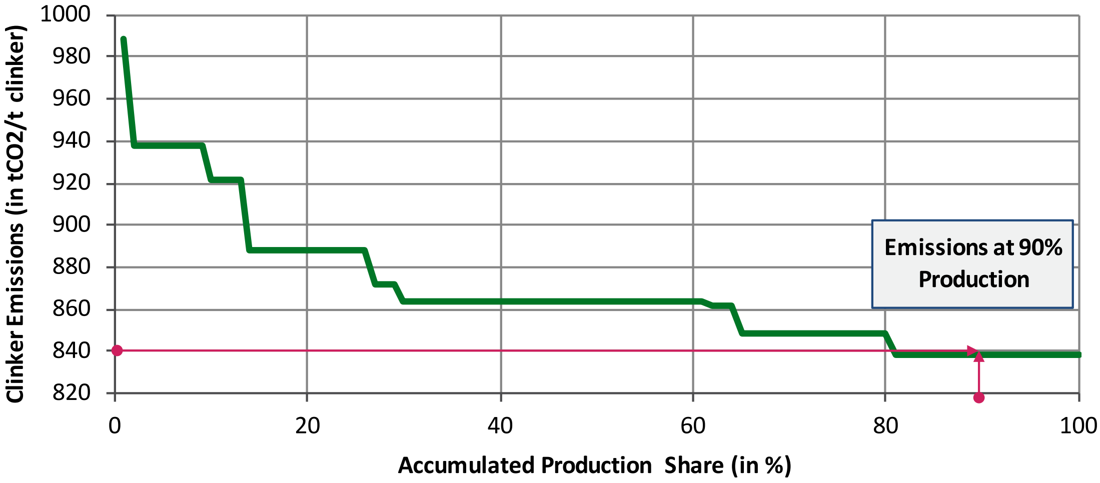


Figure 8: Determination of the Baseline Emission Factor for Clinker Production

Table 3: Standardised Baseline Assessment – Clinker Emissions

Item	1	2	3	4	5	6	7	8	9
Clinker Emissions (in kg CO_2/t clinker)	988.5	937.7	937.7	921.8	888.4	872.4	863.8	848.9	838.6
Clinker Production (in 1000 t)	95.3	3,251.2	7,939.4	1,930.1	4,621.3	1,033.5	12,628.6	6,313.7	7,939.4
Accumulated Production Share (in %)	0%	7%	25%	29%	41%	31%	69%	83%	100%

4.2.2 Clinker to Cement Ratio

The identical approach was pursued for the establishment of a standardised baseline benchmark for the CCR: The three year average CCR ratio was determined on a company level complemented by the three year averages of cement production. The latter allows for the determination of the aggregated production share. Please note, here company 1 to 9 were ranked acceding to their CCR and the companies do not necessarily correspond to companies 1 to 9 in Table 3 above. The findings are illustrated in Figure 9 and summarized in Table 4.

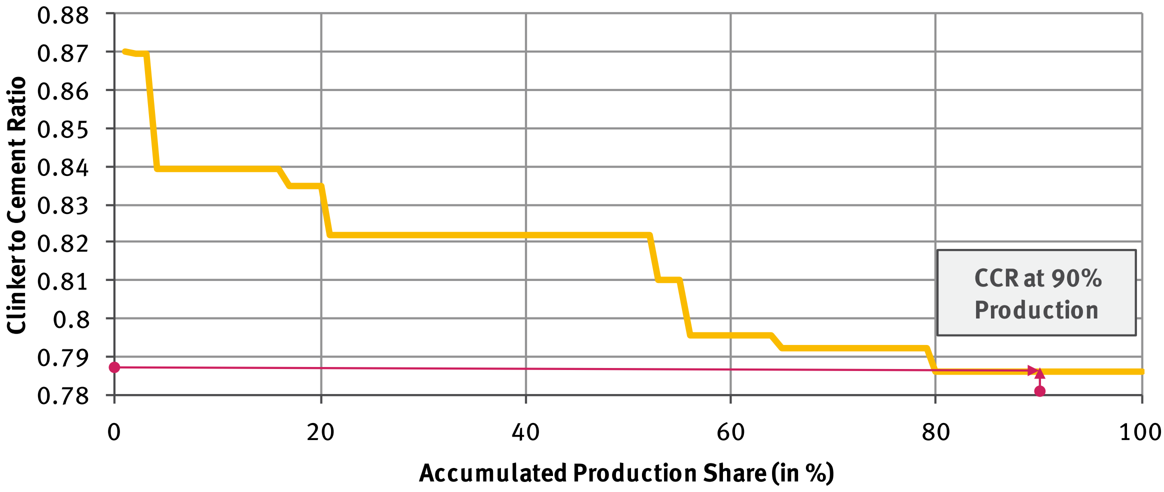


Figure 9: Determination of the Clinker to Cement Ratio Benchmark

Table 4: Standardised Baseline Assessment – CCR

Company	1	2	3	4	5	6	7	8	9
CCR (in %, t clinker/t cement)	87.0%	87.0%	83.9%	83.5%	82.2%	81.0%	79.6%	79.2%	78.6%
Cement Production (in 1000 t)	109.5	1,191.5	6,205.2	2,020.3	15,396.7	674.7	4,088.2	7,357.9	10,080.0
Accumulated Production Share (in %)	0%	3%	16%	20%	53%	54%	63%	79%	100%

Following this approach allows for determining the CCR benchmark: Company 9 contributes 21% (i.e. from 79% to 100%, accumulated) to the national production and hence was identified as the company which determines the CCR for baseline establishment. The baseline CCR amounts to 78.6%.

4.2.3 A Combined Baseline Emission Factor

To arrive at a combined emission benchmark for the cement sector as a whole that is comparable to what we calculated in the previous section on Option A it is necessary to multiply the two benchmarks:

$$specific\ emissions\ of\ clinker\ production \left[\frac{kg\ CO_2}{t\ clinker}\right] \cdot CCR \left[\frac{t\ clinker}{t\ cement}\right]$$

$$838.6\ \frac{kg\ CO_2}{t\ clinker} \cdot 0.786 \frac{t\ clinker}{t\ cement}$$

$$= 659.1\ \frac{kg\ CO_2}{t\ cement}$$

Again, this result does not include emissions from external electricity generation.[1] To allow for comparability it is necessary to add these emissions. Coincidently, one and the same company sets the benchmark both for the CCR as well as the specific emissions of clinker production. It is also the same company that sets the benchmark for specific emissions of cement production in Option A above. This particular company specifies external emissions from electricity generation of 70.5 kg CO_2/t cement (for a discussion of grid emission factors see also Box 4 below). Adding these to the emission factor calculated above yields a combined emission factor of **729.6 kg CO_2/t cement** which differs slightly from the result obtained in Option A. The results are therefore identical in our case for Option A and Option B. The slight deviation of 0.1 kg CO_2tone/t cement can be explained by rounding errors in the data template.

4.3 Option C – Low Level of Integration

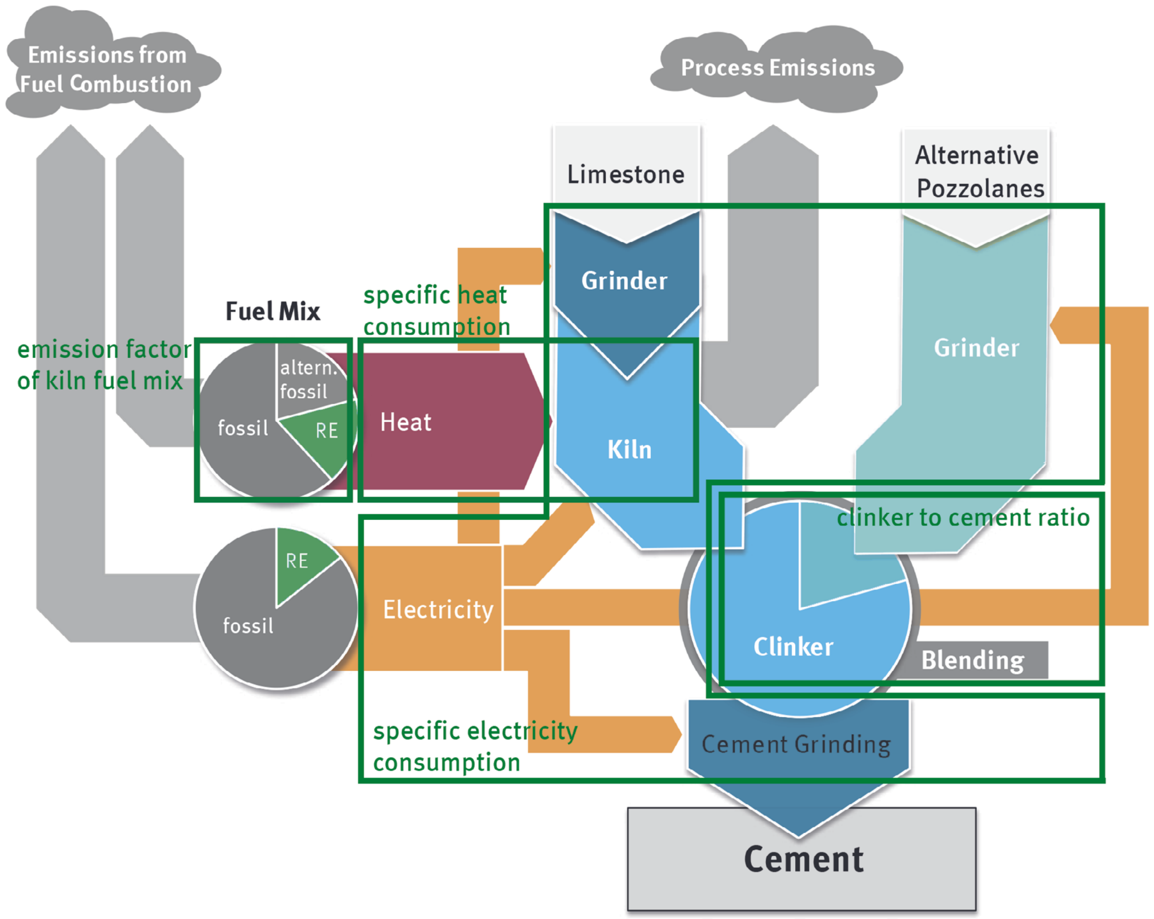
Under this third scenario we try to explore an as detailed as possible approach. We therefore dis-integrate the cement production process into as many separate sub-process benchmarks as possible. These are:

- The **clinker to cement ratio**, which covers the relation of clinker to cement and hence indirectly the overall emissions of one tonne of cement.
- The **specific heat consumption** in MJ/t clinker, which is based on the efficiency of the kiln.
- The **emission factor of the kiln fuel mix** in kg CO_2/GJ, which also accounts for the use of alternative fossil fuels and biomass and biomass residues.
- The **specific electricity consumption** in kwh/t cement.

The set of sub-indicators is schematically illustrated in Figure 10 below.

---

[1] Please note that the above formulae do not include emissions from cement production apart from the emissions from the clinker production (i.e. excludes emissions related to off-site electricity consumption) Considering average electricity consumption of 99.20 kWh/t cement and considering an average grid emission factor of 0.781 t CO_2/MWh (please refer to Box 4), this assessment slightly underestimates the real emissions (i.e. by approx 77.47kg CO_2/t cement.



Source: Wuppertal Institute

Figure 10: Figure 10: Schematic Illustration of the Measurement Approach applied in Option C – low Level of Integration.

Ideally, this set could be complemented with a plant specific emission factor for the power consumed on site, but data is not available to calculate this benchmark for all companies. Such a detailed approach allows tracking more accurately in which sectors mitigation options are successful or not. Furthermore the SB Guidelines in §46 EB65 Annex 23 specifies:

'When multiple measures are simultaneously applied in a sector or in a section of the sector it is necessary to derive a baseline emission factor that integrates the combined effect of all the measures applied and other influencing factors e.g. fuel/feed stock and respective Net Calorific Values (NCV), baseline technology and its design features such as electricity/heat consumption/generation capacity, grid emission factor of electricity consumed. For example in the cement sector there can be several GHG emission reduction actions associated with cement production such as: a) substitution of fossil fuels with alternative fuels, b) use of alternative raw materials, c) decrease of the clinker content in the cement production mix, d) energy efficiency improvements and e) electricity generation from waste heat and renewable energy. A baseline emission factor for this sector in a region may be determined through a calculation based on the following information: baseline fuel/feed stock and its carbon emission factor and NCV, baseline technology particularly its specific fuel/ feed stock/electricity consumption per its design and the grid emission factor of the electricity."

If a fully integrated approach is chosen, it is not possible to explicitly account for the type of information. As defined in chapter 2, full integration would mean to take into account only specific emissions from cement production as an aggregated indicator, concealing a more nuanced assessment through the indicators mentioned above.

4.3.1 Clinker to Cement Ratio

The calculation of the CCR is identical to the one carried out in section 4.2.2 above. The benchmark CCR is 78.6 per cent.

4.3.2 Specific Heat Consumption

The specific heat consumption expresses the thermal efficiency of a plant. The thermal process takes place in the pre-heater and kiln components of a cement plant. Mitigation options such as improved kiln design and waste heat recovery to pre-heat raw material are the main means to decrease specific heat consumption and consequently to reduced emissions from fuel combustion.

The calculation of the benchmark follows the same methodological approach applied in the benchmark setting exercises above. The companies are ranked in descending order of their respective specific heat consumption in GJ/t clinker. The cumulative share of production was calculated as above. The results are illustrated in Figure 11 and summarized in Table 5.

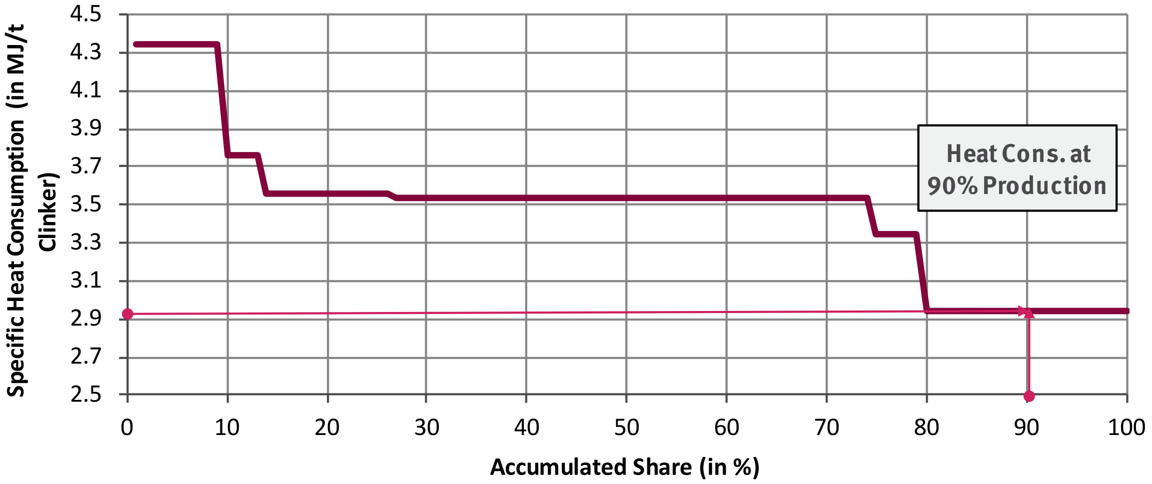


Figure 11: Determination of a Benchmark for Specific Heat Consumption

Table 5: Standardised Baseline Assessment – Specific Heat Consumption

Company	1	2	3	4	5	6	7	8	9
Specific Heat Consumption (in MJ/t Clinker)	4.344	3.759	3.556	3.542	3.542	3.503	3.345	3.344	2.946
Cement Production (in 1000 t)	4,088	2,020	6,205	110	1,348	1,191	7,358	15,397	9,837
Accumulated Production Share (in %)	9%	13%	26%	41%	74%	74%	77%	79%	100%

Again, the 90 per cent benchmark falls into the realm of company 9 which contribute 21 per cent of the total sectoral output. The baseline factor is determined with 2.946 GJ per tonne clinker.

4.3.3 Emission Factor of the Kiln Fuel Mix

In Indonesia, coal is the staple fuel for cement kilns. All companies heavily rely on coal and some use it exclusively. However, it is possible to reduce emissions by co-firing with biomass residues or alternative fossil fuels such as tyres, waste oils or plastics, or other forms of (industrial) fossil based wastes. Since direct emissions from fossil fuel combustion are the second most important source of emissions in the cement production process (IEA 2009), there is substantial potential for emission reductions available.

The development of two separate benchmarks, one for alternative fossil fuels, one for biomass was considered. However, the two indicators can at least partially overlap and/or offset each other's effect. A company with a relatively high share of alternative fossil fuels might feature the same emission factor of the fuel mix as a company that does not use alternative fossil fuels but co-fires biomass in a limited amount. In such case it would not be possible to generate a non-ambiguous ranking of the companies. We therefore reverted to the emission factor of the kiln fuel mix as indicator.

The available data set does not cover the required data for all companies. For three out of nine companies the emission factor hence was estimated on the basis of the quotas of biomass and alternative fossil fuels in the fuel mix. For biomass we assumed it would be sustainably resourced and therefore an emission factor of 0 would apply and for alternative fossil fuels we reverted for the value of 'mixed industrial waste' (with a value of 83 kg CO_2/GJ) as specified in the WBCSD CSI's data template. Cross-checks with other data where values were available suggested that the estimates are reasonably accurate.

The calculation of the emission factor benchmark for kiln fuel mix follows the same structure as the various benchmarks presented above. Companies are ranked in descending order of their respective emission factor. Subsequently they are associated with their respective accumulated share of total sectoral production. For this indicator, the 90 per cent benchmark is set by company 8. The best performing company in this indicator only provides 9 per cent of the total sectoral output. So the 90th percentile of output is provided by the second best performing company. The benchmark emission factor of kiln fuel mix is set at 93.11 kg CO_2/GJ. The results are illustrated in Figure 11 and summarized in Table 6.

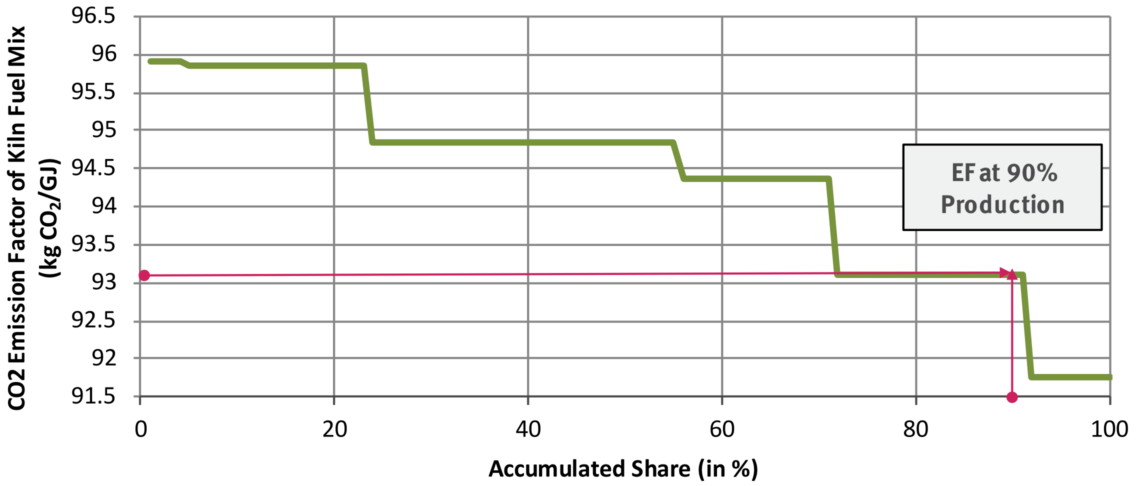


Figure 12: Determination of a Benchmark for Emission Factor of Kiln Fuel Mix.

Table 6: Standardised Baseline Assessment – CO_2 Emission Factor of Kiln Fuel Mix

Company	1	2	3	4	5	6	7	8	9
CO_2 Emission Factor of Kiln Fuel Mix (kg CO_2/GJ)	95.91	95.86	95.85	95.85	95.85	94.86	94.37	93.11	91.75
Cement Production (in 1000 t)	2,020	6,205	110	1,348	1,191	15,397	7,358	9,837	4,088
Accumulated Production Share (in %)	4%	17%	18%	20%	23%	55%	71%	91%	100%

4.3.4 Specific Electricity Consumption

Similarly to the specific heat consumption indicator, the specific electricity consumption allows to examine the efficiency of a given cement plant; however, not thermal- but electric efficiency. There are numerous ways to reduce the electricity consumption of e.g. electric motors. These are for example the use of improved grinding media, high efficiency classifiers, efficient grinders/mills but also efficient kiln design to some extent.

The calculation of the specific electricity consumption benchmark follows the established SB approach: Companies are ranked in descending order of their respective specific electricity consumption. Subsequently they are associated with their respective accumulated share of total sectoral production. For this indicator, again the 90 per cent benchmark is set by company 9, which provides 21 per cent of the total sectoral output. The baseline specific electricity consumption is set at 89.17 kWh/t cement. The results are illustrated in Figure 13 and summarized in Table 7.

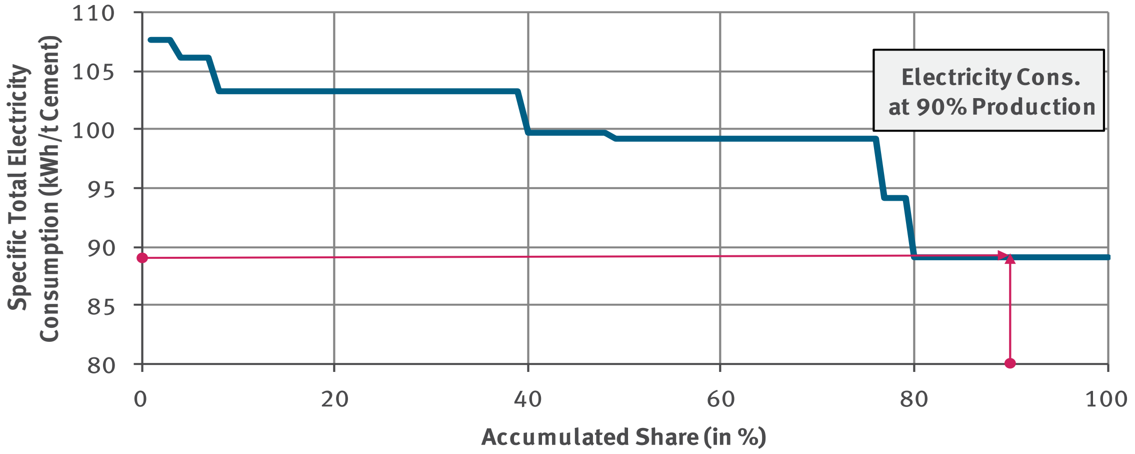


Figure 13: Determination of a Benchmark for Specific Electricity Consumption

Table 7: Standardised Baseline Assessment – Total Specific Electricity Consumption

Company	1	2	3	4	5	6	7	8	9
Specific Total Power Consumption (kWh/t Cement)	107.52	106.17	103.18	99.70	99.20	99.20	94.43	94.21	89.17
Cement Production (in 1000 t)	1,191	2,020	15,397	4,088	110	1,348	7,358	6,205	9,837
Accumulated Production Share (in %)	3%	7%	39%	48%	63%	76%	76%	79%	100%

4.3.5 A Combined Baseline Emission Factor

To determinate a combined benchmark emission factor that is comparable to the emission factors determined in chapters 4.1 and 4.2 respectively we calculate in a first step the specific emission factor of the three basic streams of carbon emissions in the cement industry: [1] process emissions from the calcination process, [2] direct emissions from fuel combustion for heat generation and [3] indirect emissions from electricity consumption. To obtain the combined emission factor, the three emission factors (EF) are to be added up.

Two basic parameters are relevant for the determination of the specific emission factor of the process emissions [1]: The CCR and clinker emission factor. The clinker emission factor is the product of the fraction of lime in the clinker multiplied by the ratio of the mass of CO_2 released per unit of lime. This in turn depends on the content of CaO in the raw material that is used to produce clinker.

Unfortunately, only 5 of the 9 companies in the Indonesian cement sector specify a clinker emission factor. The IPCC default value for clinker emission factor is 507kg CO_2/t clinker (IPCC 2000). However, the data specified by the 5 companies indicate that presumably due to the type of limestone that is available in Indonesia as a raw material, the clinker emission factor is significantly higher than the IPCC default value. The average clinker emission factor of the five companies for which data is available is 545kg CO_2/t clinker. We use this more conservative value to determine the benchmark emission factor for the process emissions.

The specific emissions from the calcination process can be calculated as:

$$
\begin{aligned}
clinker\ emission\ factor \left[\frac{kg\ CO_2}{t\ clinker}\right] \cdot CCR \left[\frac{t\ clinker}{t\ cement}\right] \\
= 545\ \frac{kg\ CO_2}{t\ clinker} \cdot 0.786\ \frac{t\ clinker}{t\ cement} \\
= \mathbf{428.37}\ \boldsymbol{\frac{kg\ CO_2}{t\ cement}}
\end{aligned}
$$

To calculate [2] the specific emission of fuel combustion to for heat generation in order to maintain the calcination process in the cement kiln the product of three basic parameters is relevant: The thermal efficiency of the kiln, the emission factor of the fuel kiln mix and the CCR.

$$
\begin{aligned}
thermic\ efficiency \left[\frac{GJ}{t\ clinker}\right] \cdot EF\ of\ kiln\ fuel \left[\frac{kg\ CO2}{GJ}\right] \cdot CCR \left[\frac{t\ clinker}{t\ cement}\right] \\
= 2.946\ \frac{GJ}{t\ clinker} \cdot\ 93.11\ \frac{kg\ CO2}{GJ} \cdot\ 0.786\ \frac{t\ clinker}{t\ cement} \\
= \mathbf{215.60}\ \boldsymbol{\frac{kg\ CO_2}{t\ cement}}
\end{aligned}
$$

The baseline emissions factor of [3] the indirect emissions through electricity consumption can be calculated as the product of the electric efficiency and the specific emission factor of the electricity provided. Unfortunately it was not possible to obtain plant specific electricity emission factors (see Box 4). We therefore revert to the average combined margin grid emission factor for Indonesia (IGES 2014). The average combined margin grid emission factor is determined at 0.7568 kg CO_2/kWh.

The specific emissions from electricity consumption calculate as:

$$
\begin{aligned}
electricity\ emission\ factor \left[\frac{kg\ CO_2}{kWh}\right] \cdot specific\ electricity\ consumption \left[\frac{kWh}{t\ cement}\right] \\
= 0.7568\ \frac{kg\ CO_2}{t\ clinker} \cdot 89.17\ \frac{t\ clinker}{t\ cement} \\
= \mathbf{67.48}\ \boldsymbol{\frac{kg\ CO_2}{t\ cement}}
\end{aligned}
$$

The combined baseline emission factor is the sum of these three streams and amounts to **711.45 kg CO_2/t cement**. As it is again the same company that sets the benchmark for each and every indicator, the combined baseline emission factor under Option C should be identical to the emission factors calculated under Option A and B. The slight difference can be explained by the application of the combined margin grid emission factor which is slightly lower than the average grid emission factor for the benchmark setting company that operates its cement plants in Java.

BOX 4: Grid Emission Factors

The emission factor of electricity of a given electricity grid is essentially determined by two parameters: the fuel mix that is used to produce electricity and the efficiency of the power plants that supply this energy (not accounting for losses in the grid itself). However, the situation is more difficult in Indonesia. Being an archipelago, a single electricity grid does not exist. Instead, the National Committee on the CDM (the Indonesian DNA) lists GEFs for the 8 largest electricity grids in the country and these GEFs vary substantially (see table).

Table 8: Grid Emission Factors in Indonesia

Interconnection System and Reference Year		Emission Factor (tCO_2/MWh)	
		Ex-ante	Ex-post
1.	Interconnection System Jawa-Madura-Bali (JAMALI) a. 2011 b. 2012	 0.770 0.814	 0.778 0.823
2.	Interconnection System Sumatra a. 2011 b. 2012	 0.717 0,686	 0.724 0.687
3.	Interconnection System Khatulistiwa (West Kalimantan) a. 2011 b. 2012	 0.730 0,730	 0.726 0,732
4.	Interconnection System Barito (South & Central Kalimantan) a. 2011 b. 2012	 0.912 0,900	 0.888 0.900
5.	Interconnection System Mahakam (East Kalimantan) a. 2011 b. 2012	 0.930 1.030	 0.959 1.069
6.	Interconnection System Minahasa-Kotamobagu a. 2011 b. 2012	 0.465 0,532	 0.480 0.600
7.	Interconnection System South & West Sulawesi a. 2011 b. 2012	 0.388 0,710	 0.364 0.746
8.	Interconnection System Batam a. 2011 b. 2012	 0.485 0.806	 0.473 0.839

Source: National Committee on the Clean Development Mechanism – Indonesia (2014)

As the data is available at company level and most companies operate plants on different islands, it was not possible to associate island-specific emission factors with electricity consumption of cement production.

4.4 Comparison of different Benchmark Setting Approaches

All three benchmarks produce identical results. This outcome is a particularity of the Indonesian cement sector where the same company sets the benchmark for every process. On the basis of the available data it is therefore possible only to discuss the different approaches qualitatively.

Apparently, one company is a top performer in all sub-processes of cement production and also contributes a significant share (21%) of the sectors total output. The only benchmark in which this particular company is not the top performer is the CO_2 emission factor of kiln fuel mix. In this benchmark the company comes second but due to the small production share of the top performer in this benchmark, it is again the same company that does set the baseline at an accumulated production share of 90 per cent. Due to this peculiarity of the sector, the subsequent discussion of different levels of integration remains theoretical.

As indicated above, the Indonesian cement sector may be considered as a specific case. Assuming the case where one company is not leading in all specific processes, the subsequent section discusses the differences of an approach with high- and low level of integration.

- **Integrated Approach:** One company may perform well in one specific process, but may perform badly in others. The good performance in one sector may be compensated by the bad performance in other sectors. This will lead to a higher emission factor for the sector.
- **Low level of integration Approach:** Different companies will lead each specific process. The emission factor would be the sum of the best performers and hence will be lower than the integrated approach above.

The following conclusions are drawn:

- Most importantly, the above findings demonstrate that the SB framework allows for developing a sector SB which can host a set of very heterogenic processes such as cement blending, emissions from heat consumption, fuel types for clinker production, electricity consumption and other.
- The low integration approach may lead to a lower sectoral emission factor and hence is more conservative. However the sector benchmark would be set by a hypothetical or virtual company combining best practices of all sub-processes in the cement industry. This virtual company does not necessarily exist in this constellation. Hence, despite being conservative, a low level of integration may not always be appropriate.
- The company which sets the benchmark for all options of integration produces 21.12% of Indonesia's total cement production (average 2010-12). The fact that this company defines the best benchmark for all options indicates that in the cement sector larger companies have more opportunities to produce efficiently (e.g. larger kilns are more efficient than smaller ones).
  For sectors which are characterized by such effects of scale, the SB aggregation over all companies may not allow to incentivize mitigation measures for small companies. If a small company would implement a mitigation measure (e.g. installation of a waste heat recovery system), the intervention's impacts may not reduce the company's overall emission level below the benchmark set by a large company.
  Consequently, for sectors which are characterized by scale effects of production, it may be worthwhile to investigate different levels of aggregation (please refer to Section 5.2 for a detailed discussion).
- However, the low integration approach requires individual companies to report relevant data at the level of processes. This does not only allow to identify mitigation potentials in a more detailed manner, but the data may also be of high value if the SB is applied in the context of a NAMA, as it allows for accurately monitoring the impact of different initiatives e.g. financing facility for waste heat recovery or change of regulations to promote a decrease of CCR (see also section 7).

5 Robustness of the Performance Penetration Approach

5.1 Assessment of the Relevance of Number of Market Players

This section explores the impact of fragmentation of the sector, i.e. the number of market players on the determination of the Standardised Baseline emission factor. In Indonesia, there are only 9 market players which is considered as a low figure. We therefore explore in the following how the emission factor changes, if the number of market players would e.g. double.

Methodology. The following methodology was applied:

- A hypothetical case is constructed, where the number of market players, currently 9 companies (subsequently referred to as scenario 1), doubles to 18 (i.e. scenario 2).
- This case is solely investigated for 'Option A – No Integration' which explores the determination of the baseline emission factor for the specific emissions of cement production (i.e. in kg CO_2/t cement).
- To increase the number of companies of the sector, all 9 existing companies are split into two separate companies with identical production shares.
- It is assumed that the average emission factor of the two companies generated from each original company is the same as the one of the respective original companies.

- The emission factor of one of the newly generated companies increases by 10 per cent as compared to the original company and the other companies' emission factor decreases by 10 per cent. To give an example, if the original Company 1 features an emission factor of 800 kg CO_2/t cement and an output of 10 per cent of total sectoral production, we generate Company 1-A with an EF of 880 kg CO_2/t cement and Company 1-B with an EF of 720 kg CO_2/t cement, both with an output of 5 per cent of total sectoral production.

The table below presents the results of the approach outlined above.

Table 9: Evaluating SB EF Setting for different Numbers of Market Players

Scenario 1: 9 Market Players				**Scenario 2: 18 Market Players**			
ID	**Cement Emissions (in tCO_2/t cement)**	**Cement Production (in t)**	**Accumulated Production Share (in %)**	**ID**	**Cement Emissions (in tCO_2/t cement)**	**Cement Production (in t)**	**Accumulated Production Share (in %)**
Company 1	935.07	36,500	0%	Company 1-A	1,028.58	18,250	0%
				Company 1-B	841.57	18,250	0%
Company 2	848.84	2,020,263	4%	Company 2-A	933.72	1,010,131	2%
				Company 2-B	763.95	1,010,131	4%
Company 3	840.74	1,191,481	7%	Company 3-A	924.82	595,740	6%
				Company 3-B	756.67	595,740	7%
Company 4	828.92	6,205,179	20%	Company 4-A	911.81	3,102,589	13%
				Company 4-B	746.03	3,102,589	20%
Company 5	797.75	1,348,466	23%	Company 5-A	877.53	674,233	21%
				Company 5-B	717.98	674,233	23%
Company 6	786.35	15,396,673	55%	Company 6-A	864.98	7,698,337	39%
				Company 6-B	707.71	7,698,337	55%
Company 7	776.90	4,088,195	63%	Company 7-A	854.60	2,044,097	59%
				Company 7-B	699.21	2,044,097	63%
Company 8	771.88	7,357,917	79%	Company 8-A	849.07	3,678,959	71%
				Company 8-B	694.69	3,678,959	79%
Company 9	729.45	10,079,999	100%	Company 9-A	802.40	5,040,000	89%
				Company 9-B	656.51	5,040,000	100%
	Total	**47,724,673**			**Total**	**47,724,673**	

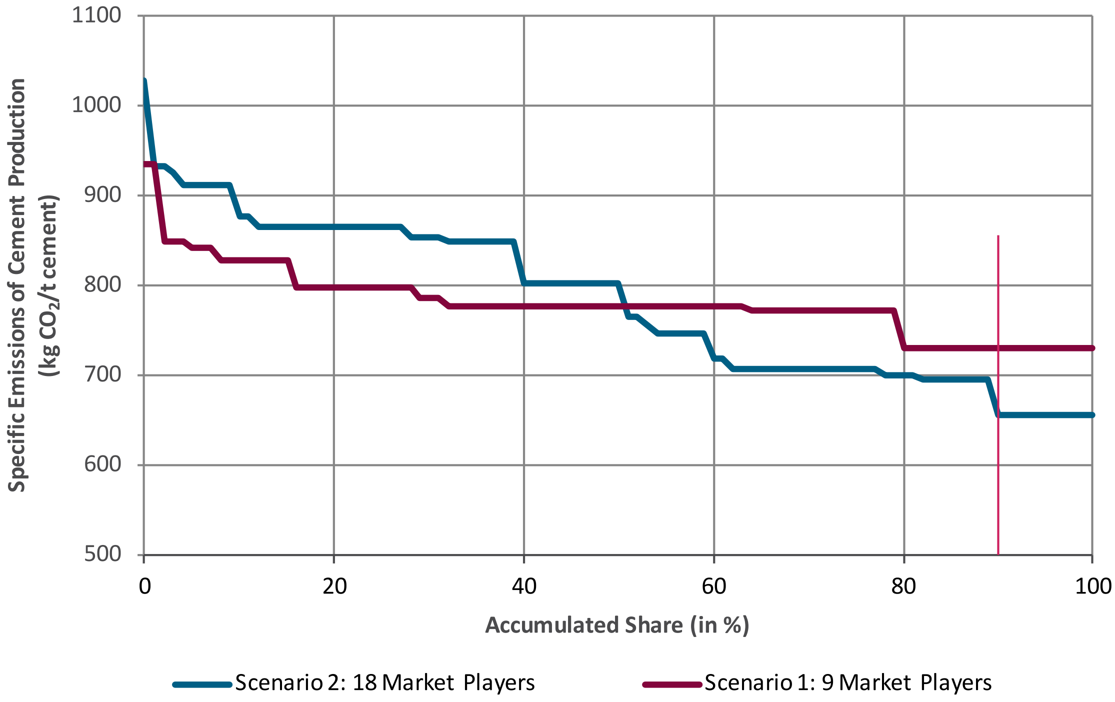


Figure 14: Comparing Benchmark Setting for Different Number of Market Players

Figure 14 shows the impact of a higher degree of fragmentation in the market:

- Scenario 2 amounts to the same total emissions but features a much steeper gradient resulting in a baseline emission factor of 593.03 kg CO_2/t cement.
- At the 90 per cent threshold Scenario 1, which is identical to the calculation in section 4.1 (Option – A) features a baseline emission factor of 658.92 kg CO_2/t cement.

This analysis points to the critical role of exact and highly disaggregated data. In our case, it was only possible to obtain company-specific data. However, most of these companies operate more than one production line and some even more than one production site. The company that sets the baseline in all three options above, for example, comprises 13 production lines at three different production sites. It is very much likely that these production lines vary in their individual performance, much like the dummy companies we have generated in Scenario 2.

The following conclusions are drawn:

- A higher number of market players leads to a lower and more accurate SB emission factor. The current SB Guidelines do not specify whether the benchmark shall be developed based on company data or based on production facility data.
- Providing some room for flexibility to DNAs and project developers seems reasonable. However, the impact on the SB emission factor may increase, the smaller the number of market player.
- Against this background, it may be worthwhile to introduce stipulations in the SB Guidelines which requires the DNAs and project developers to establish the SB on the level of production facilities if the number of market players is below a certain threshold, e.g. 20.

5.2 Investigating the Level of Aggregation

As Section 5.1. explored the level of integration, this section evaluates the level of aggregation. The respective paragraphs of the SB Guidelines allow for some flexibility. In this chapter we will therefore discuss if and which kinds of alternative approaches to setting the level of aggregation are conceivable. Furthermore, we will investigate the impact in terms of differences in combined emission factors for various options.

We will specifically look at two alternative approaches: Splitting the sector in state-owned and private sector-owned cement plants and dividing the sector by the production capacity of the plant/production line.

5.2.1 Aggregation by Ownership

The Indonesian cement sector is dominated by private owned companies operating on an international scale. However, the two smallest cement producers are publicly owned. These companies operate under different circumstances. These companies do not necessarily need to generate substantial profits but are supposed to provide construction materials and employment in remote places. Due to this market structure there is some room to argue for a disaggregation between publicly and privately operated parts of the sector. The effects of this disaggregation will be discussed subsequently.

Table 10 summarizes the benchmark for the public cement sector. The baseline is set by company 2 at 757.9 kg CO_2/t cement. The baseline emission factor is substantially higher than the one determined in the fully aggregated approach above.

Table 10: Standardised Baseline Assessment – Emissions of Cement Production: State Owned

Item	Company 1	Company 2
Cement Emissions (in tCO_2/t Cement)	860.0	757.9
Cement Production (in t)	36,500	1,191,481
Accumulated Production Share (in %)	3%	100%

A dis-aggregation of the sector has the effect that the respective market share of every company increases. It is therefore possible that due to this increase in market share a top performing company gets to set the baseline at the 90 per cent threshold that has not done so in a fully aggregated approach. In our case, however, the top performing company already had a market share above 10 per cent in the entire sector and thus an increase of market share due to a disaggregation of the sector does not lead to an increased baseline emission factor. The baseline emission factor is thus the same as in the benchmarking exercises above, 958.9 kg CO_2/t cement (see **Table 11**).

Table 11: SB Assessment – Emissions of Cement Production: Privately Owned

Company	1	2	3	4	5	6	7
Specific Emissions (in tCO_2/t Cement)	768.7	746.1	745.7	728.3	700.7	696.3	658.9
Cement Production (in t)	2,020.3	4,088.2	6,205.2	1,348.5	15,396.7	7,357.9	10,080
Accumulated Production Share (in %)	4%	13%	26%	29%	62%	78%	100%

The effect of the disaggregation of the sector into private and public sub-sector is illustrated in Figure 15. The green graph represents the public sub-sector benchmark, red represents the private sub-sector and the fully aggregated benchmark of section 4.1 is represented in blue.

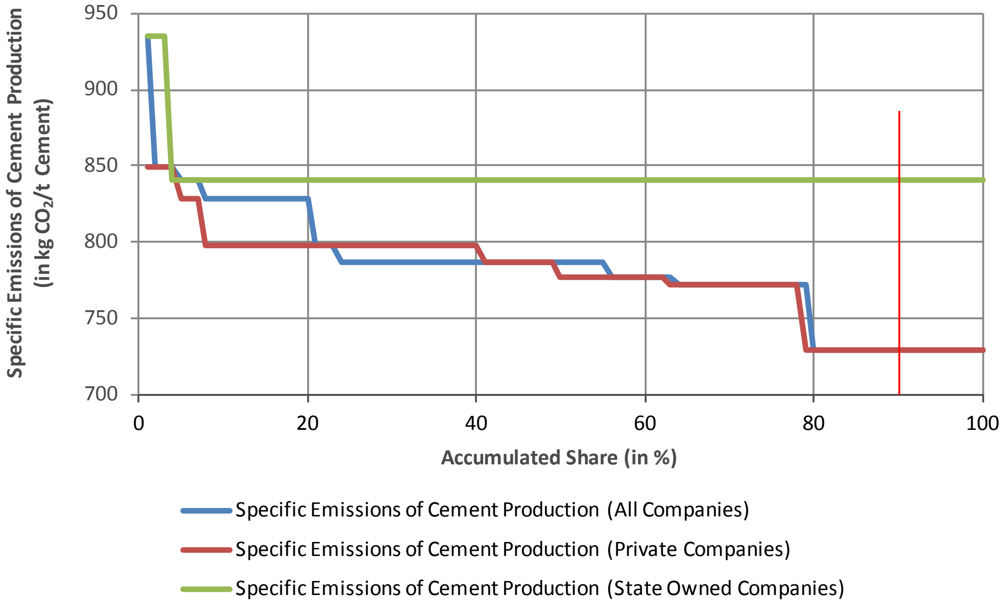


Figure 15: Comparing Benchmark Setting for different Levels of Aggregation

5.2.2 Aggregation by Capacity of the Production Line

The scale of the production line is an important factor for the efficiency of a plant. For example, the thermal efficiency of a plant is directly linked to the volume of the kiln. Furthermore, some mitigation options may involve scale independent costs and thus prove unfavourable in small production sites.

A disaggregation on the basis of size of the production line may therefore be worth exploring. Such a disaggregation could in fact decrease the baseline emission factor for large scale production lines, demanding a higher level of ambition from this kind of facilities and at the same time set a benchmark for small-scale production lines which is not too ambitious to discourage investments in climate change mitigation.

However, since data on the size of individual production lines is not available, it was not possible to conduct a quantitative analysis of this approach.

5.2.3 Discussing Different Levels of Aggregation

A disaggregation of the sector into smaller sub-sectors can theoretically lead to more accurate results if the resulting sub-sectors are more homogenous than the total sector. Disaggregation can increase the level of ambition necessary to meet the benchmark for better performing sub-sectors and still set a reasonable benchmark for lower performing sub-sectors, which still encourage investments in mitigation.

However, our analysis shows that such disaggregation achieves the desired effect only if the number of companies/production lines in the benchmark is sufficiently large and correspondingly their respective market share is low. The example of chapter 5.2.1 shows that, if the market share of the top performing company is too large, a disaggregation does not alter the benchmark for the sub-sector.

6 Sector Standardised Baselines and Automatic Additionality

Besides the development of a baseline emission factor, the SB Guidelines in general allow for establishing a positive list of technologies or fuels that are deemed automatically additional under the CDM. Alongside the development of the baseline emission scenario the demonstration of additionality is arguably one of the most cumbersome and laborious elements of developing a CDM project. The development of a positive list allows to limiting the transaction cost for project developers. It is therefore often considered one of the most valuable elements of an SB. The SB Guidelines require to demonstrate additionality in a two-step approach. Firstly, candidates for the positive list can be identified using the PP approach (see Box 1 above).

Second, for each of these technologies, fuels or feedstock it has to be established on a sectoral level that these are either not financially viable (i.e. through investment analysis) or are facing barriers. However, this second step seems not to be practical in the case of the cement sector for a number of reasons:

- Some of the mitigation options (e.g. blending and co-firing with biomass/alternative fossil fuels) can be optimized gradually. In this case it is possible to calculate a benchmark, but hardly possible to argue why a certain quota of co-firing or blending is not yet additional but another quota is.
- Barrier analysis is difficult to conduct on a sectoral scale, because barriers may exist for some potential projects and not for others. For example, alternative pozzolanic materials or alternative fossil fuels may be available at one site but not at another. Furthermore, some of the technology switch mitigation options listed in Table 1 may be additional (through barriers or financial viability) for retrofit of existing plants but not if they are implemented in a newly constructed production line.
- If several mitigation options are combined, it would be necessary to demonstrate additionality for all possible combinations of mitigation options, which creates an enormous list of different 'sets of technologies'. It is also difficult to rank these sets of technologies in the required way if different combinations of the available mitigation options lead to similar or identical emission factors.

Despite these fundamental challenges we briefly discuss the establishment of a positive list in the light of an integrated SB based on the data set available. However this section does not aim at the conduction of an investment analysis for specific measures and hence remains on a general level.

The development of a positive list faces a structural challenge. If the performance benchmark is calculated on the basis of highly integrated indicators (as in Chapter 4, Option A and B), it is virtually impossible to conduct an investment analysis or barrier analysis for these indicators. As discussed above, there is a large number of mitigation options available. Any emission factor can be explained by a large number of different combinations of production processes. Given that some of these can also be introduced gradually (e.g. co-firing biomass), one emission level may be related to large number of possible combinations of technologies. Against this background, it will not be possible to develop a positive list for all possible combinations of technologies. However the DNA may start to establish a positive list for one technology, e.g. WHR, and the positive list may be expanded along with the actual needs of the cement sector in the future.

However, the dis-integrated approach proposed in Option C above does allow for a more detailed assessment of the mix of different mitigation options. While not conform with the current SB Guidelines, such an approach could open methodological pathways to further assess additionality. For example, given the set of sub-benchmarks proposed in Option C, it would be possible to establish positive lists for the individual sub-processes, i.e. for example establish an additionality threshold for cement blending as in defining a CCR threshold beyond which blending is considered additional or a rate of biomass/ alternative fossil fuel co-firing which is deemed additional. In such a semi-standardised approach the project proponent's responsibility would be reduced to demonstrating the additionality of those types of mitigation measures that cannot directly be covered by indicators.

7 From Benchmark to NMM/NAMA Baseline Setting

This section discusses the application of Standardised Baselines for New Market Mechanisms and Nationally Appropriate Mitigation Actions using Indonesia's cement sector as a practical example.

Both NMM and NAMAs may require the establishment of a business as usual (BAU) scenario and a project/ programme scenario in terms of GHG emissions. In some cases, such baselines may be based on the BAU emissions (e.g. five year average). However, where the BAU dataset indicates a systematic decrease of specific emissions over time, a five year average of GHG emissions is not considered to be conservative and alternative approaches need to be explored.

Standardised Baselines are considered as an instrument that may allow for transferring the knowledge and the wealth of methodological approaches to such new climate financing mechanisms. As the SB rules and procedures are developed under the UNFCCC framework, SBs are internationally recognized.

As indicated above, if the BAU emissions show a decrease of emissions, the NAMA/NMM requires the derivation of a trend. The trend component of the BAU dataset may be accounted for through reference to the CDM framework: The SB features a validity of 3 three years (CDM EB65, Annex 23, Appendix I, §1). A CDM project or programme may feature a crediting period of at least 7 years (cp. 4 CMP.1 Annex, §29) totalling a period of ten years where Certified Emission Reductions (CERs) may be claimed based on a specific SB. For the development of a steady NMM/NAMA baseline it hence may be assumed that the BAU emissions approach the SB benchmark linearly over a period of ten years. This approach allows for accounting for a systematic decrease of BAU emissions (and hence satisfies the baseline needs if BAU emissions decrease).

The SB's performance-penetration approach (cp. CDM EB65, Annex 23) allows establishing a GHG benchmark for a whole sector. Using this instrument ceteris paribus for NMM/NAMA development, a baseline would be structured as follows: The country may claim emission reductions at a specific point in time, if the sector's actual emissions are below the BAU emission level's steady approximation to the SB emission factor over ten years.

Such an application of the SB framework may look straight forward at first view. However it is hampered by two aspects:

- First, the performance penetration approach allows for issuing of CERs if a single project performs below the 90% (80%) threshold as specified in CDM EB65, Annex 23, Appendix I, §1. This requirement seems appropriate for individual facilities that want to earn CERs.
- However, it is far more demanding to require this from a sector as a whole: For the sector to generate emission reductions, the application of SB framework to NMM/NAMAs would require the sector as a whole to perform below the sector's approximation to the 90% (80%) threshold over 10 years.
- Second, the SB framework is binding if the GHG benchmark is to be developed under the CDM. The performance penetration approach however is not the necessarily the only reasonable approach for establishing sector specific benchmarks and NMM and NAMAs may eventually consider to deviate from this approach.

Against this background, the following section explores an alternative approach for NMM/NAMA baseline establishment and compares this with the results of the SB benchmark.

Table 12: Findings CSI GHG Database – World

Item	Value
Weighted average GHG Emissions (in kg CO_2/t Clinker)	852
Corresponding Percentage (in %)	57.7%
Number of Plants	651
Total Production (in Mt Clinker)	670
Formula of the linear Regression between 10% and 90%	Y = 1.08x + 793
Regression Coefficient (R2) between 10% and 90%	0.98
Standard Deviation (in kg CO_2/t Clinker)	83

Source: CSI, 2014

The alternative approach is based on the CSI database which reports the worldwide emissions from cement and clinker productions from all cement companies which partner with CSI. The table above provides key data which is subsequently used for the further analysis. In the most recent year, where data is available (2011), these companies jointly covered 651 cement plants and produced 670 Megatons clinker making up for 57.7% of the world's total clinker production. The average emissions of worldwide clinker production amounts to 852 kg CO_2/t clinker with a standard deviation of 83 kg CO_2/t clinker.

The statistical distribution of CO_2 emissions among individual companies is illustrated by the figure below. The vertical axis indicates the specific emission intensity (i.e. in kgCO_2/t clinker) whereas the horizontal axis presents the share of clinker production, ranked from lowest emission intensity (left) to highest emission intensity (right).

The average emission intensity (i.e. 852 kg CO_2/t clinker) is indicated by the thin black line, whereas the thick black line indicates the actual emissions, ranked from the best- (left) to worst performance (right).

The table above presents a formula which is the outcome of a linear regression analysis which has a high explanatory value (i.e. the R2 as statistical indicator for the explanatory value of a function indicates a value 0.98 for the companies ranked from 10% to 90%.)

In a first step, we use the CSI data set to establish a benchmark based on the best available technology (BAT) for the cement sector. Using above formula, the emissions of the top 10% percentile amounts to 793.11 kg CO_2/t clinker.

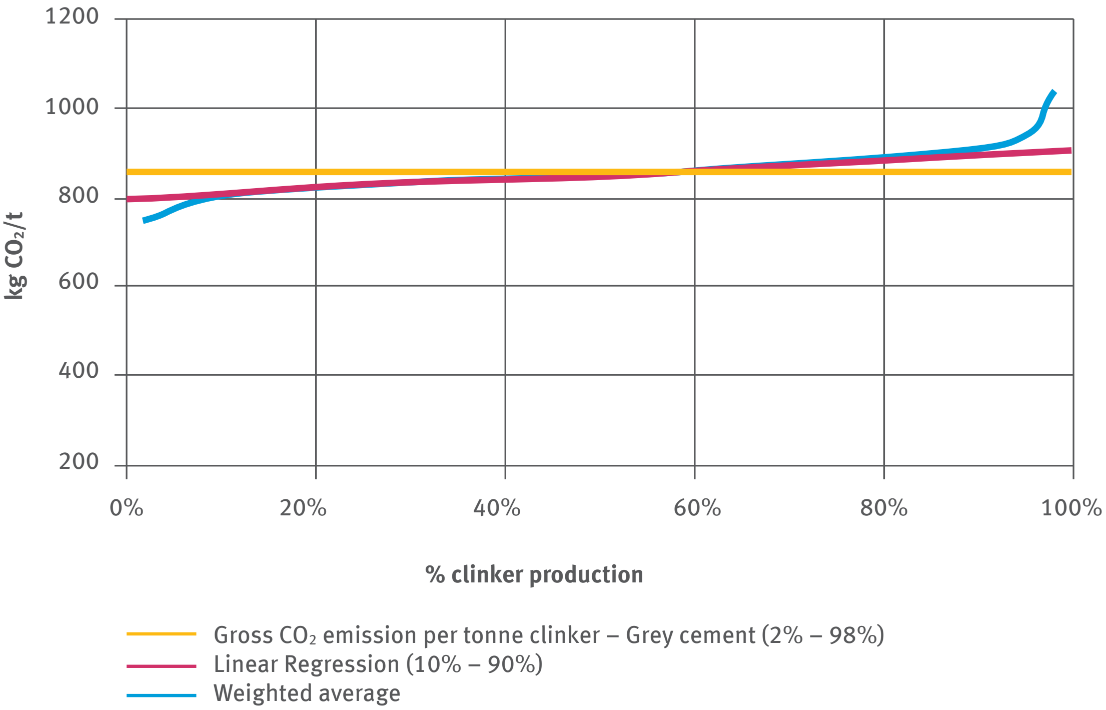


Figure 16: Worldwide specific Emissions of Clinker Production

In a second step, we follow the subsequent rationale for baseline. As cement production is highly capital-intensive, the typical lifetime of cement plants is 30 to 50 years (40 year average, CSI, 2009, p8). Looking at the actual dates of commissioning, Indonesia's two oldest cement plants were commissioned in 1980 (i.e. referring solely to integrated plants and neglecting grinding plants, which may be older). Hence we conclude that, as BAU scenario, the current average emissions of the clinker production in Indonesia adopts today's world's best available technology within a time period of 40 years.

This finally allows establishing an alternative BAU scenario based on the BAT dataset which is indicated in the table below as 'BAT based BAU Scenario'.

Table 13: Comparison of Baseline Approaches

Year	1	2	3	4	5	6	7	8	9	10	Decrease
BAT based BAU Scenario	868.35	866.47	864.59	862.71	860.83	858.95	857.06	855.18	853.30	851.42	1.95%
SB based BAU Scenario	868.35	866.41	864.46	862.52	860.57	858.63	856.68	854.74	852.79	850.85	2.02%

Comparing the two approaches to establish a BAU scenario over time for NMM/NAMA indicates that the BAT based approach indicates a business as usual decrease of specific clinker emissions of 1.95% over ten years. The SB based approach indicates a corresponding decrease of 2.02%. It is concluded that both approaches lead to similar results, whereas the SB approach being slightly more stringent.

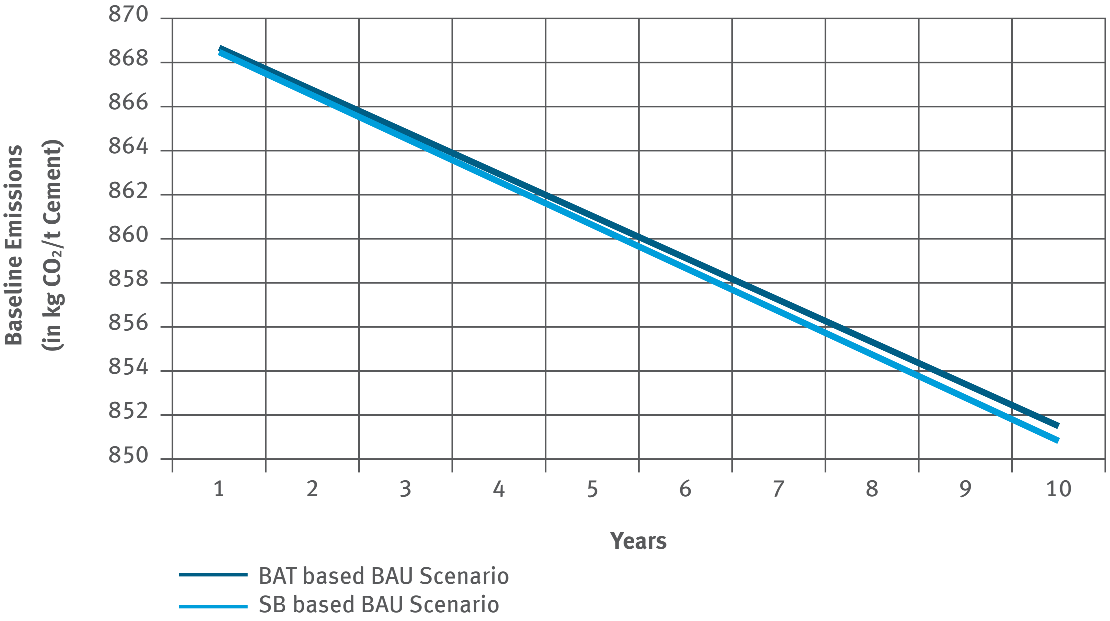


Figure 17: Comparison of alternative Approaches to BAU Scenario Setting for NMM/NAMA Development.

The following conclusions are drawn:

- Overall, there is a lack of internationally acknowledged guidance on the how to establish a BAU scenario for NAMAs and NMMs. This becomes evident if historic data indicates a systematic decrease of specific emissions.
- As such the SB framework may be a versatile instrument for establishing baselines, shaping (and monitoring) national sector-specific policies and serve as a building block for the development of NAMAs and New Market Mechanisms which will require an independently assessed and internationally acknowledged baseline.
- Comparison of the SB's performance-penetration approach with the BAT approach indicates that both concepts lead to similar results with the SB framework being slightly more stringent.
- However, the application of the SB framework faces constraints with respect to NMM/NAMA baseline development. For example, there is a lack of guidance on how to convert an SB (which is one value, valid for three/ten years) to a BAU scenario which reflects an annual decrease of BAU emissions.
  Considering the original purpose of the SB framework (linked to baseline establishment for CDM projects and programmes), this cannot be considered as shortcoming.

8 Cement SB Potentials in African Countries

High hopes have been placed in the concept of standardised baselines to alleviate the unbalanced regional distribution of the CDM. By reducing transaction costs for mitigation options, SBs could make projects financially viable that would otherwise be too small to recover the associated transaction costs. This problem has been associated as one factor why Africa has hitherto been largely bypassed by the CDM (cp. Kreibich et al. 2013), a factor that can be addressed through the development of SBs. In fact, the majority of proposed and approved SBs cover host countries located in Africa.

Furthermore, the EU ETS as the largest source of demand for CERs has determined that for the current trading period CERs from new projects (registered after 2012) are only eligible if these projects are located in LDCs, most of which are again in Africa.

Hence, this section explores the African emission potential that may be tapped by cement SBs. Table 14 and Table 15 below present the cement production in Africa from 2008 to 2010 (USGS 2011), split into Least Developed Countries (LDCs, having preferential access to the EU Emission Trading Scheme).

To estimate the total potential, the actual emissions are investigated. The Word Business Council on Sustainable Development reports on specific net emissions[2] of 629 tCO_2/t cement worldwide (GNR, 2014a) and 614 tCO_2/t cement in Africa (GNR, 2014b). It is interesting to note that Africa's specific emission level is below the world-average. This may be related to the fact that in Africa a comparably small share of companies participate in the WBCSD's survey. Only 45 per cent of African cement producers do so as compared to up to 97 per cent in Europe for example (CSI, 2012, p. 12). It can be assumed that under these 45 per cent are mainly large cement producers that operate relatively efficiently. The low emission level of the cement sector in Africa may be due to an overrepresentation of good performing companies in the survey.

To estimate the annual CO_2 emissions from cement production per country we multiplied the annual cement production of the years 2008 to 2010 with the specific emission factor cited above. The total production of 16 African LDCs amounts to 16.58 million tonnes cement (vintage 2010), the total related emissions amount to 10.18 million tCO_2. The total production of 13 African Non-LDCs amounts to 75.55 Million tons of cement, the related emissions amount to 45.78 million tCO_2.

Sector analysts predict the African cement market to grow substantially in the coming years (Cardinal Stone, 2013). It is expected that for example in Eastern Africa, the market growth will outpace GDP growth. The main driver for this expected growth is Africa's huge infrastructure deficit. Per capita consumption of cement is still extremely low as compared to other world regions. These prospects are also reflected by recent investments of cement producers. For example Nigeria has doubled its production capacity in recent years.

To assess a country's suitability of cement SB development, a first and rough approximation was developed: It is assumed that a cement sector in a given country may reduce its specific emissions at least by 10%, if appropriate provisions are offered (e.g. removal of political barriers, technical support and training as well as financing instruments for the implementation of low carbon technologies in the cement sector). It was further assumed that SB development is only reasonable if a host country's abatement potential is above 100,000 tCO_2 per year. If the potential would be smaller, the SB development costs would be in an inappropriate proportion compared to the actual emission reductions and related abatement costs. This should be considered as first, careful approximation, but this may be evaluated in detail on a country level evaluating country specific abatement costs and as well as related Marginal Abatement Costs (MAC, cp. MoI and AFD, 2010).

Table 14: Emissions of Cement Production in African Non-LDCs

Country	Cement Production (in mio t cement)			Cement Emissions (in mio tCO_2)			SBL Suitability
	2008	2009	2010	2008	2009	2010	(Yes/No)
Algeria	18.73	19.10	20.00	11.50	11.73	12.28	Yes
Morocco	14.52	14.00	12.00	8.91	8.60	7.37	Yes
Nigeria	5.00	6.00	11.60	3.07	3.68	7.12	Yes
South Africa	11.78	10.87	11.23	7.24	6.67	6.90	Yes
Tunisia	7.51	8.07	8.00	4.61	4.95	4.91	Yes
Kenya	3.32	3.71	3.97	2.04	2.28	2.44	Yes
Ghana	1.80	2.40	3.00	1.11	1.47	1.84	Yes
Libya	6.50	6.00	3.00	3.99	3.68	1.84	Yes
Zimbabwe	0.70	0.80	0.90	0.43	0.49	0.55	No
Côte d'Ivoire	0.28	0.28	0.30	0.17	0.17	0.18	No

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[2] Please note, net emissions refer to direct CO_2 emissions related to the production of cement and clinker excluding the emissions of biomass fuel sources as well as excluding emissions from alternative fossil fuels such as used tires (cp. CSI, 2012, p14).

Country	Cement Production (in mio t cement)			Cement Emissions (in mio tCO_2)			SBL Suitability
	2008	2009	2010	2008	2009	2010	(Yes/No)
Namibia	0.00	0.01	0.25	0.00	0.00	0.15	No
Gabon	0.25	0.20	0.20	0.15	0.12	0.12	No
Congo	0.11	0.08	0.10	0.07	0.05	0.06	No
Totals	**70.51**	**71.52**	**74.55**	**43.29**	**43.91**	**45.78**	

Source: Cement Production Data USGS 2011, Specific emissions from cement production in Africa, GNR, 2014

Table 15: Emissions of Cement Production in African LDCs

County	Cement Production (in mio t cement)			Cement Emissions (in mio tCO_2)			SBL Suitability
	2008	2009	2010	2008	2009	2010	(Yes/No)
Senegal	3.32	4.07	4.00	2.04	2.50	2.46	Yes
Ethiopia	2.10	2.90	4.00	1.29	1.78	2.46	Yes
Angola	1.80	1.50	1.50	1.11	0.92	0.92	No
Benin	1.50	1.43	0.80	0.92	0.88	0.49	No
Togo	1.16	1.15	1.78	0.71	0.71	1.09	Yes
Zambia	0.88	1.13	1.40	0.54	0.69	0.86	No
Mozambique	0.78	0.88	0.98	0.48	0.54	0.60	No
Uganda	0.65	0.65	0.65	0.40	0.40	0.40	No
Congo DR	0.46	0.49	0.38	0.28	0.30	0.23	No
Mauritania	0.34	0.35	0.40	0.21	0.21	0.25	No
Sierra Leone	0.24	0.30	0.31	0.14	0.18	0.19	No
Malawi	0.23	0.19	0.20	0.14	0.12	0.12	No
Liberia	0.07	0.07	0.06	0.04	0.04	0.04	No
Eritrea	0.05	0.05	0.05	0.03	0.03	0.03	No
Niger	0.04	0.04	0.04	0.02	0.02	0.02	No
Burkina Faso	0.03	0.03	0.03	0.02	0.02	0.02	No
Totals	**13.64**	**15.22**	**16.58**	**8.38**	**9.35**	**10.18**	

Source: Cement Production Data USGS 2011, Specific emissions from cement production in Africa, GNR, 2014.

Our analysis shows that there is significant potential for the application of SBs in the African cement sector. The data suggests that the markets of Algeria, Morocco, Nigeria, South Africa, Tunisia, Kenya, Ghana and Libya deserve a closer look. With regards to LDCs the prospects are less favourable. Our first rough analysis suggests that only Senegal, Ethiopia and Togo bear sufficient potential to justify the investments necessary to establish a standardised baseline.

However, our analysis is based only on historic data. If the prediction of strong growth rates in the Sub-Saharan cement sector come true, this may further increase the opportunities for SB development.

9 Conclusions

In the course of this study we presented three different approaches for determining a baseline emission factor for the cement sector as example for a complex and highly integrated production process. The three approaches differ with regard to their level of integration of the sub-process. A benchmark based on a high level of integration may be easy to determine. Still, our analysis shows that such an approach does not allow for assessing the performance of the various sub-processes in cement production.

We have also shown that a highly dis-integrated approach (Option C, Chapter 4.3) with a series of sub-benchmarks is feasible leading to a more conservative baseline emission factor. However, in this case study this was not the case because of the particularity of the Indonesian sector: It is the same large and efficient company that dominates all benchmarks.

However, this particularity may, in fact, be not as particular as it seems at first sight. Experience with other SBs (e.g. ASB0004 "Technology switch in the rice mill sector of Cambodia") suggests that dominance by one or a small number of firms may be a common feature in many emerging industrial sectors in developing countries. Developing a coherent sector-wide benchmark emission factor may be problematic in cases in which emerging industrial-scale production competes with manufacturing in traditional small-scale enterprises in one and the same sector. Choosing a different level of aggregation may be an appropriate way to deal with this problem.

Apart from being the most conservative approach, there are other advantages to approaches with lower levels of integration:

- It allows for a more detailed assessment of the sector as well as of each company's performance. The various sub-benchmarks can help cement producers and policy makers alike to identify in which sub-processes the highest mitigation potentials remain. This supports making informed investment decisions and facilitates the development and monitoring of tailor-made policies.
- The increased level of detail of such an approach also expands the potential for use in other instruments. A highly detailed benchmark may prove a more valuable resource for applications beyond the CDM, such as NMM or NAMAs, than a fully integrated one.
- In a completely integrated SB, automated additionality may be difficult to establish. With a larger set of sub-benchmarks there could be the basis for a 'semi-standardised' approach to additionality demonstration in which positive lists of technologies/fuels/feedstock are established for some sub-processes while the requirements for project proponents to demonstrate additionality would be limited to those processes, where a sectoral approach to additionality demonstration is not feasible.

A further central conclusion is related to the number of market players. In Section 5 we show how sensitive the performance penetration approach is to the number of entities in the sector. If the market is too concentrated, the performance penetration approach comes to its limits. In our case study, it was e.g. not possible to identify candidates for a positive list as indicated in the SB Guidelines. The idea of the Guidelines is that all technologies/fuels/feedstock performing better than the baseline technology/fuel/feedstock are such candidates. In the Indonesian cement sector, however, the top performing company also set the baseline. There were simply no entities left to be candidates for a positive list.

Also, the assessment of alternative levels of aggregation shows that disaggregation may improve the environmental integrity of the SB through a decreasing the baseline emission factor. At the same time, disaggregation allows for retaining an incentive for those parts of the sector where poor performance is a result of structural differences as compared to the top performers. This effect, however, only materializes if the sector is sufficiently fragmented, i.e. it comprises a sufficient number of companies with comparatively low respective market shares. In our case, again, the large production share of some companies lead to a situation where disaggregation only increases the baseline emission factor for the weaker performers, but does not increase the level of ambition for top-performers.

We also found that a data set aggregated at company level is not appropriate to establish a robust and conservative benchmark. We were able to demonstrate that the aggregation of data on a company level already leads to an ’averaging out‘ of top performances with low performances. As a result, the baseline emission factor determined on company aggregates is likely to be less conservative than one that would use the data of individual production lines or at least production sites. In our case, using cement plant data instead of company data, would have mitigated the effect with regards to the number of market players described above.

While the study was conducted for the case of an emerging economy sector, our rough analysis of potentials revealed that SBs for the cement sector could also have significance for Africa including some African LDCs. The markets of Algeria, Morocco, Nigeria, South Africa, Tunisia, Kenya, Ghana, Libya, Senegal, Ethiopia and Togo are presumably large enough to justify the development of a SB.

For the development of baselines and related monitoring schemes beyond the CDM, the SB framework offers a suitable building block. The SB must undergo an independent third party assessment and would be accepted by UNFCCC bringing international recognition and acknowledgement to a NAMA/NMM baseline. However, in specific cases (i.e. if BAU emissions decrease over time), there are constraints for NAMA/NMM baseline development which cannot be covered by the current SB framework (e.g. approximation to SB benchmark over 10 years).

From this perspective SBs should be as detailed as possible. We therefore would like to recommend designing SBs in line with the low integration approach as applied in Option C of chapter 4.3. However, the feasibility of this approach is bound to the availability of data. It may also not be appropriate as it could lead to overly conservative emission factors, especially if benchmark thresholds as stringent as 90 per cent of accumulated production are applied. Furthermore, we were able to analyse the low integration approach for one very specific case. Calculating combined emission factors from a larger set of indicators may prove more difficult or even impossible for other sectors. Consequently, the SB framework should not prescribe a specific level of integration. Still, it should provide guidance and make explicit the consequences of integration but ultimately leave it to the DNAs and project developers to define the level of integration as appropriate.

In order to enable DNAs to take an informed decision, it is necessary to provide them with the required information. This study can only be a first step in understanding the complexities of highly integrated production process with respect to developing a robust baseline emission factor.

As a follow-up we recommend to explore other sectors and under different socio-economic circumstances. Furthermore, we propose to investigate alternative approaches to determining additionality within the CDM SB framework, as we found that the technology-specific approach stipulated in the SB Guidelines is not feasible in complex production processes. One way forward would be to explore the idea of ’semi-standardised‘ approaches in which positive lists of mitigation activities are determined for some sub-processes. Only for the remaining sub-processes where this is not feasible, project proponents would be obliged to demonstrate additionality using conventional tools.

References

- Blodgett, C., Rohe, J., Kabisch, S., Tänzler, D. (2012): Nationally Appropriate Mitigation Actions – A Technical Assistance Source Book for Practitioners, GIZ, Eschborn, Germany. Available online at http://www.mitigationpartnership.net/sites/all/modules/contributed/pubdlcnt/pubdlcnt.php?file=http://mitigationpartnership.net/sites/default/files/giz_nama_ta_source_book_1.0.pdf_0.pdf&nid=1222 [Accessed 22 August 2013].
- Bolscher, Hans, Jeroen van der Laan, Stephan Slingerland, Jos Sijm, Stefan Bakker, Tom Mikunda, Timon Wehnert, Wolfgang Sterk, Jelmer Hoogzaad, Matthieu Wemaere and Darragh Conway (2012): Design options for sectoral carbon market mechanisms and their implications for the EU ETS (Final Report No. CLIMA.B.3/SER/2011/0029). Rotterdam: Ecorys. Available online at http://ec.europa.eu/clima/policies/ets/linking/docs/study_20120831_en.pdf [Accessed 14 August 2013].
- Booth, S., Mary (2012): Biomass Energy in Pennsylvania: Implications for Air Quality, Carbon Emissions and Forests, Partnership for Public Integrity: USA.
- Burian, Martin, Haake, Frauke, Widowati, Lusy, Janssen, Jan, Berndt, Kai, Indrawan, Ery. (2013): Nationally Appropriate Mitigation Actions – A Low Carbon Development Programme for the Cement Sector in Indonesia, GIZ: Eschborn, Germany.
- Butler, K. (2011): Guidance/reference for industry sector on the development of BAU Baseline – A study towards development of NAMAs for the Indonesian industry sector. PAKLIM - Policy Advice for Environment and Climate Change, GIZ.
- Cardinal Stone (2013): Nigeria Cement Sector Report – Emerging Prominence from a Deficit Past, available online at http://www.proshareng.com/reports/6294 [accessed 9 July 2014].
- Castro, P., Hayashi, D., Harthan, R., Cames, M., Michaelowa, A. (2012): Setting Baselines for the New Market Mechanism: Examples from the Power, Cement and Buildings Sectors. Discussion Paper – German Environmental Agency.
- CDM Executive Board (2010): ACM15 Consolidated baseline and monitoring methodology for project activities using alternative raw materials that do not contain carbonates for clinker production in cement kilns, Version 3. EB53, Annex 8. UNFCCC: Bonn, Germany.
- CDM Executive Board (2011a): Guidelines for the Establishment of Sector-Specific Standardised Baselines, Version 2.0. EB65, Annex 23. UNFCCC: Bonn, Germany.
- CDM Executive Board (2011a): Report of the Sixtieth Meeting of the Executive Board of the Clean Development Mechanism. EB60. UNFCCC: Bonn, Germany.
- CDM Executive Board (2012a): AMS III.Q, Waste energy recovery (gas/heat/pressure) projects, Version 5.0. EB69, Annex 25. UNFCCC: Bonn, Germany.
- CDM Executive Board (2012b): Guidelines for the Consideration of Suppressed Demand in CDM Methodologies, Version 2.0. EB68, Annex 2. UNFCCC: Bonn, Germany.
- CDM Executive Board (2012c): Procedure for Submission and Consideration of Standardised Baselines, Version 2.0. EB68, Annex 32. UNFCCC: Bonn, Germany.
- CDM Executive Board (2012d): ACM5 Increasing the blend in cement production, Version 7.1. EB67, Annex 14. UNFCCC: Bonn, Germany.
- CDM Executive Board (2012e): Guidelines for Quality Assurance and Quality Control of Data used in the Establishment of Standardised Baselines, Version 1.0. EB66, Annex 49. UNFCCC: Bonn, Germany.
- CDM Executive Board (2013a): Tool to calculate the emission factor of an electricity system – Version 4.0. CDM EB75 Annex 15. Available online at http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v4.0.pdf [accessed 13 October 2014].
- CDM Executive Board (2013b): ACM3 Emissions reduction through partial substitution of fossil fuels with alternative fuels or less carbon intensive fuels in cement or quicklime manufacture, Version 4. EB76, Annex 8. UNFCCC: Bonn, Germany.
- CDM Meth Panel (2011): Proposed New Methodology Meth Panel summary recommendation to the Executive Board CDM: Proposed New Methodology – NM302. MP48. UNFCCC: Bonn, Germany.
- CSI (2009): Developing State of the Art-Techniques in Cement Manufacturing: Trying to Look Ahead. CSI/ECRA-Technology Papers, WBCSD: Düsseldorf and Geneva.

- CSI (2011): Cement CO_2 and Energy Protocol, Version 3.04.
- CSI (2012): The Cement Sustainability Initiative – 10 Years of Progress Moving on to the Next Decade. World Business Council for Sustainable Development: Geneva, Switzerland.
- DIFID (2012): Assessment of the Current Market and the Market Potential for Refuse Derived Fuel. ENV – A Greencap Consulting Company: United Kingdom.
- Federal Republic of Ethiopia (2012): Standardised Baselines for Clinker Production in Ethiopia. UNFCCC: Bonn, Germany. Availaible online at http://cdm.unfccc.int/methodologies/standard_base/St_Ethiopia.pdf [accessed 13 October 2014].
- Füssler, Jörg (2012): CDM Baseline Approaches for PoA Upscaling and New Market Mechanisms (NMM) - Building NMM on CDM Elements. KfW: Frankfurt, Germany. Available online at http://www.jiko-bmu.de/files/basisinformationen/application/pdf/infras_cdm_baseline_approaches_cdm_elements_for_nmms_20apr2012.pdf [Accessed 14 August 2013].
- GNR (2014a). Net CO_2 Emission per Tonne Cementitous (World), World Business Council for Sustainable Development: Geneva, Switzerland. Available online at: http://www.wbcsdcement.org/GNR-2011/world/GNR-Indicator_336-world-2011.html [accessed 13 October 2014].
- GNR (2014b). Net CO_2 Emission per Tonne Cementitous (Africa), World Business Council for Sustainable Development, Geneva, Switzerland. Available online at http://www.wbcsdcement.org/GNR-2011/world/GNR-Indicator_336-world-2011.html [accessed 13 October 2014].
- Hermwille, L., Arens, C., & Burian, M. (2013): Recommendations on the Advancement of the CDM Standardised Baselines Framework. DEHSt: Berlin.
- IEA / WBCSD. (2009): Cement Technology Roadmap 2009: Carbon emissions reductions up to 2050. Paris, Geneve.
- IETA (2010): Thinking Through the Design Possibilities for a Sectoral Crediting Mechanism, Version 1, Published 5 March 2010. International Emissions Trading Association. Available online at http://www.ieta.org/index.php?option=com_content&view=article&id=126:thinking-through-the-design-possibilities-for-a-sectoral-crediting-mechanism&catid=26:reports&Itemid=93 [Accessed 14 August 2013].
- IPCC (2000): Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.
- IPCC (2006): Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.
- Kollmuss, Anja, Jörg Füssler, Michael Lazarus, Martin Herren and Lambert Schneider (2013): New Climate Mitigation Market Mechanism - Stocktaking after Doha. Infras: Zürich, Switzerland. Available online at http://www.infras.ch/e/news/displaynewsitem.php?id=4947 [accessed 20 March 2013].
- Kriebich, N., Hermwille, L. and Arens, C. (2013): Quo Vadis, Africa? An Update on the Uptake of the CDM in Africa. JIKO Policy Paper 03/2013.
- Lacy, Sallie, Hansen, Nils, Sehlleier, Friedel, Wienges, Sebastian, Wenzel, Klaus, Lutz, Annette (2013): NAMA Tool - Steps for Moving a NAMA from Idea towards Implementation, Version 8.6. GIZ: Eschborn, Germany. Available online at http://mitigationpartnership.net/nama-tool-steps-moving-nama-idea-towards-implementation [accessed 22 August 2013].
- Lazarus, Michael (2012): Transitioning Away from Large-Scale Power Projects: a Simple and Effective Fix for the CDM?. Stockholm Environment Institute: Somerville, USA.
- Madlool, N. A., Saidur, R., Hossain, M. S., & Rahim, N. A. (2011): A critical review on energy use and savings in the cement industries. Renewable and Sustainable Energy Reviews, 15, 2042–2060.
- Michaelowa, Axel (2012): Scenarios for the Global Carbon Markets, Paper 1 for the CDM Policy Dialogue. Center for Comparative and International Studies, Political Economy of Development, Institute of Political Science, University of Zurich: Zurich, Switzerland.
- MoI and AFD, (2010a): Emission Reduction Scheme of the Cement Industry in Indonesia – Interim Report. Indonesian Ministry for Industry and Agence Française de Développement, developed by PT GHD Indonesia in cooperation with Ecofys.
- MoI and AFD, (2010b): Emission Reduction Scheme of the Cement Industry in Indonesia – Final Report. Indonesian Ministry for Industry and Agence Française de Développement, developed by PT GHD Indonesia in cooperation with Ecofys.

- Prag, Andrew and Gregory Briner (2012): Crossing the Threshold: Ambitious Baselines for the UNFCCC New Market-Based Mechanism. OECD/IEA: Paris, France. Available online at http://www.oecd.org/dataoecd/12/2/50315387.pdf [accessed 14 August 2013].
- Sharma, Sudhir and Desgain Denis (2013): Understanding the Concept of Nationally Appropriate Mitigation Action, Roskilde, UNEP Risø Centre. Available online at: http://mitigationpartnership.net/sites/default/files/understanding_the_concept_of_nama_web.pdf [accessed 14 August 2013].
- Sterk, Wolfgang and Florian Mersmann (2012): New Market Mechanisms: Prerequisites for Implementation. JIKO Policy Paper. Wuppertal Institute: Wuppertal. Available online at http://www.jiko-bmu.de/files/basisinformationen/application/pdf/pp_readiness_new_mex_fin_barrierefrei.pdf [Accessed 14 August 2013]
- UNFCCC (2009): Decision 2/CP.15, Page 4, Report of the Conference of the Parties on its fifteenth session, held in Copenhagen from 7 to 19 December 2009, Addendum, Part Two: Action taken by the Conference of the Parties at its fifteenth session, FCCC/CP/2009/11/ Add.1.
- UNFCCC (2010): Decision 1/CP.16, Page 2, Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010, Addendum, Part Two: Action taken by the Conference of the Parties at its sixteenth session, FCCC/ CP/2010/7/Add.1.
- UNFCCC (2010a): The Cancun Agreements (Decision 1/CP.16), FCCC/CP/2010/7/Add.1, December 2010, Bonn, UNFCCC. Available online at http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf [Accessed 14 August 2013].
- UNFCCC (2011a): Decision 2/CP.17, page 4, Report of the Conference of the Parties on its seventeenth session, held in Durban from 28 November to 11 December 2011, Addendum, Part Two: Action taken by the Conference of the Parties at its seventeenth session, FCCC/CP/2011/9/Add.1.
- UNFCCC (2011b): Compilation of information on nationally appropriate mitigation actions to be implemented by Parties not included in Annex I to the Convention: Note by the secretariat, FCCC/AWGLCA/2011/INF.1.
- UNFCCC (2011c): Decision 3/CP.17, page 55, Report of the Conference of the Parties on its seventeenth session, held in Durban from 28 November to 11 December 2011, Addendum, Part Two: Action taken by the Conference of the Parties at its seventeenth session, FCCC/CP/2011/9/Add.1.
- UNFCCC (2012a): Nationally appropriate mitigation actions by developing country Parties. AWG-LCA agenda item 3 (b) (ii). Bonn, UNFCCC. Available online at http://unfccc.int/files/adaptation/application/pdf/itmit_3b2_v1.pdf [Accessed 14 August 2013].
- UNFCCC (2012b): Report of the Conference of the Parties on its eighteenth session (Decisions 11/CP.18 – 18/CP.18), Bonn, UNFCCC. Available online at http://unfccc.int/resource/docs/2012/cop18/eng/08a02.pdf [Accessed 14 August 2013].
- UNFCCC (2012c): Report of the Conference of the Parties on its eighteenth session, held in Doha from 26 November to 8 December 2012, (Decisions 1/CP.18 – 10/CP.18), Bonn, UNFCCC. Available online at http://unfccc.int/resource/docs/2012/cop18/eng/08a01.pdf [Accessed 10 September 2013]
- UNFCCC (2012d): NAMA Seeking Support for Implementation: Template for NAMA Registry. Availaible online at https://unfccc.int/files/cooperation_support/nama/application/pdf/02-nama-seeking-support-for-implementation-v1.0.pdf [accessed 13 October 2014].
- USGS (2011): Cement Statistics and Information, U.S. Geological Survey. Available online at http://minerals.usgs.gov/minerals/pubs/commodity/cement/myb1-2011-cemen.xls [accessed 13 October 2014].
- WBCSD/IEA, 2009, Cement Technology Roadmap 2009 – Carbon Emission Reductions up to 2050, World Business Council for Sustainable Development and International Energy Agency.

Annex I: Overview on Cement Companies in Indonnesia

Currently there exist nine companies operating 18 plants (i.e. including grinding facilities) and a total of 32 lines (i.e. not considering grinding plants). The following table provides an overview on these companies, their lines, plant location and the date of commissioning.

Moreover a column was included which indicates specific circumstances e.g. if a production site comprises only a grinding plant.

Finally the groups A and B were created; group A refers to plants in private ownership, group B refers to state owned plants. This was done to interpolate missing data from other plants having the same ownership structure.

Using average values of group A and/or B as approximation values seems reasonable: Private owned companies are typically producing at large scale and very efficiently. State owned companies typically feature smaller production capacities and may be created to serve multiple purposes such as cement production and the creation of jobs and economic stimulus in specific regions. Hence, state owned companies feature higher specific emission factors than private owned. Consequently, the interpolation using group specific average values may be more accurate compared to using simple national averages. The following table presents above data on a company level.

No		Company Name	Line	Plant Location	Remark	Commissioning Year	Group
1	PT Semen Indonesia Group	PT Semen Indonesia Tbk (previous known as Semen Gresik, PT SI)	Tuban 1, Tuban 2, Tuban 3, Tuban 4	Tuban, East Java	Integrated Plant, Tuban 4 operated by 2012	1994, 1997, 1998, 2012	A
			Gresik	Gresik, East Java	Grinding Plant only	1978	
2		PT Semen Tonasa (PT ST)	Tonasa 2, Tonasa 3, Tonasa 4, Tonasa 5	Pangkep, South Sulawesi	Integrated Plant, Plant Tonasa 5 Operated by 2013	1980, 1985, 1996, 2013	
3		PT Semen Padang (PT SP)	Indarung II, Indarung III, Indarung IV, Indarung V	Padang, West Sumatera	Integrated Plant	1980, 1984, 1989, 1998	
4	PT Holcim Indonesia Tbk		Nar 1, Nar 2	Narogong, West Java	Integrated Plant	1993, 1996	
			Cil 2	Cilacap, Central Java	Integrated Plant	1995	
			Ciwandan	Ciwandan, West Java	Grinding Plant only	2012	
			Tuban	Tuban, East Java	Full Operation by 2014	2014	
5	PT Indocement Tunggal Prakarsa Tbk. (PT ITP)		P1, P2, P3, P4, P5, P6, P7, P8, P11	Citeureup, West Java	Integrated Plant	P1-P8: 1985, P11: 1997	
			P9, P10	Cirebon, West Java	Integrated Plant	1991, 1996	
			P12	Tarjun, South Kalimantan	Integrated Plant	1997	
6	PT Semen Bosowa (Sbo)		Bosowa Plant	Bosowa, South Sulawesi	Integrated Plant	1999	
			Batam Plant	Batam	Grinding Plant only	2012	
7	PT Semen Kupang (PT SK)		SK 2	Kupang, East NusaTenggara	Integrated Plant	1999	B
8	PT Lafarge Cement Indonesia (PT LCI)		Lhok Nga Plant	Lhok Nga, Aceh	Integrated Plant	1984	
9	PT Semen Baturaja (PT SB)		Baturaja	South Sumatra	Integrated Plant	1999	B
			Lampung	Lampung	Grinding Plant only	1980	
			Palembang	South Sumatra	Grinding Plant only	1980	

Note : All 9 companies are member of Indonesia Cement Association