DEVELOPING BENCHMARKING CRITERIA FOR CO_2 EMISSIONS

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February 2009

Ecofys project number: PECSGB073248

By order of the:

European Commission
Environment Directorate-General
Service contract ENV.C.4/SER/2007/0059

Disclaimer and acknowledgements

Disclaimer

The views expressed in this study represent only the views of the authors and not those of the European Commission. The focus of this study is on deriving allocation principles for free allocation of emission allowances under the EU Emission Trading Scheme for the period 2013 – 2020 based on benchmarking and on the application of these principles to four selected product groups. Given the focus on *principles*, the benchmark emission *values* given in this report are based on public information readily available to the authors. These values should be regarded as indicative only. The selection of product groups studied in this study is intended to help assessing the feasibility of applying the allocation principles. The selection does not imply a standpoint on which sectors should receive free allocation of allowances and how many. The basis for this study is the Commission proposal for a revised ETS directive put forward on 23 January 2008 and does not take into account any changes to this proposal in the co-decision procedure that resulted in the adoption of the Energy and Climate change package in December 2008.

Acknowledgements

The authors would like to thank representatives from the iron and steel, pulp and paper, lime and glass industry for their valuable contributions at the stakeholder workshop on 2 July 2008 and for in-depth discussions on possible benchmarking options for their industries during the execution of the project.

SUMMARY

Introduction

A European Union (EU) wide greenhouse gas (GHG) allowance trading scheme (EU ETS) was implemented in the EU in 2005. In the first two trading periods of the scheme (running up to 2012), free allocation based on historical emissions was the main methodology for allocation of allowances to existing installations. For the third trading period (2013 – 2020), the European Commission proposed in January 2008 a more important role of auctioning of allowances rather then free allocation. (Transitional) free allocation of allowances to industrial sectors will be determined via harmonized allocation rules, where feasible based on benchmarking. In general terms, a benchmark based method allocates allowances based on a certain amount of emissions per unit of productive output (i.e. the benchmark).

This study aims to derive criteria for an allocation methodology for the EU Emission Trading Scheme based on benchmarking for the period 2013 – 2020. To test the feasibility of the criteria, we apply them to four example product groups: iron and steel, pulp and paper, lime and glass. The basis for this study is the Commission proposal for a revised ETS directive put forward on 23 January 2008 and does not take into account any changes to this proposal in the co-decision procedure that resulted in the adoption of the Energy and Climate change package in December 2008.

Benchmarking and the EU ETS so far – key findings

In phase I and II of the EU ETS, many Member States (MS) used benchmarking for new entrant allocation in the industrial sector. Some MS also used benchmarking for existing installations. The benchmarking approaches (e.g. with respect to the benchmark levels) were not harmonized across MS and did also not converge from phase I to phase II. Many MS used the Best Available Techniques Reference documents (BREFs) developed under the IPPC directive to establish benchmark values. However, the current versions of the individual BREFs for the different sectors differ strongly in their level of detail and the stringency of the included GHG efficiency values. We therefore conclude that the BREFs cannot be used as the primary source for an EU-wide benchmark-based allocation methodology in the framework of the EU ETS.

Many industries have significant experiences with benchmarking and support a benchmark based allocation methodology for the EU ETS. At the same time, however, few of them developed concrete benchmark methodologies to be applied under the EU ETS.

Allocation principles

A benchmark based allocation methodology requires several choices, e.g. on

- The number of products to distinguish

- The emissions the benchmark relates to: only direct emissions or also the indirect emissions from electricity use
- The benchmark for the specific energy consumption for a certain product
- The benchmark for the fuel mix that is used to produce a certain product
- The inclusion of correction factors for e.g. different technologies used or the size of the installation
- The production (activity) levels that is used to convert the benchmarks (specific emission per unit of production) to an absolute emission allowance

In this study, we formulate 11 allocation principles that could form the basis for a benchmark-based allocation methodology. As stated above, underlying starting point in the derivation of these principles is the Commission proposal for a revised directive (dated 23 January 2008), assuming an ex-ante allocation of allowances for direct emissions within a certain emission cap and without free allocation to any electricity production.

1: Base the benchmark level on the most energy efficient technology
2: Do not use technology-specific benchmarks for technologies producing the same product
3: Do not differentiate between existing and new plants
4: Do not apply corrections for plant age, plant size, raw material quality and climatic circumstances
5: Only use separate benchmarks for different products if verifiable production data is available based on unambiguous and justifiable product classifications
6: Use separate benchmarks for intermediate products if these products are traded between installations
7: Do not use fuel-specific benchmarks for individual installations or for installations in specific countries
8: Take technology-specific fuel choices into account in determining benchmarks
9: Use historical production to allocate allowances for existing installations
10: Use product-specific capacity utilization rates in combination with verifiable capacity data to allocate allowances to new installations
11: Use heat production benchmark combined with a generic efficiency improvement factor for heat consumption in processes where no output-based benchmark is developed

Principle 1 Most energy efficient technology as basis for benchmark

The choice for most energy efficient technology as basis for the benchmark allows the use of the same benchmark for both existing and new installations and is also well in line with the proposal for a revised directive where explicit reference is made to most efficient technology. Furthermore, it puts the benchmarks for the different products at the same reference level. This is advantageous in view of the uniform correction factor foreseen by the European Commission to bring the sum of allowances within the total available emission cap. The benchmark for one product influences in this way, via the correction factor, the allowance for another product. This requires a uniform reference level for the benchmarks.

Principle 2,3,4 and 7 Do not specify the benchmarks in too much detail

The objective of the EU ETS is to give incentives for GHG efficient technologies. Ideally, a benchmark-based allocation methodology should thus provide incentives for companies to select the most cost-effective emission reduction options available. Such incentives are removed when a single product with a single benchmark (principle 2) is further specified into products that can be produced with different techniques and fuel mixes (principle 2 and 7) or by installations with a different size or age (principle 3 and 4), each having their own benchmark.

Principle 5 and 6 Number of products to distinguish

Principle 1 leaves the definition of “the same product” open. Criteria that can be used to establish the number products to distinguish include the availability of the relevant production data and the difference in emission intensity between the different products. We regard the availability of production data following unambiguous and justifiable product classifications as indispensable (principle 5), but do not further recommend general allocation principles for the number of products to distinguish. To allow determining an allocation of allowances also for those installations producing intermediate products sold to other EU ETS installations, we recommend having separate benchmarks for these traded intermediates (principle 6).

Principle 7 Fuel mix benchmark

Various options exist for the choice of fuel mix (e.g. average fuel mix of the sector, best practice fuel mix, most dominant fossil fuel). Given the strong political dimension of the fuel mix choice we did not formulate an allocation principle on this issue. As allocation principle we do recommend, however, not to distinguish the fuel mix benchmark for individual installations or for individual countries (principle 7). In some cases, the most energy efficiency technology for a certain product implies an inherent choice for a certain fuel mix. An example is the use of biomass which is inherent to pulp making. We do recommend taking into account technology-specific fuel mix choices in determining the benchmarks (principle 8).

Principle 9 and 10 Choice of activity level to convert the benchmark to an allowance

The use of historical production in determining allowances to existing installations (principle 9) has as advantage that no data are required on capacity of installations or on subjective assumptions regarding sector growth. These advantages in our opinion outweigh potential advantages of other methodologies. For new installations, where historical production is not available, we recommend product-specific capacity utilization rates in combination with verifiable capacity data (principle 10).

Principle 11 What if benchmark based on production is not available

A complication arises for those situations where an output-based benchmark is not available, because of the limited amount of producers or the difficulty of determining output for some installations. For those products, a generic efficiency improvement factor could be used in combination with a benchmark based on the production of heat (principle 11). Options to derive such a generic factor include a factor based on average improvement potentials for other products or on technical analyses of the improvement potential.

Sector definition and treatment of heat

A fair harmonized free allocation methodology based on benchmarking should ensure that all producers of the same product are treated equally, regardless the classification of the installation that produces this product into an industrial sector or sub-sector or into an activity as specified in the EU ETS directive and regardless the system boundary or ownership situation of the installation. We therefore propose not to use pre-defined activities or sectors in the design of harmonized allocation rules, but instead apply in principle a product-specific benchmark to products produced by ETS installations regardless of sector classification. This also implies that the allowance for heat consumption for those products that receive allocation based on a benchmark should be treated equal, regardless where this heat is produced. To keep in line with the overall EU ETS architecture (allocation to the emitter), this would mean that the benchmark for heat consumption is taken into account in the allocation of the heat producer. We recommend assessing in more detail the feasibility of such an approach taking into account issues such as data availability etc.

Application of principles to the iron and steel, pulp and paper, lime and glass industry

We applied the allocation principles as developed in this project to four example product groups to test the overall applicability and feasibility of the principles proposed.

For the manufacture of iron and steel, we propose:

- Separate benchmarks for coke, sinter and pig iron as these are traded intermediate products in steel making as well as for crude steel, hot and cold rolled steel, surface-treated products and products from iron foundries.
- Emission benchmarks based on fuel mix choices that are inherent to specific processes where this is relevant, i.e. for the electric arc furnace and for the two processes that produce derived gases: coke ovens and the blast furnace (see next point).
- To correct the benchmark for coke and pig iron production for the inherent production of derived gases in these processes. The correction is based on the difference in emission factor between the default fuel of choice (natural gas) and the emission factor of blast furnace gas and coke oven gas respectively. This methodology avoids double counting with the benchmarks for downstream process using the derived gases.

For the manufacture of pulp and paper, we propose:

- The use of separate benchmarks for pulp and different grades of paper as pulp is a traded intermediate product and similar grades of paper are produced via multiple process routes and with different shares of virgin and recycled pulp input. The six product classification used by the confederation of European paper industries in their statistics could, in line with allocation principle 5, be a suitable starting point for the number of products to distinguish.
- A benchmark of 0 t CO_2 per t pulp, because market pulp can be produced without the input of fossil fuels due to the inherent availability of biomass in pulp making. An exception could be made for the lime kiln in the kraft pulping process.

For the manufacture of lime, we propose:

- A single benchmark for lime production based on best-practice vertical kiln technology and a separate benchmark for dead-burned dolime, for which higher specific energy consumption is required.
- To add to the benchmark a separate amount for the process emissions (i.e. non-energy related emissions).

For the manufacture of glass, we propose

- Separate benchmarks for container glass, flat glass, filament fibre production and specialty glass products.
- To add to the benchmark a separate amount for the process emission from glass making in line with a reasonable use of cullet for each of the product groups.

The analyses for the sectors support that product-specific capacity utilization factors are required for the allocation to new entrants rather than more generic sector-wide utilization factors.

In the analyses for the four product groups, we also assessed the fuel mix currently applied by installations in the EU ETS to the extent possible. After correction for technology-specific fuel mix choices (as summarized in the sector conclusions above), the dominant fossil fuel in use by the product groups is natural gas. If the dominant fossil fuel would be chosen as allocation principle, this would thus be natural gas for the product groups studied, except for the production of pulp, coke and pig iron.

Conclusion and outlook for further work

The application of the allocation principles to the four example product groups shows that a transparent and applicable benchmark-based allocation methodology can be developed and that no a-priori bottlenecks exist in developing such methodology. It is clear, though, that within the scope of this project no approach is developed that is fully ready for implementation. To come to a fully harmonized free allocation methodology based on benchmarking, we envision the following next steps:

1. Development of a comprehensive definition of products for which benchmarks can be applied including their link to sector classifications.
2. Application of recommended allocation principles to all products and further development of a fall-back approach for products that cannot be covered via an output-based benchmark.
3. Set-up of a comprehensive and efficient stakeholder involvement process, also in view of the limited time availability.
4. Detailed assessment of data requirements and the feasibility of making the data available for all installations in all MS within the time frame available.

Although we do not see any a-priori bottlenecks regarding data availability and overall applicability of the proposed approach, we recommend proceeding as soon as possible along the four steps given above to further asses e.g. the timely availability of all required data and the feasibility of the proposed allocation methodology for those sectors not yet studied in any detail like the chemical industry.

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1 Introduction

1.1 Background

An EU-wide greenhouse gas allowance trading scheme (EU ETS) was implemented in January 2005 in accordance with the Greenhouse Gas Emission allowance Trading Directive (further referred to as ETD) (EC, 2003). For Phase I (2005-2007) and Phase II (2008-2012) of the system, no EU-wide harmonised allocation methodology has been developed. The ETD leaves the choice and design of allocation methodologies largely to the Member States. The ETD states that at least 95% of the allowances should be distributed for free in Phase I and 90% in Phase II, thereby restricting the use of auctioning as allocation methodology. In the National Allocation Plans (NAPs), Member States mainly used grandfathering based on historical emissions as the allocation method, in some cases in combination with benchmarking.

Objective of the ETD is ‘to contribute to fulfilling the Greenhouse Gas (GHG) emission abatement commitments of the European Community and its Member States more efficiently, through an efficient European market in greenhouse gas emission allowances with the least possible diminution of economic development and employment’ (EC, 2003). Although grandfathering is conceptually a relatively simple allocation methodology, the experiences during Phase I of the EU ETS and also in the design of the NAPs in Phase II have shown that its use can undermine the given objective of the EU ETS in a number of areas such as:

- Rewarding high historic emissions, rather than early action;
- The impossibility to use grandfathering for new entrants;
- Competitive distortion across Member States;
- Windfall profits due to passing on the opportunity cost of the free allowances to clients.

The mid-term review of the EU ETS[1] has also highlighted these issues. There is a clear signal from many stakeholders that changes to the allocation methodology are needed in Phase III. Alternatives to grandfathering, i.e. auctioning and benchmarking, have been discussed at length. Whatever methodology were to be chosen, the most important claim referred to the necessity of EU-wide harmonised allocation rules.

Auctioning has important advantages over free allocation. Firstly, auctioning best respects the “polluter-pays” principle, which is a key principle of EU environmental policy. Secondly, auctioning avoids windfall profits for installations that pass on the opportunity costs of the freely allocated allowances to clients. Thirdly, auctioning avoids distortions of the signal from the carbon price such as the reduction of the incentive to close inefficient polluting installations due to the termina-

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[1] http://ec.europa.eu/environment/climat/emission/review_en.htm

tion of free allocation after closure. Fourthly, auction revenues could be used for other purposes, including compensation to households or companies for increased power prices, funding for R&D in energy-efficient technologies, reducing public debt, or lowering distorting taxes, thus improving the efficiency of the entire economy (double dividend). Finally, auctioning is potentially simpler and involves less administrative burden. It e.g. eliminates the need for authorities to assess industrial growth projections, thereby limiting the room for gaming. These advantages could avoid most of the problems of free allocation which have resulted in inefficient and complex rules in several Member States.

The Commission proposal for a new EU ETS directive (EC, 2008), which forms the basis for this study, requires the power sector to buy CO_2 allowances at an auction or from the secondary market straight from 2013 but the industry sector will have more time to adjust to the full auctioning scheme with a share of 80% of allowances still to be received for free in 2013 slowly decreasing to 0% by 2020. For sectors exposed to carbon leakage, a possible larger share of free allocation is foreseen until 2020. The Commission proposes any allocation for free to be determined by fully harmonised allocation rules, where feasible based on benchmarking.

Allocation based on benchmarking is often preferred over grandfathering because of the possibility to improve the environmental integrity of the system, reward early action, and, under the proper conditions (e.g. a harmonised approach in the various Member States), increase the transparency of allocation. Also benchmarking could be used not only for existing installation but also for new entrants as it is currently in several Member States (see Chapter 2 for more details). In this report, allocation based on benchmarking refers to allocation methods making use of a harmonised performance measure for a group of installations based on the productive output of these installations. Throughout this report, allocation based on benchmarking refers to ex-ante benchmarking where allocations for free are determined prior to the start of trading period without ex-post adjustments based on actual production.

The feasibility and the outcome of an allocation methodology based on benchmarking depend on a variety of factors. In the design of a robust, fair and transparent allocation methodology based on benchmarking, issues that should be dealt with include:

- Definition of sectors or products to which benchmarking will be applied
- Availability of sufficient data to derive benchmark levels
- Availability of sufficient data on capacity or on historic production of installations
- Transparent choices on the benchmark levels
- Transparent choices on the conversion from benchmark levels to total allocation (production levels, capacity utilization assumptions)
- Consistency across sectors and across countries in the approach towards issues such as raw material quality, different process options etc.
- Balance between simplicity and sufficient sophistication to measure real performance ensuring maximal simplicity

1.2 Objective and structure of the report

In this study we aim to assess the feasibility of benchmarking as allocation methodology for the various sectors and activities under the EU ETS, to develop rules and criteria for such a benchmark-based allocation methodology and to apply these to a selected number of sectors. More specifically we aim to:

1. Gather, summarise and assess the existing relevant information on benchmarking for allocation of CO_2 emission allowances under the ETD.
2. Assess the definition of sectors/activities under the ETD in relation to developing and applying harmonised benchmark allocation rules and criteria, taking into account e.g. data needs.
3. Develop rules and criteria for a benchmark based allocation methodology and apply them to a selected number of sectors/activities;
4. Derive possible benchmark values for a small number of sectors/activities;
5. Define the further work needed for the possible development and application of benchmarks.

In Chapter 2 of this report, we review the existing relevant information with respect to benchmarking and the EU ETS (1st objective). Chapter 2 will be an input into the design of a benchmark based allocation system described in Chapter 4 - 9. In Chapter 3, we discuss issues related to the definition of sectors and activities in relation to the development of a benchmark-based allocation system (second objective) We develop rules and criteria (e.g. related to feasibility) for a benchmark based allocation in Chapter 4 and 5 (3rd objective) and apply them to a selected number of products in Chapter 6 – 9 (3rd and 4th objective). Below, we discuss briefly the choice of products. In Chapter 10, we draw conclusions and define further work needed (5th objective).

1.3 Definitions

Benchmarking is a widely used term and can broadly be defined as ‘the comparison of performance against peers’, which can entail the comparison of performance in many fields (e.g. profitability, safety). Within the scope of this study, it refers to the comparison of the performance with respect to GHG emissions. We use the following definitions in this study (adapted from a study by Öko Institute, 2005):

- ‘Benchmarking’ means the comparison of performance with respect to GHG emissions against peers.
- ‘Activity’ means the commodity the emission benchmark refers to.
- ‘Activity level’ means the amount of production of a certain commodity defined as ‘activity’
- ‘Load factor’ or ‘capacity utilization benchmark’ means a predefined value for the load factor or the utilization of an installation capacity to produce a certain commodity.

- ‘Emission benchmark’ means a predefined value for the specific emissions for a certain activity. The emission benchmark can be differentiated by products, fuel and technologies, defined below.
- ‘Product-specific emission benchmark’ means an emission benchmark where the activity the benchmark is applied to is a specific product type without further specification.
- ‘Technology-specific emission benchmark’ means an emission benchmark where the activity the benchmark is applied to is differentiated by technologies.
- ‘Fuel-specific emission benchmark’ means an emission benchmark where the activity the benchmark relates to is differentiated by fuels.
- ‘Benchmark level’ refers to the level of specific emissions for a certain activity that will be used to determine the allocation of that activity.
- ‘Input-specific emission benchmark’ means an emission benchmark where the activity the benchmark is applied to, is not subject to further specification than the specified input material to the activity.

1.4 Choice of example products to be studied in detail

In Chapter 6-9, we apply the allocation principles developed in Chapter 4 and 5 to a number of example product groups to test the feasibility of these principles. The selection of product groups was made in close consultation with the European Commission:

- Manufacture of lime
- Manufacture of pulp, paper and paperboard
- Manufacture of basic iron and steel, including also the coke ovens and the further processing of ferrous metals.
- Manufacture of glass including glass fibre.

The selection of product groups is solely intended to help assessing the feasibility of the methodology set out in this report and does not imply any standpoint related to the question of which sectors should receive free allowances under the revised Directive and how many. The selection of product groups was made to include the group of products contributing most the total ETS emissions (iron and steel)[2] and to allow assessing the main issues related to a benchmark-based allocation mechanism such as the treatment of traded intermediate products in integrated installations (pig iron and pulp). It also includes one product (lime) that is normally regarded as rather uniform and a product group (glass) which is regarded as a rather heterogeneous product group to assess the issues related to a feasible number of different benchmarks.

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[2] The cement and lime industry (mainly cement) and iron and steel industry together represent about half of the emissions when excluding the emission related to power supply. The cement sector has already been covered in a pilot study on benchmarking in the EU ETS prepared by Ecofys and the Öko-Institute (2008).

The work on the iron and steel and glass industry (Chapter 6 and 9) was led by the Fraunhofer Institute for Systems and Innovation Research. Ecofys led the work on the pulp and paper and lime industry (Chapter 7 and 8). All chapters were reviewed by the two project partners.

2 Benchmarking and the EU ETS

2.1 Introduction

In this chapter we summarise relevant existing information in relation to the use of benchmarking as allocation methodology for the EU ETS. The chapter is divided into the following sections. In Section 2.2, we give an overview of the historical developments with respect to benchmarking as allocation methodology in the EU ETS. In Section 2.3, we discuss benchmarking approaches as they are used in the NAPs of the various Member States. In Section 2.4., we discuss the definition of sector and activity as used in the EU ETS. In Section 2.5, we discuss the standpoint and suggested approaches of the various industrial stakeholders in the EU ETS. In Section 2.6, we provide a review of selected relevant experiences with benchmarking outside the EU ETS and in Section 2.7 we discuss the Best Available Techniques reference documents. In Section 2.8 we summarize the key findings.

2.2 Benchmarking in the ETD and the Commission proposal for a revised directive

Benchmarking and the current emission trading directive

The ETD establishing the EU ETS gives Member States the choice on how to allocate emission allowances to the participants in the system with a restriction on the use of auctioning of 5% (phase I) and 10% (phase II). Annex III of the ETD lists the criteria to be used by the Member States for the National Allocation Plans (NAPs).

Criterion 3 of this Annex gives Member States the opportunity to base the distribution of allowances on average emission of greenhouse gases by product in each activity and achievable progress in each activity. Criterion 7 is even more direct on the use of benchmarking stating that benchmarks derived from reference documents concerning the best available technologies may be employed by Member States in the development of their NAPs, and that these benchmarks can incorporate an element of accommodating early action. Criterion 8 states that the NAPs should contain information on the manner in which clean technology, including energy efficiency technology, is taken into account, thereby leaving room to take the technology level (i.e. a performance or benchmark level) into account in determining allowances. In the further guidance to criteria 3 and 8 (EC, 2003), reference is made to the Best Available Techniques reference documents (BREFs, various years) in assessing the potential of activities and the level of technology. The guidance to Criterion 8 mentions that the minimum requirement for clean technology should be Best Available Techniques (BAT) as defined in the IPPC directive 2008/1/EC (EU, 2008, codified version, formerly directive 96/61/EC). In addition, since the BREFs relate to the total environmental performance, it should be demonstrated that this technology is particularly effective in limiting GHG emissions. The guidance recommends considering homogenous groups of installations in determining benchmarks and to separate input-derived fuel benchmarks for energy-related activities.

The further guidance on allocation plans for the 2008 to 2012 trading period (EC, 2005), contains the following paragraph on benchmarking:

"EU-wide benchmarking is not a sufficiently matured allocation method to be used for the second phase. Member States may however find appropriate use for benchmarking at national level for the installation level allocation in certain sectors and for new entrants, e.g. in the electricity sector. Experiences from such use will be examined by the Commission in the context of the review. The Commission is interested in whether the additional data requirements for benchmarking can be mastered and whether Member States consider the additional administrative effort worthwhile".

EU ETS review

Article 30 of the ETD requires the Commission to review the application of the EU ETS and report on it to Parliament and Council. This review has been supported by a number of documents including a report on the harmonisation of allocation methodologies (Ecofys, 2006). This report notes that benchmarking will be a suitable allocation methodology for some sectors although it may not be possible to develop benchmarks for all sectors in a meaningful way due to a highly diverse product portfolio. The power sector, iron and steel and cement are mentioned as sectors for which benchmarking could be suitable. Various harmonisation options across the EU are discussed such as the harmonisation of benchmark levels or harmonisation of the sources and approaches used in determining production levels.

The final Communication from the Commission in response to Article 30 of the ETD (EC, 2006) has been followed by further stakeholder consultation in a separate Working Group on the Review of the EU ETS within the framework of the European Climate Change Programme (ECCP). The issues identified have been grouped in four categories each discussed at an ECCP meeting in 2007. These are:

- The Scope of the ETD
- Further harmonisation and increased predictability
- Robust compliance and enforcement
- Linking with emission trading schemes in third countries, and appropriate means to involve developing countries and countries in economic transition

With regard to the allocation of allowances and installations, the Communication states that the Working Group will explore which (mix of) more harmonised allocation methodologies should be applied in future trading periods. The need for sector-specific allocation methodologies (considering the degree of pass-through of allowance prices in product prices) will be part of the review. At the 3rd ECCP meeting on the ETS Review, these issues have indeed been discussed (ECCP, 2007).

Various industry representatives gave presentations advocating free allocation via benchmarking as opposed to auctioning. The chairman concluded inter alia that:

- There is no agreement among stakeholders on the preferred allocation method.
- Benchmarking would still require a lot of work to be done and the approach is complicated and demanding.
- Industrial sectors are invited to look into benchmarking, but that ex-post benchmarks are not compatible with the way the EU ETS is set-up.
- There is also a matter of confidential treatment of data emerging from the need for reliable production data and other inputs when applying benchmarking.

Benchmarking in other EU ETS related studies

Benchmarking as allocation methodology has been studied extensively, directly in relation with the preparation of National Allocation Plans (NAPs, discussed in the next section), and in overview studies with a more general scope. Key relevant findings from these studies are given here. In the preparation of this section, we made use of the bibliography from the LETS update scoping phase report (AEA Technology / Ecofys, 2006) supplemented with additional, more recent material. The LETS update report concluded in 2006, based on the review of the implementation of Phase I of the EU ETS and preparations for phase II, that benchmarking is considered a valuable tool for future allocation. The report concluded that benchmarking is however not possible for all sectors and that a great deal of work is required before benchmarking as an allocation methodology could be used. Further work is especially needed on data collection and setting up an approach for various sectors.

This confirms the findings of the EU ETS mid-term review discussed above.

Ecofys and the University of Utrecht (2005) studied the application of benchmarking in general and by specific calculation examples for the power sector, the iron and steel sector and the cement sector. The results clearly demonstrate that for the NAPs in the first trading period (2005-2007), benchmarking based allocation based on ‘best practice’ energy efficiency would have resulted in less total allowances for the three sectors studied (3-4% for the power sector, 18% for the iron and steel sector and 4% for the cement sector) and in significantly different distribution of allowances over the various Member States, both as compared to grandfathering using historical emissions. The results thus clearly demonstrate the disadvantages of allocation based on grandfathering using historical emissions (e.g. lack of harmonisation and penalisation of early action).

The reports from the Öko Institute (Öko Institute, 2005) to WWF and by the Fraunhofer Institute on the environmental effectiveness and economic efficiency of the EU ETS (Betz et al., 2006, Rogge et al., 2006 and Schleich et al., 2007) analyse and discuss various structural effects related to allocation methodologies with a clear focus on the power sector. Amongst others, the report by the Öko Institute concludes that for the power sector, a benchmark-based allocation for both existing installations and new entrants should be limited to product-specific benchmarks (i.e. independent from the fuel or technology used), because fuel-specific benchmarks would level off the carbon pricing effect, thereby eroding the environmental efficiency of the system.

Commission proposal for a revised directive

The EU ETS review has resulted in a Commission proposal for a revised EU ETS directive that was put forward on 23 January 2008 as part of the EU Energy and Climate change package (EC, 2008). The proposed amended directive puts auctioning forward as the preferred allocation methodology, “as it is simplest and most economically efficient system. This should also eliminate windfall profits and put new entrants and higher than average growing economies on the same competitive footing as existing producers” (recital 13). As a consequence, “full auctioning should be the rule from 2013 onwards for the power sector, taking into account their ability to pass on the increased costs of CO_2, and no free allocation should be given for carbon capture and storage as the incentive for this arises from allowances not being required to be surrendered in respect of emissions which are stored” (recital 16). No free allocation shall be made in respect of any electricity production (article 10a).

For other sectors, a transitional system is foreseen with free allocation of 80% in 2013 and decreasing to no free allocation in 2020. Allocation will be done using Community wide and fully harmonised implementing measures for both existing installations and new entrants. The Commission proposes these fully harmonised allocation rules to be based on benchmarking where feasible. The maximum amounts of allowances forming the basis for allocations for the total of all sectors that receive free allocation are the verified emissions in 2005 – 2007. One single correction factor for all sectors will be used to ensure that this maximum is not exceeded.

An exception will be made for certain energy-intensive sectors or sub-sectors that are exposed to a significant risk of carbon leakage, which may receive up to 100%. The sectors or sub-sectors concerned will be determined at the latest by 30 June 2010. In addition, the Commission will make an analytical report in the light of the outcome of the international negotiations on climate change and this report will be accompanied by appropriate proposals, which may include adjusting the proportion of allowances received free of charge and inclusion in the Community scheme of importers of products.

The proposed revised directive went into a co-decision process in the Council and European Parliament that resulted in the adoption of the Energy and Climate change package in December 2008. In the context of this study, we take the Commission Proposal of 23 January 2008 as the working point in our analysis without taking the amendments during the co-decision procedure into account (see further Chapter 4).

2.3 Overview of experiences in National Allocation Plans

In preparing this overview, we primarily used for Phase I the analysis of the NAPs prepared by Ecofys (Ecofys, 2005) and the fact sheets on NAPs for phase I by the Deutsche Emissionshandelsstelle in close cooperation with Fraunhofer and Öko Institute (Dehst, 2005). The analysis for phase II relies primarily on an internal Ecofys analysis of the NAPs for phase II (Ecofys, 2007), the early assessment of NAPs for Phase II prepared by the Fraunhofer Institute (Rogge et al, 2006, Schleich et al., 2007) and the analysis of the key NAPs for phase II prepared by WWF and the Climate Action Network Europe (WWF/CAN, 2006).

Grandfathering based on historical emissions data has been the main approach used to distribute free allowances to individual installations in the EU ETS in phase I and II. However, benchmarking was also used. As seen in Table 1, a majority of Member States used benchmarking for new entrants during the Phase I of the EU ETS. Only a few countries (Belgium, Denmark, the Netherlands and Italy) used benchmarking also for existing installations.

During the Phase II, benchmarking has also been widely chosen as the approach to distribute free allowances to new entrants, but the use of benchmarking also increased for existing plants. Below, we discuss the benchmarking approach with a clear focus on the methodologies for industrial sectors. In Annex 1-A, we provide an overview of the main characteristics of the benchmarking approaches used for the NAPs (Phase I and II) as far as information could be found in these documents.

Use of benchmarking for power generation and combined heat and power generation

The overview shows that benchmarking as allocation methodology is mostly used for new entrants in the power sector, with some countries also applying benchmarking for existing plants. Luxembourg, Sweden, Belgium (Flanders and Wallonia) and the UK apply uniform emission benchmarks (not distinguished by technology or fuel). All other Member States developed benchmarks for the power sector that are fuel and / or technology specific.

A large share of the Member States that use benchmarking for the power sector whether for new or existing plants apply a product-specific emission benchmark for the heat and power components produced in Combined Heat and Power (CHP) plants, see Annex I-A. This is relevant, because the approach for benchmarking CHP installations suggested in this study (Chapter 5) also distinguish separate benchmarks for heat and electricity. Some Member States further refined the allocation approach for CHP taking into account aspects such as the:

- Quality of the CHP installation defined by its electricity efficiency: power produced as a share of the energy input (e.g.: the UK).
- Phase and properties of the delivered heat: water versus steam, temperature level etc. (e.g.: Germany, Luxembourg, etc.).
- Use of district heating: (e.g.: Bulgaria) for the economical and environmental advantages it bears.

Table 1 Benchmarking used by Members States in National Allocation Plans for phase II (Y means benchmarking used in ETS phase II, * means benchmarking used in ETS phase I (based on Dehst, 2005)

		Power generation		**Industry**[1]	
		New plants	**Existing plant**	**New plants**	**Existing**
Austria		Y*	Y	Y*	
Belgium	Belgium Brussels	Y*		*	
	Belgium Wallonia	Y*	Y*	Y*	
	Belgium Flanders	Y*	Y*	Y*	Y*
Bulgaria		Y		Y	
Cyprus		Y*		Y*	
Czech Republic		Y*		*	
Denmark		Y*	*	Y*	
Estonia		*		*	
Finland		*		*	
France		Y*	Y	Y*	Y
Germany		Y*	Y	Y*	
Greece		Y		Y*	
Hungary		Y*	Y	Y*	Y
Ireland		Y*		Y*	
Italy		Y*	Y*	Y*	Y*
Latvia		Y			
Lithuania		Y*		Y	
Luxembourg		Y*		Y*	
Malta		Y*		Y*	
Poland		Y*	Y	Y*	Y
Portugal		*		Y*	
Romania		Y		Y	
Slovakia		?	Y	?	Y
Slovenia		Y*	Y	Y	
Spain		Y*	Y	Y*	
Sweden		Y*	Y	Y*	Y
The Netherlands		Y*	Y*	Y*	Y*
United Kingdom		Y*	Y	Y*	

[1] Industry as a manufacturing activity other than the generation of electricity. Benchmarking efforts on the industry are reported as long as at least one sector or product is covered.

Use of benchmarking for industrial sectors

In Phase II of the EU ETS, a number of Member States also used benchmarking for specific industrial sectors and products. While benchmarking has been used mostly for new entrants, some countries also used this approach for existing plants or special cases (e.g. recently built plants with insufficient data, etc.). A qualitative overview of the chosen emission benchmark level and the approach for the level of activity is presented in Table 1, more detailed quantitative information can be found in Annex 1-B. In the overview, we distinguish the approach with respect to emission benchmark level (i.e. the specific emissions per unit of activity) and with respect to activity level (i.e. the production level the specific emissions are applied to).

Table 2 Overview of benchmark levels used in Phase II National Allocation Plans for industrial sectors

Country	**New entrants**	**Existing plants**
Austria	Level: BAT (BREF) Activity level: utilization on the sub-sector & expected Activity level utilization of the new entrant	Not used
Belgium Flanders	Level: world best practice Activity level: forecasted production	Level: world best practice Activity level: forecasted production
Belgium Wallonia	Level: BAT (non specified) Activity level: planned capacity and estimate	Not used
Bulgaria	Level: BAT (non specified) Activity level: IPPC permit and business plan	Not used
Cyprus	Level: BAT (BREF) Activity level: unclear	Not used
Germany	Level: own benchmark Activity level: standardised load factors	Not used
Denmark	Level: own benchmark effort Activity level: standardised factor	Not used
Greece	Level: BAT (BREF) and type of fuel Activity level: permit and exploitation factor based on similar installations	Not used
Spain	Level: BAT (BREF) Activity level: unclear	Not used
France	Level: BAT and least emitting fuel Activity level: Production forecast	Level: National average per process Activity level: Historical sectoral average -8.9%
Hungary	Level: BAT (BREF) Activity level: Forecasted production	Level: BAT (cement); Sectoral average (lime) Activity level: historical production
Ireland	Level: BAT (non specified) Activity level: Forecasted production	Not used
Italy	Level: BAT (own specified levels) Activity level: Forecasted production	Level: own benchmark Activity level: historical production

Country	New entrants	Existing plants
Lithuania	Level: own benchmark Activity level: unclear	Not used
Luxembourg	Level: own benchmark Activity level: standardised load factors	Not used
Malta	Level: BAT(non specified) Activity level: unclear	Not used
The Netherlands	Level: World best practice Activity level: standardised factor	Level: World best practice Activity level: forecasted production
Poland	Level: BAT (KASHUE procedure and others) Activity level: permit and production forecast	Level: own benchmark Activity level: forecasted production
Portugal	Level: BAT (non-specified)	Not used
Romania	Level: BAT (non-specified) Activity level: forecasted production	Not used
Sweden	Level: BAT (BREF technology and fuel specific) Activity level: unclear	Level: EU average Activity level: historical production
Slovenia	Level: BAT (BREF) Activity: Forecasted production	Level: BAT (BREF) Activity level: historical level
Slovakia	Unclear	Level: own benchmark Activity: forecasted production
United Kingdom	Level: own benchmark Activity level: standardised load factors	Not used

[1] In many cases, benchmarking is only applied to a selected number of plants. For more info, we refer to Annex I and the text below this table.

Only for a few Member States, the NAPs for phase II contain clearly defined benchmarking approaches in which quantitative information on the emission benchmarks used can either be directly found or calculated. These countries were Belgium (Flanders), the Netherlands, Denmark, France, Germany, Hungary, Italy, Luxemburg, Poland, Sweden and the UK. We discuss the approaches for those countries below. A quantitative overview is given in Annex I-B. In cases where the NAPs did not provide clear information, the Commission consistently requested and obtained confirmation that allocations to new entrants would not surpass levels that can be achieved by applying BAT.

In Belgium (Flanders) and the Netherlands, the relative energy efficiency of plants compared to the worldwide best 10th percentile of similar plants is used as correction factor in the allocation formula. In the Netherlands, the correction factor for those plants that are part of the benchmarking covenant (further discussed in Section 2.6) is determined based on their relative energy efficiency performance compared to the best decile of the comparable plants worldwide. This distance is determined as part of the benchmarking covenant. In the Netherlands, these are all plants with yearly energy consumption above 0.5 PJ. The correction factor is a measure for the relative energy efficiency performance compared to the world top. In case the performance is better than world top, the factor can be above one, but it can never exceed a value of 1.15 to avoid a disproportionally large allocation to installations compared to the installation's need. For installations that do fall under the long term agreements on energy efficiency, a relative energy efficiency of 1 is assumed, whereas for installations that do not fall under any agreement with the government, a factor of 0.85 is used as default, assuming an energy efficiency improvement of 15% in 2008-2012 compared to 2001-2005, which forms the basis for the level of historical emissions. The latter is done to prevent installations from ceasing to participate in covenants and agreements with the government because of a lighter regime. In Belgium (Flanders), the benchmarking system has been developed on the same basis. Due to the set-up of the system (all data flows via independent entity ensuring confidentiality of the processed data), the actual benchmark levels are not public.

Pursuant to Article 24 of the ETD, the Netherlands applies benchmarking to installations emitting N_2O from the production of nitric acid, which for this purpose is unilaterally included in the scope of the EU ETS. (France also considers opt-in of N_2O emissions from nitric acid production and possibly from the production of adipic and glyoxylic acid as well as the production of glyoxal, for which it may also apply benchmarking.) For the existing installations, the Netherlands has proposed a declining benchmark which is significantly below the highest BAT associated emission level, but above the emission levels that can be expected after implementation of the additional abatement technologies that are encouraged by the inclusion in the EU ETS. A study for the Commission (Entec, 2008) showed that this benchmark is an appropriate one. For new entrants, the Netherlands proposed to apply a benchmark at the lower end of the range indicated to be associated with BAT for new installations. The Dutch request for this unilateral inclusion was adopted by Commission. In the Dutch case, the production level is based on historical emissions without applying any growth forecasts. Opting-in N_2O emissions from a sector is a voluntary act for the Member States in the second trading period. This implies a different legal and economic context compared to benchmarking for sectors mandatorily included in the EU ETS in the third trading period. Therefore, we will not further discuss benchmarking for N_2O emissions in this report.

In Denmark, benchmarking is used only for new entrants. The Danish benchmarking approach differs from other countries as the capacity utilization and the performance level have been merged into one single figure of CO_2 allowances per capacity of the plant. For example, cement plants will receive an annual allowance of 5469 t CO_2 per tonne of cement capacity per hour. Denmark applied a benchmark to close to 30 products or product categories with a noticeable large number in the food or agriculture sector: greenhouse heating, milk powder, animal feedstuff processing, animal meal powder processing, green meal, pectin, alcohol distillation, fish oil and fishmeal, beet sugar, potato flower and protein and malt drying. Other sectors include the iron and steel sector, white and grey cements, refining, pulp, lime and lime products, ceramic, mineral fibres, glass and saline solutions evaporation.

Hungary was one the few new Member States (with Poland) to use not only a benchmarking for new entrants but also for some existing installations on the industrial sector. This is the case for the cement production where the Best Available Techniques (BAT) as defined in the BREF are used for the calculation of allowances combined with historical production levels. For the lime sector also a benchmark concept was used as the allowances for the sector are divided proportionally to the historical levels of production. All new entrants are to receive their free allowance on the basis of an EU BAT level (based on BREF) multiplied by the expected production. The only technology differentiation for new entrants is on the electricity sector where the supply of district heating with waste heat, the use of local resources and the sustainability are taken into account.

Poland applies a benchmarking approach to existing paper, refining, coking, cement, lime, iron and steel, glass, ceramic, sugar and chemicals installations. All of these have been negotiated for the specific sector and are either based on BAT (no further details on the BAT level are given) or on an own calculated national level of performance. Historical records corrected with a growth factor are used as a basis for production levels.

In Italy, the following industrial sectors also received their free allowances based on a benchmarking approach: other combustion installations, refineries, iron and steel, cement, lime, glass, ceramic, bricks, pulp and paper. Benchmark levels refer to own national data and are determined by a hybrid formula taking mostly into account the best 10th percentile. Activity levels are determined by standard factors for the power sector and historical levels corrected by a growth factor for industries. For all new plants in the industry sector, a BAT based benchmarking is applied together with production forecasts.

In Germany, benchmarking is used for new entrants with a product specific benchmark for power, heat, steam, cement, flat glass, other glass, clay bricks (2 categories) and roof tiles (2 categories). This benchmark is further differentiated between gaseous and other fuels for the generation of power, steam and hot water. The benchmark for the clinker production has been differentiated according to the number of pre-heater cyclones (3, 4 or 5-6). In the case of cogeneration, the double benchmark concept (allowances according to the heat and power components) is applied. All non specified sectors will receive their allocations based on a specific study to determine the applicable Best Available Techniques (BAT) level. A standard utilization factor has been developed for 25 energy conversion and reforming plants. A standard utilization factor is also applied to the petroleum industry, coking plants, sintering plants, ferrous metal production and processing, cement, lime (lime and sugar), glass, bricks, pulp and paper & cardboard industry. Since the associated standardized utilization factors differ for hard coal (7500 hours) and lignite fired power plants (8250 hours), the benchmarks for power plants are in effect fuel-specific. For activities which have no stated standard load factor, the German competent authority (Dehst) will “forecast the probable load for the relevant installation”. For installations installed in 2002 and afterwards, standardized utilization rates will be used rather than historic production levels.

In Luxemburg, benchmarking only applies to new entrants in the form of a product specific benchmark. This is the case for the production of cement, flat glass, other glass, clay bricks and roof tiles. No technology or fuel differentiation is applied. A standard activity level utilization factor is used for paper and pulp, power and heat generation, iron and steel, and minerals. New entrants for whom the standard values are not stated will receive allowances based on a study to determine the applicable BAT level as well as the production capacity.

In Sweden, existing primary steel plants receive their allowances according to a benchmarking approach (unless the grandfathering based allocation of free allowances yields lower free allowances). Integrated steel works receive 1.91 tonnes of carbon dioxide per tonne of steel ingot. This figure is based on a 2005 EU-wide average of all European integrated steelworks. A non detailed BAT level is used for new plants, including primary steel plants.

In the United Kingdom, benchmarking is used for all new entrants based on benchmark levels determined via various studies which have been reviewed and updated in between phase I and phase II (ENTEC-NERA, 2005). Standard values have been used for the utilization factor. All applied benchmarking procedures have been collected in a database which is transparent and publicly available. In total, 19 sectors have been differentiated in the UK NAP Phase II. The UK can be regarded as the country for which the most comprehensive benchmarking approach has been developed for the new entrants with a high transparency of the studies used, the chosen levels and the collected data. In between phase I and phase II, a review study was done by ENTEC-NERA (2005) which primarily aimed to assess the feasibility and limitations of a benchmark approach to allocation also in phase II. The report first summarises important parameters for which a selection should be made in developing a benchmarking approach: the type of benchmark (input, output, capacity), the basis for benchmark level (either best available technology or among the best x % in Europe or the World), aggregation level (number of subsectors and number of benchmarks in these subsectors) and the basis for the activity level. The following evaluation criteria are presented that can be used to evaluate benchmark approaches:

1. Simplicity, transparency and standardisation
2. Feasibility
3. Verifiability
4. Consistent with site need for allowances
5. Minimisation of gaming and perverse incentives.
6. Providing incentives for best practice and clean technology
7. Certainty

Each of these evaluation criteria are applied to the sectors ‘Electricity, CHP, Chemicals, Food and Drink, Engineering, Vehicle and Services, Petroleum refineries, Iron and Steel, On-shore gas distribution, Off-shore Oil and Gas, Pulp and Paper, Ceramics, Cement and lime, Aluminium, and Glass. Some results of the assessments that are of importance for this study are summarised below:

- For electricity, cement, on-shore gas distribution, offshore Oil and Gas and aluminium, output based benchmarks are feasible without further sector disaggregation.
- For iron and steel, glass, ceramics, paper and lime, the development of output based benchmarks is possible, albeit with further disaggregation of the sector into sub-sectors (e.g. primary and secondary steel).

- For petroleum refineries and the ‘other combustion activities’ (chemicals, food and drink, Engineering and Vehicles, Services and other combustion), the number of individual products is so large that it can be seen as prohibitive towards the development of output based benchmarks.
- The variation in efficiency levels at incumbent installations is considered low for the primary iron and steel and aluminium industry, medium for ‘other combustion’, CHP, refineries and on-shore gas and high for the other sectors. This gives an indication of the discriminative effect in stimulating clean technology.
- The variation in load between installations in the various sectors is considered low in the refinery, cement and aluminium industry, medium in the pulp and paper and iron and steel industry and high in the others. This give some indication on the implications of using standardised load factors across sectors of industry in relation to actual emissions of the individual sites.
- The annual differences in load factor are substantial in all sectors, for instance, the maximum variation over the period 1998 – 2003 ranged from 4% (aluminium) to 59% (other oil and gas). This gives some indication on the implications of using capacity utilization factors for specific historic years.

Conclusions regarding benchmark levels used for industrial sectors

The overview given above (and the more detailed overview given in Annex I) highlights that a wide variety of approaches have been used in determining benchmark emission levels and how these levels are used in the distribution of allowances per installation. This clearly demonstrates the lack of harmonization between Member States in the phase I and II of the EU ETS. Many Member States using benchmarking for industrial sectors outside the power sector refer in the NAP to undefined levels of performance, in general "Best Available Technology". In some cases there is explicit reference to the Best Available Techniques reference documents (BREFs) (BREFs, various years). We discuss these BREFs in a separate Section (Section 2.7). Some Member States use BAT levels in a non differentiated product-specific manner (e.g. one benchmark for cement) while others account for different technologies used (e.g. different benchmarks for different kiln types in the cement sector). A limited number of Member States developed own benchmark levels, which are not always quantitatively documented. Most quantitative data is available for the UK, but the approaches applied in the UK differ quite widely from sector to sector, making their direct use for the EU as a whole doubtful, given the wish for uniform allocation rules from sector to sector. Other countries using benchmarking for a large number of sectors based on own benchmark levels are the Netherlands and Belgium (Flanders), but due to the set-up of the benchmarking approach (involving an independent entity ensuring confidentiality of the data), these data are not publicly available. We conclude that none of the approaches and benchmark levels from the NAPs (as summarized in this report) can directly be used for an EU-wide benchmark based allocation methodology. The approaches used, as summarized in this report, can, however, serve as useful reference in the process to come to an EU-wide, benchmark-based allocation methodology (see also the examples in Chapters 6 - 9).

Conclusions regarding activity levels used for industrial sectors

The benchmark levels (specific emissions per unit of activity) discussed above need to be combined with an estimate for the level of activity, i.e. the level of production to come to a benchmark-based allocation. For existing installations, either historical production data or some sort of forecasted production can be used, whereas for new installations, the production always needs to be forecasted, because historical production data is not available.

The activity level (i.e. production) can always be expressed as the product of the capacity of an installation and the utilization factor of this installation.

For new entrants, the capacity is often referenced in the permit under the IPPC directive, although the NAPs are rarely explicit on this issue. The same holds for capacity utilization factors. The approach of standardised load factor has been widely used for the power generation, including existing plants, but the application of standard utilization factors has been much more limited for the industrial sectors. Denmark has an approach giving the allocation directly in tonnes allowances per installed capacity, but the underlying assumptions regarding utilization are not made explicit. Germany, Belgium (Flanders), Luxembourg, the Netherlands and the UK used a combination of a plant capacity and a standard utilization factor (in hours per year) in different sectors for new entrants. The values for Germany, Luxemburg and the UK are given explicitly in the NAP (Annex I-B) and can serve as a useful reference in developing capacity utilization factors for phase III of the EU ETS. Also here, the lack of harmonization is apparent. Some other countries used a forecast specific to the new entrants which might be in some cases more accurate but bears the risk of an uneven treatment between installations.

For existing installations, either historical productions or a production forecast is used by Member States. None of the Member States used the concept of capacity in combination with utilization factors for existing installations. This is in line with the proposal done in this study for existing installations (Section 4.7).

2.4 Sector classification in the EU ETS

It is crucial for any allocation system based on benchmarking that it is clear under which allocation rule a certain installation falls and that all installations are covered.

In this paragraph, we briefly summarize observed issues in phase I and II of the EU ETS related to the interpretation of “sector” and “installation” in view of the relevance of this issue with respect to an allocation system based on benchmarking. In Chapter 3, we then discuss in more detail the issue of sector definition and the way the observed issues from phase I and II could be dealt with.

In the first and second phase of the EU ETS, the interpretation of ‘sector’ and ‘installation’ varies significantly across Member States as highlighted in the first reviews of the NAP I undertaken by Ecofys (2005) and in the Scoping phase report of the LETS update (AEA Technology/Ecofys, 2006). Between the NAPI and II there are also inconsistencies. The ETD defines ‘installation’ as ‘*a stationary technical unit where one or more activities listed in Annex I are carried out and any other directly associated activities which have a technical connection with the activities carried out on that site and which could have an effect on emission and pollution’;* This definition has remained unchanged in the proposed revised directive, although the list of activities in Annex I has been extended. Various interpretation issues related to the definitions of these activities in Annex I were raised in phase I and II such as the interpretation of “combustion installations” and the use of the words and/or in the definition of installations that produce ceramic products.

The following issues from phase I and II that are relevant in relation to the scope of the current project (benchmarking for phase III of the EU ETS) can be identified:

- In the list of activities in Annex I, there is no clear definition of system boundaries for industries that operate Combined Heat and Power (CHP) plants or other units producing electricity (e.g. the paper industry). Some of these CHP plants are classified under the activity ‘combustion installations’ and others being considered as part of the separately identified industrial activity in Annex I. Partly this is also due to the differentiated ownership structure of such CHP plants (i.e. owned by the industrial company, by a utility company or by a joint-venture between the utility and the industrial company). In the design of a benchmark based allocation methodology, it should be ensured that uniform allocation rules are applied for all CHP and auto-generation plants, regardless of ownership structure.
- The definition of installations is often linked to existing operating permits, e.g. those issued under the implementation of the IPPC-directive. According to the definition of "permit" under the IPPC Directive, a permit may cover one or more installations or parts of installations on the same site operated by the same operator. Therefore, one IPPC permit might either cover many individual production processes on an industrial site (e.g. all processes within a refinery) or one individual production process (e.g. a separate permit for a hydrogen plant within a refinery), also depending on the ownership structure. The aggregation of individual production processes in an installation thus results in installations where the different processes can be categorized into different activities specified in Annex I of the ETD. Next to CHP plants mentioned earlier on, other examples include the production of lime in the food, pulp and steel industry and the production of hydrogen in the chemical and refinery industry. For a benchmark based allocation methodology, a consistent treatment of those installations operating more than one activity as specified in Annex I of the ETD is necessary.
- The activity ‘combustion installations’ covers installations from a variety of industrial and non-industrial sectors. This activity is defined by the size of the combustion installations rather than by the type of the installation product output. To design an allocation system based on product-specific emission benchmarks, a further classification based on output of the installations is thus required for those installations.

2.5 Overview of industry positions and suggested approaches

Positions of sector organizations on the EU ETS design

Benchmarking is by many industrial stakeholders regarded as the preferred option for free allocation as the below overview shows.

The Alliance of Energy Intensive Industries (uniting the chemical, cement, paper, ceramics, glass, lime, ferro-alloys, chlorine, iron and steel, non-ferrous metals and clay industries) argued for free allocation tailored to sector-specific performance indicators (e.g. benchmarks) instead of "auctioning or using emission caps indifferent to improvement potentials" (Alliance of Energy Intensive Industries, 2008).

The European cement industry (Cembureau), calls for a worldwide sectoral approach with regional targets (Cembureau, 2006). Some cement producers (Holcim) have clearly stated their position against the present “grandfathering system” (Holcim, 2006) which by distributing large allowances to inefficient plants works again the aim of the EU ETS to reduce CO_2 emissions. The distribution of allowances based on a past situation is also seen as inhibiting competition and innovation, giving little predictability and generating an additional running cost due to lobbying. A benchmarking approach is favoured by the cement sector with an allocation of free allowances based on the real production if possible with ex-post adjustments (Holcim, 2006) and with a CO_2 intensity benchmark becoming more stringent in time but taking into account the fact that process related CO_2 emissions can not be decreased.

The European chemical industry (CEFIC) also proposes to carefully consider the allowances allocation according to performance (CEFIC 2007).

The pulp and paper industry (CEPI) supports a benchmarking based on the energy efficiency and calls for a fuel (carbon intensity) and product (paper, pulp and integrated pulp and paper) differentiated approach (Hyvärinen, 2005).

The European Aluminium Association (EAA) wishes to receive free allowances through a benchmarking system. They stated to be open to a global sector agreement possibly linked to the EU ETS. The aluminium sector would prefer not to be included in the EU ETS on the basis of its direct CO_2 emissions (EAA paper, unknown year). Instead a system outside the EU ETS is preferred with goals on the sectoral level, using similar tools (monitoring, reporting, verification) using a benchmark and with penalties for non compliance.

The European glass industry (CPIV) states that future allocation should not be based solely on auctioning, since this will lead to unfair competition and unfair treatment between industries. In a discussion between the UK government and British glass in relation to the EU ETS review, the UK glass sector proposes a benchmarking methodology (British Glass, 2007). The industry supports targets based on energy efficiency expressed in GJ/tonne of product. Furthermore, a product differentiation is seen as necessary (summary by authors based on non-public documents obtained via personal communication with CPIV, 2008).

For the European Federation of Industrial Energy Consumers (IFIEC), the power prices are a major problem along with the distortion created by the ex-ante approach (IFIEC Europe, 2006). Due to the large variation in load and the difficulty to predict it, benchmarking in combination with an ex-post approach (based on actual production data) is preferred in order to reduce distortions in the competition. A solution to leakages from outside the EU is also desired. The approach proposed by IFIEC[3] to use actual production levels by using ex-post corrections would be a far reaching change to the EU ETS architecture. It is therefore not further considered in this study as already indicated in Chapter 1.

Conclusions regarding industry positions

We conclude based on the above that benchmarking is supported by a wide part of the European industry as a possible methodology for free allocation of allowances in the EU ETS. Several industrial sectors have experience with benchmarking, independently from the allocation discussion in the EU ETS. These experiences will be discussed in the next section. However, only a very limited number of proposals including allocation formulas, methodological approaches etc. have been prepared by the industry on benchmarking in the EU ETS.

2.6 Other selected benchmarking experiences

Many industries have experience with benchmarking. However, benchmarking is mainly used as a management tool for identifying the potential for (economic) improvement. Below we discuss selected benchmarking experiences in which benchmarking is used for international comparisons in GHG performance among installations that could be used in the framework of the EU ETS.

The Dutch covenant on benchmarking:

In the Netherlands, the energy-intensive industry (installations with yearly energy consumption above 0.5 PJ) has signed a voluntary agreement which requires industry to be as energy efficient as the most efficient industry in the world by 2012 (the Energy Efficiency Benchmarking Covenant). A total of 103 companies with 528 different processes participate. Companies develop their own benchmark methodology, subject to verification and approval by a verifying entity (VBE), related

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[3] The 'performance standard rate (PSR)' methodology proposed by IFIEC uses ex-post correction based on actual production values but still guarantees an absolute emission cap for the sector. The absolute emission cap for a certain sector is based on the present production, growth forecasts, the technological potential to reduce emissions and the level of ambition in the mitigation of CO_2 emissions. The actual allowances are determined ex-post in a dynamic manner based on real production data and the benchmark level adjusted in order to reach the desired cap. IFIEC suggests that the PSR methodology could avoid the main problems of ex-ante allocation. Drawbacks of the method are an additional uncertainty for operators, a larger administrative burden and, if applied to electricity production, a suppressed carbon price signal in the power price thereby reducing the incentive to limit power consumption.

to the national energy agency (SenterNovem). Data supplied to this verifying entity is confidential. The energy efficiency performance of plants is compared to the world top. This level is reassessed every four years. The benchmarks have been determined by 49 consultants in total (Iestra, 2005).

Four methods can be applied to determine the world top:

- The regional method (comparison with the most energy-efficient region in the world)
- The decile method comparison with the top 10% of all comparable installations worldwide)
- The best practice method (the energy efficiency of the best operating facility worldwide)
- Individual assessment method (improvement potential is determined for each individual firm participating)

The decile and regional methodologies are only possible for sectors where global or regional benchmark studies are available, which is the case for approximately 30 process installations. Good best practice studies are available for about 60 processes. The companies for which benchmark and best practice studies are used cover about 90% of the energy use of the companies that signed the covenant (VBE, 2006). The sectors for which benchmarking (either via determination of the best practice or by regional or global comparison) is used include:

- Refineries
- Aluminium
- Iron and steel
- Breweries
- Cement
- 60 processes in the Chemical industry
- Pulp and paper industry
- Glass
- Power sector

In Belgium, Flanders decided to follow the Dutch example and has also set up its benchmarking institute for the industry. Both used the benchmarking effort to determine a correction factor (the relative energy efficiency performance against the world top) which was then used in the allocation of allowances within the EU ETS (as discussed above). Due to the set-up of the system (all data flows via independent entity ensuring confidentiality of the processed data), the actual benchmark levels are not public and can therefore not be used for benchmarking in the EU ETS.

Glass industry

One of the main problems for the glass industry is that products are not comparable in their energy use since the shape of a glass product will largely influence the energy needed per tonne of product. Ultimately, a model is needed to determine a standardized level of energy required per tonne of glass according to its shape. For container and flat glass, mathematical models are available at the EU-level using global data, based on work by TNO in the Netherlands preformed as part of the benchmarking covenant. A model for the continuous fibre market is currently under review. The models incorporate all energy consumption in the glass furnace, fuel types and process emissions. The models have successfully been tested by UK and other European glass manufacturers (British glass, 2007)

Refineries and steam crackers - Solomon Associates

An example of an industry initiative that existed well before the Dutch benchmarking covenant and the EU ETS are the benchmarks for refineries and steam crackers developed by Solomon Associates. They are used by its customers for self assessing the performance compared to peers. Only those that supply data get access to the anonymous data in the database. The assessment has a very broad coverage and calculates a variety of indexes including a Greenhouse Gas Intensity Index. It covers all sources of greenhouse gases including CO_2 from purchased electricity, flare losses of CO_2 and methane, venting, fugitive emissions, etc. Greenhouse gas emissions from refineries are some of the most complex to benchmark. Nevertheless the Solomon benchmarking offers a sophisticated and trusted approach to the sector. Both the data from surveys and the database are the property of Solomon Associates. Solomon has a proven track record[4] and has expressed its willingness to develop benchmarking tools for the EU ETS (Ecofys/ Öko Institute, 2008). The benchmark by Solomon was also used as part of the Dutch and Flemish benchmarking covenant as discussed above and as such was used in the NAP-II for those countries.

Other Chemicals

The chemical industry is very complex with over 1,500 commercial processes. Not all of these processes are equally important in view of the total energy use of the sector. For the Dutch chemical industry, 60 product benchmarks covered 96% of the 87 chemical installations above the threshold of 0.5 PJ/year (Iestra, 2005). Tam and Gielen (2006) estimate that the production of just 49 products covers over 95% of all energy used by the chemical and petrochemical industry. SRI consulting has developed a reference “Greenhouse Gases Handbook” for the chemical industry which encompasses around 100 of the greenhouse gas emitting processes (Johnson and Heinen, 2006) and could be used as a reference document for developing benchmarks. Companies active in benchmarking for the chemical industry are Plant Service International (PSI, for ammonia and urea units), Process Design Centre (various processes including PVC), Philip Townsend Associates (polymers) and Nexant (melamine).

Cement Sustainability Initiative

For already some years, cement companies report their CO_2 emissions using the Cement CO_2 Protocol developed by the WBCSD Cement Sustainability Initiative (CSI). The CSI comprises 18 of the largest cement manufacturers of which a large number are European companies. Together, the

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[4] Solomon Associates EII used for the US Environmental Protection Agency’s ENERGY STAR program for the recognition of the top-25% of energy-efficient refineries in the United States. US EPA was allowed to review the model under a disclosure agreement to see if the model would meet the legal requirements of the US Government refineries.

CSI member companies cover over 70% of the cement production in the EU27. Plant data from all over the world representing over 50% of the production outside China have been collected through this Protocol which ensures a standardised reporting with a very complete set of data for the sector. While the reporting of each plant comprises more than hundred indicators, a set of selected key ones will be included into a database. This database called “Getting the numbers Right” (GNR) could easily serve as a basis for a benchmarking approach. The CSI is the owner of the GNR database but the data is managed by PriceWaterhouseCoopers (PWC) acting as a neutral third party. The CSI aims to develop a benchmark-based Clean Development Mechanism methodology based on this database, which could also play a role in a post 2012 global climate agreement.

Aluminium

The production of primary aluminium leads to both direct and indirect greenhouse gas emissions. Indirect emissions consist of CO_2 emitted as a result of the production of the required electricity and are as such already covered by the EU ETS. Direct emissions of perfluorocarbons (PFC) contribute to roughly one third of direct greenhouse gas emissions (Marks, 2007) in the process while CO_2 emissions contribute to the remaining two third of direct greenhouse gases emitted (Marks, 2007). Both PFC’s and direct CO_2 emissions from this activity are presently not included in the EU ETS. According to the Commission's Proposal for a revised ETS Directive they will be included in the EU ETS from 2013 onwards. For the aluminium industry, a standardised protocol developed by the World Resource Institute (WRI) / World Business Council on Sustainable Development (WBCSD) exists, amended by the International Aluminium Institute (IAI, 2006). The protocol is widely used, especially to quantify the results in PFC emission reductions which the industry committed itself to through voluntary agreements. The aluminium industry also uses the protocol to compare plants to the worldwide Best Available Techniques (Porteous, 2006). It has to be noted that two CDM methodologies ACM0030 and ACM0059 have been developed for the Aluminium sectors and parts of the methodological aspects could be reused in the frame of a benchmarking approach. Furthermore, the International Aluminium Institute has an extensive reporting of the energy used in the aluminium sector.

2.7 Best Available Techniques Reference Documents (BREFs)

As discussed, several NAPs make reference to the best available techniques reference documents prepared under the IPPC directive. The permits for installations that fall under this directive must contain conditions based on Best Available Techniques (BAT). The directive calls for an exchange of information which is organized by the European Integrated Pollution Prevention and Control Bureau of the Commission. The outcome of this exchange is the adoption and publication of BAT reference documents (BREFs) which Member States are required to take into account when determining BAT in general or for specific cases. In principle, the BREFs are ‘benchmark’ documents in describing the current best available techniques. Annex I-C of this report gives an overview of specific energy consumption figures that are contained in the relevant BREFs.

As can be seen from the overview provided in Annex I-C, the BREFs vary strongly with respect to the amount and level of detail of information on these issues:

- Some documents (e.g. the one for pulp and paper) give specific values for specific energy consumption of technologies, whereas other documents give (often wide) ranges or contain no values at all.
- The background and status of the figures mentioned (i.e. BAT or rather typical values for certain example plants) are in many cases unclear.

The reason for these differences is that the main focus of the BREFs is on different pollutants than GHG emissions and most of the documents to date contain only rather limited information concerning energy efficiency. With the introduction of the EU ETS, the IPPC permits shall not contain GHG emission limit values for activities and gases covered by Annex I of the ETS.

Given these drawbacks, we conclude that most of the BREFs cannot be used directly as a source for benchmark levels for the EU ETS. Nevertheless, for many sectors (e.g. glass), the BREFs are among the very few reports that contain values for specific energy consumption and GHG emission data for European installations under the EU ETS. The data can therefore form a good starting point in the determination of values associated with BAT for energy efficiency and GHG emissions, although independent verification and comparisons with the actual performance of the relevant installations in the EU will be necessary, before the figures on specific energy use and emissions can be applied.

2.8 Summary of key findings

In this paragraph, we give a summary of the key findings of the review described in this chapter with a focus on the relevant conclusions in relation to the design of a free allocation methodology based on benchmarking.

2.8.1 Benchmarking in the ETD and the Commission proposal for a revised directive

- In the Commission proposal for a revised directive, free allocation would be provided for via harmonised Community-wide rules, where feasible based on benchmarking.
- In the Commission proposal for a revised directive, the maximum amount of allowances available for free allocation for all sectors except electricity generators is explicitly defined as a share in the total cap based on emissions of those installations in 2005 – 2007. One single correction factor for all sectors will be used to ensure that the total maximum amount of free allocation will not be exceeded.
- The Commission proposal for a revised directive explicitly refers to the ability of individual installations in the sector to reduce emission levels, for instance on the basis of most efficient techniques,

- The Commission proposal for a revised directive explicitly refers to the “sector” and “subsector” level. A consistent and reasonable sector and subsector classification of incumbent and new installations in the EU ETS is required as one of the steps come to a (benchmark based) free allocation methodology for specific sectors.
- The Commission proposal for a revised directive rules out free allocation in respect of any electricity production, thereby creating a level playing field for all power producers.

2.8.2 Existing experiences in national allocation plans

- Benchmarking has been used for the allocation of allowances by a number of Member States. Ironically, benchmarking has been used mostly for the power sector for which free allocation is ruled out in the proposed revised directive post 2012.
- Many Member States also used benchmarking for new entrant allocation in the industrial sector, but in many cases, only non-quantitative performance levels, typically Best Available Technology, were given. A few Member States (Belgium, the Netherlands, Denmark, France, Germany, Hungary, Italy, Luxemburg, Poland, Sweden and the UK) to a certain extent developed their own benchmark emission values.
- The benchmark emission levels and approaches with respect to the use of product-specific, technology-specific and fuel-specific benchmarks followed by the various Member States illustrate clearly the lack of harmonisation in phase I and II of the EU ETS.
- The same holds for the approaches in determining the activity levels. For existing installations the activity levels are currently either based on historical activity data or projected production, whereas for new entrants, both standardised, sector-specific or projected installation utilization factors are used.
- A study on the use of benchmarking in the UK strongly showed that annual variations in capacity utilization factors for installation can be substantial and that also differences in capacity utilization factors per sector can be large. The ‘level of activity’ which is part of any benchmark-based allocation methodology should thus receive substantial attention.
- Between phase I and phase II there has been no convergence in the approaches followed by Member States for allocating allowances based on benchmarking.

2.8.3 Sector classification

- Many installations in the EU ETS operate production processes that can be categorized into different activities from Annex I of the Commission proposal for a revised directive. Examples are the production of lime in the pulp and steel industry and the production of hydrogen in refineries. For a uniform allocation methodology based on benchmarking, a consistent treatment of installations operating processes that fall under more than one activity is required.
- This is also the case for industrial sectors with combined production of heat and power or other auto-production of electricity. A consistent of treatment of those installations is required to come to a uniform allocation methodology for similar type of processes.

- A sectoral definition of those installations included only in the EU ETS as part of the activity ‘combustion installations’ is required to design allocation rules for those installations. These installations are part of a wide variety of industrial sectors.

2.8.4 Other experiences

- Many industries have positioned themselves as proponents of benchmark- based allocation methodologies, but the number of worked-out approaches, including discussions on issues such as benchmark types, benchmark levels, activity levels, and data availability etc. is limited.
- Many industries have experience with benchmarking. However, benchmarking is mainly used as a management tool for identifying the potential for (economic) improvement. Only a limited number of sectors (Cement and lime, Steel, Glass, refineries, part of the chemical industry, aluminium) have experience with benchmarking used for international comparisons in GHG performance among installations.
- In the Dutch and Flemish benchmarking covenants, benchmarking was applied to determine for many products (~100) the performance of the world top regarding energy efficiency. The benchmarks used are not available due to reasons of confidentiality.

2.8.5 BAT reference documents (BREFs)

- The Best Available Techniques Reference documents (BREFs) prepared in the context of the Integrated Pollution Prevention and Control directive often include information on BAT regarding energy efficiency. They are, however, not consistent on this issue regarding the level of detail for different sectors and contain emission factors with different stringencies (e.g. data ranges or single figures indicating BAT). The BREFs mainly focus on other issues than energy use and CO_2 emissions. With the introduction of the EU ETS, the IPPC permits shall not contain GHG emission limit values for activities and gases covered by Annex I of the ETS.
- The BREFs can thus not be used directly as source for an EU-wide benchmark based allocation methodology in the framework of the EU ETS. They can, however, be an important starting point in the determination of BAT specific energy consumption values, although independent verification of the data and comparison with the actual performance of the sector will be necessary.

3 Sector definition

3.1 Introduction

Annex I of the ETD contains a list of activities covered by the scheme. This list has been updated in the Commission proposal for a revised directive. The list is intended for the identification of the installations that should be participating in the system. In phase I and II of the ETS, some Member States have also used the classification of activities in Annex I to determine growth rates and partial caps for certain activities, although other national and international classifications of industrial activities have also been used. The Commission proposal for a revised directive in addition to activities also contains statements on sectors and sub-sectors for which the allocation rules might differ, e.g. in relation to the exposure of sectors to the risk of carbon leakage.

Benchmarking, however, relates the emissions of installations to the products and the allocation of allowances based on benchmarking is thus linked to the products of an installation rather than the industrial sector of the installation.

This raises the question what the link is between classifications of products, sectors and activities and how these links should be dealt with in a harmonised free allocation methodology. We discuss this issue in the present chapter.

3.2 Activities, installations, sectors and products

A harmonised free allocation based on benchmarking should ensure that all producers of the same product are treated equally, regardless the classification of the installation that produces the product into an industrial sector or into an activity as specified in Annex I of the ETD and the Commission proposal for a revised directive. This Annex I can by definition not be regarded as a sector classification, because the list of activities in Annex I of the ETD and the Commission proposal for a revised directive contains two different types of definitions of activities:

- Definitions of activities using the product output of industrial processes (e.g. production of paper and pulp) or a clear description of the activity based on the type of products made (e.g. coke ovens, mineral oil refineries). These activities could, in principle be linked to existing national and international classifications of activities. In Annex II of this report, the match with the NACE classification used in the European Union is presented.
- An activity “combustion installation” using the thermal input into combustion for the definition of the inclusion threshold. This activity cannot directly be linked to classifications of industrial activities, because there is no direct link between the operation of combustion installations and the output of the sector. Installations included in the EU ETS as part of

this activity thus include installations for the production of public electricity supply, but also installations from various industrial activities operating steam boilers, Combined Heat and Power (CHP) plants and other heat or electricity production units such as hospitals and greenhouses in the horticulture sector[5].

Classifications of industrial activities are used to categorize installations for statistical purposes to their main activity. This does not mean that these installations cannot operate production processes that, when operated stand-alone, would be categorized in another sector or sub-sector. It is therefore inevitable that some products are produced by installations that will be categorized into different industrial sectors according to NACE as the following examples show:

- The production of electricity and/or heat by auto-producers that can be classified either as a separate power plant or under a product related NACE sector. This has indeed been the case in phase I and II of the EU ETS, partly due to the different regulatory cultures[6] of the Member States and due to the widely differing ownership structure of auto-producer CHP plants and, to a limited extent, also industrial boilers.
- The production of hydrogen, which would as a separate activity be categorized as part of the basic chemical industry (NACE 241, Annex II), but as part of an integrated refinery is included under mineral oil refineries (NACE 2320).
- The production of lime, which would as main activity be classified into NACE 2652, but is often integrated as part of the food, iron and steel and pulp industry and as such included under other NACE sectors.
- The production of pulp, which is a stand-alone activity classified as NACE 2111, but might in an integrated pulp and paper mill be included as part of NACE 2112.

A straightforward alternative is not to use pre-defined activities or sectors in the design of harmonised allocation rules, but instead, apply product-specific benchmarks to the products produced by all installations covered under the EU ETS. This is compatible with the evidence-based method currently under development to determine the risk to carbon leakage that also takes a product approach to assess this risk rather than a sector based approach (EC, 2008b).

We envision the following steps to come to fully harmonised allocation rules for free allocation based on benchmarking:

1. Further categorization of the installations included in the EU ETS only via the Annex I activity “combustion installation” into their main activities to get detailed overview of the type of industrial activities included via the Annex I activity “combustion installations”.
2. Preparation of an overview of the products produced by all installations under the EU ETS based on the EU-wide used PRODCOM product classification[7],. Such an overview, which

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[5] To the authors, no comprehensive overview is available on all industrial activities that are included in the EU ETS via the group ‘combustion installations’.

[6] Some Member States may have different approaches to the definition of installations in the ETS. In some Member States separate production units get separate permits, i.e. they represent installations on their own for the purpose of the ETS even if they are owned by the same operator.

[7] More information on the PRODCOM classification can be found via:

should ideally also include the industrial sector classification of the installation involved as well as the categorization into the Annex I activity,[8] will provide insight into the degree of overlap of certain products between various industrial sectors. Special attention in the preparation of such an overview should be given to intermediate products of installations and to products that might not be covered as part of the PRODCOM such as “district heating” and “steam”.

3. Development of an output-based benchmark in line with the criteria outlined in the following chapters.
4. Development of fall-back approaches for those products where an output-based benchmark is not feasible or difficult to realise (e.g. along the lines of recommended allocation principle 11 given in Chapter 5.

A related issue in view of sector classification and benchmark-based allocation rules that will become apparent in the procedure outlined above is the need for a clear definition of the system boundary of the activities. The definition of installation in the ETD reads “*a stationary technical unit where one or more activities listed in Annex I are carried out and any other directly associated activities which have a technical connection with the activities carried out on that site and which could have an effect on emission and pollution”.* This definition thus also includes associated activities such as:

- Further processing of ‘primary’ products. Some installations producing pulp and paper might for example also operate production processes for paper products also resulting in direct emissions because of their heat demand. The same is true for metal processing installations (e.g. foundries) that might also produce fabricated metal products and for installations in the chemical industry that may also produce several downstream products that are not specified as such in Annex I, but use heat from combustion installations on the site.
- Other activities. Installations categorized as producing basic organic chemicals might also produce inorganic basic chemicals (e.g. chlorine for the production of polyvinylchloride) and speciality chemicals.

Installations categorized into some of the Annex I activities will thus operate production processes for products that are not as such specified in Annex I. In the development of benchmark-based allocation rules for these installations, it should thus be decided for which of these products, separate benchmarks need to be developed and if not, how these products will be treated (Step 4 and 5 outlined above).

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http://epp.eurostat.ec.europa.eu/portal/page?_pageid=2594,58778937&_dad=portal&_schema=PORTAL

[8] In e.g. national statistics

4 Benchmark design – allocation principles

4.1 Introduction – benchmark based allocation

In this chapter, we set out the main allocation principles that can form the basis for the development of a benchmark-based allocation methodology. The principles as they are formulated in this chapter are meant to be generally applicable to all sectors for which a benchmark-based allocation methodology could be developed. In chapters 6-9, the principles as they are formulated here will be tested and applied to four selected model sectors to further assess their feasibility in view of overall applicability with respect to data requirements etc. In these four chapters, sector-specific issues will be discussed.

The Commission proposal for a revised directive put forward by the European Commission on 23 January 2008 forms the working hypothesis for the current study. Any amendments to the proposed directive made as part of the co-decision procedure within the European Council and Parliament are not taken into consideration in this report.

In general, any allocation based on benchmarking can be calculated as:

Allocation (1) = Activity Level (2) * Benchmark (3)

Equation 1

With:

Allocation (1) =	Allocation of allowances given out for free in t CO_2 / year
Activity level (2) =	Activity level the benchmark refers to (e.g. t product / year)
Benchmark (3)=	Benchmark for the activity indicator (e.g. t CO_2 / t product)

To come to an allocation (1) based on benchmarking, the level of a certain activity (2) needs be combined with a specific emission benchmark for this activity (3). The emission benchmark is dependent on choices related to energy efficiency, fuel mix and the treatment of process emissions:

$$\text{Benchmark (3)} = \text{Benchmark}_{\text{energy efficiency}}\ (4)\ *\ \text{Benchmark}_{\text{fuel mix}}\ (5) + \text{Benchmark}_{\text{process emissions}}\ (6)$$

Equation 2

With:

$\text{Benchmark}_{\text{energy efficiency}}$ (4) =	Benchmark for energy efficiency of the activity indicator (e.g. GJ / t product)

$\text{Benchmark}_{\text{fuel mix}}$ (5) = Benchmark for the fuel mix used (e.g. t CO_2 / GJ)
$\text{BM}_{\text{process emissions}}$ (6) = Benchmark for non-fuel related process emissions (e.g. t CO_2 / tonne product)

To come to an allocation (1) based on benchmarking, the level of a certain activity (2) needs to be combined with a specific emission benchmark for this activity. This benchmark contains an element related to the energy efficiency of the production process for this activity (3), the fuel mix applied (4) and an assumption regarding non-fuel related process emissions, if applicable (6).

In this chapter we discuss the following choices regarding these elements in the allocation formula:

1. Benchmarks for direct or total emissions, i.e. the scope of the benchmark – Section 4.2
2. Basis for energy efficiency benchmark level – Section 4.3
3. Inclusion of technology-specific factors in the benchmark – Section 4.4
4. Number of activity indicators to distinguish – Section 4.5
5. Basis for fuel mix benchmark level – Section 4.6
6. Basis for determining activity levels – Section 4.7

For these issues, we aim, where possible, to recommend allocation principles (starting points) that will be applied in the following chapters to the four selected product groups.

It is important to note that the total amount of allowances allocated within the EU ETS needs to stay within a certain emission cap. The Commission proposal for a revised directive therefore introduces a “correction factor” (Article 10a, paragraph 4) to be applied where necessary (i.e. when the total amount of free allocation for installations based on certain allocation rules would exceed a given cap for these installations). This correction factor is outside the scope of this project and will therefore not further be discussed in this report[9].

Benchmarks as a supporting tool for the allocation of emissions allowances differ from the benchmarks that are developed and applied for the comparison of energy and emission intensity of plants e.g. for optimisation of production. When benchmarks are developed for the latter purpose, they focus on evaluation of similar existing plants with the aim to identify improvements within their principal technological concepts. Within the framework of the EU ETS, the objective of the benchmark is not necessarily the comparison of plants, but to give all plants producing a certain product or group of products a fair allocation. The benchmark should not be perceived as a "target" or as a "limit" on emissions. It is not necessary to focus on achievements within a given specific technological setting but rather on emission levels that can be achieved by at least one efficient technique for the same product (see further Section 4.3).

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[9] During the stakeholder meeting, several industry representatives stressed the importance of the correction factor in relation to the acceptability of stringent emission benchmarks.

4.2 Scope of the benchmark: direct or total emissions

In principle, benchmarks could relate to direct emissions only or to direct and indirect emissions together. The latter would also take into account emissions generated in the production of electricity. In this case, the operator of an electric arc furnace steel plant, for example, would receive allowances related to the emissions directly emitted by the electric arc furnace but also related to the emissions emitted by the power plant delivering the electricity (either on site or off site).

The EU ETS uses an allocation scheme for direct emissions only. This puts the point of regulation to the operator who has the full responsibility for the emissions. Thus, the same operator receives allowances, has the obligation to monitor and report emissions and to cover them with the surrender of allowances. Developing benchmarks for direct emissions only is therefore most consistent with the set-up of the EU ETS. In this study we therefore develop allocation criteria for benchmarking based on direct emissions only[10]. The potential use of benchmarking for compensation for those installations where electricity constitutes a high proportion of production costs is thus outside the scope of this study[11].

In this study, we consider all emissions from the production of heat and steam[12], e.g. via steam boilers or combined production of heat and power (CHP) as direct emissions, even if they occur off-site in a CHP plant or boiler owned by a different company. The reason for this is to avoid penalising combined production of heat in CHP plants and to put all production of heat at an equal footing as also indicated in the Commission proposal for a revised directive. For a more detailed discussion on this, we refer to the Chapter 5.

In determining the best practice direct emission level, in some cases it is nevertheless important to take into account the overall CO_2 performance of best practice plants (including the indirect CO_2 emissions from electricity) for those processes (process steps) in which a trade-off exists between direct fuel and electricity use (e.g. the use of direct drives using steam turbines e.g. for compressors and the use of electrical heating in certain sectors).

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[10] There are methods to assess the overall integrated performance of an installation (including the indirect emissions) while still allocating on the basis of direct emissions only (e.g. via a correction factor based on a total emission benchmark). Such a method would add complexity to the allocation methodology and could result in a distortion of the carbon price signal, because the costs for carbon emitted in the production of electricity would be passed on in the electricity price and also becomes a parameter in the allocation of direct emissions if the link between the allowances for power producers and consumers is not properly made.

[11] It is explicitly mentioned in recital 19 of the Commission proposal for a revised directive that decisions on such compensation is left to after the analysis of carbon leakage also in view of the negotiations on a new international climate agreement.

[12] For simplicity reasons this study normally refers to steam as a heat transfer medium only, but all other media (hot air, water, heat transfer oils etc.) are equally included here. “Heat” can include both, direct heat use in various kilns, dryers etc, and indirect heat use by means of a heat transfer medium.

4.3 Basis for energy efficiency benchmark level

For deriving the energy efficiency benchmark, three main methodologies exist:

1. A comparison of existing installations. All installations are represented on a benchmark curve and the energy benchmark level is chosen as the performance of e.g. the installation representing the 10% best installations or top quartile.
2. An external reference based on the available technological options. The benchmark level can, for instance, be chosen as the emissions of the most energy-efficient technology.
3. An external reference based on thermodynamic considerations. The energy benchmark level can for example be based on the thermodynamic minimum energy required for a certain process step.

The latter methodology does not take into account any practical and economic considerations related to industrial technology (i.e. the need for driving forces to run chemical reactions within a finite amount of time and space, resulting in inevitable energy losses etc.). Such a methodology is therefore far from the actual technological setting in which installations within the EU ETS operate and will not further be discussed in this study.

From the Commission proposal for a revised directive (as summarised in Section 2.8.1), a number of arguments can be deducted to adopt the second methodology for setting the benchmark levels and to use the most energy-efficient technology as the (external) reference level:

- The Commission proposal for a revised directive foresees that a single correction factor for all sectors will be used if necessary to ensure that the total given cap for installations receiving free allocation will not be exceeded. The stringency of the emission benchmark in one sector therefore will thus influence other sectors receiving free allocations based on benchmarking. To ensure fairness and environmental integrity of the free allocation methodology based on benchmarking, a uniform approach is therefore preferable compared to one based on the distribution of performance over existing plants in operation.
- The Commission proposal for a revised directive also explicitly refers to ‘most efficient techniques’, i.e. to a reference not based on a comparison of the actual performance of existing installations.
- The use of the most energy-efficient technology as external reference level allows a uniform allocation for both existing and new installations.

As first allocation principle, we therefore recommend to base the benchmark level on the most energy efficient technology:

Recommended allocation principle 1:
Base the benchmark level on the most energy efficient technology

For applying this allocation principle, it is still necessary to define what is considered the most energy efficient technology. This requires choices related to the required technical maturity and level of application of technologies to be taken into account. We recommend considering only those technologies that are currently applied EU-wide at an industrial scale in determining the most energy efficient technology. The argument in doing so is that such a benchmark directly relates to technologies that are currently available at the relevant scale in the relevant geographic area (i.e. the EU) and thus relates to greenhouse gas reduction options that are currently within reach of installations under the EU ETS. This is not (yet) the case for technologies which are currently only applied in laboratory or pilot scale experiments.

To apply these definitions, data is thus required on the specific energy consumption of the best technologies that are currently applied at an industrial scale.

As source for specific energy consumption values of the most energy efficient technologies that are applied at an industrial scale, use can be made of:

- Public literature such as the BREFs and other sources.
- Industrial data collection efforts, i.e. existing benchmark curves
- Data from technology suppliers
- Data from specialised consultants, as far as transparency and confidentiality issues can be solved
- (Independently verified) data collected from operators[13]

In the individual sector chapters, we briefly touch upon the availability of this data for the selected sectors.

In view of the single correction factor that may be applied (see Section 4.1), it is important that the same stringency is applied for all sectors. We recommend that the determination of the best practice is done in close cooperation with industry, but that at the same time an independent verification step is included to ensure inter-sectoral fairness and consistency of the chosen levels. In this verification, it would be good, albeit not strictly necessary, to compare the benchmark with the actual specific energy consumption figures of the relevant installations. This ‘automatically’ yields the performance of the best performing installation in the EU (not worldwide), which can be an important basis in determining the most energy efficient technology in place.

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[13] Such a data collection could be done under a legal requirement, e.g. updated monitoring and reporting guidelines.

4.4 Inclusion of technology-specific indicators in the benchmark

The activities of a sector (element (2) in Equation 1) can be defined as being determined by the 'mix of processes applied' or the 'mix of products'. In the first case, activity indicators take the following form:

- Product A, produced by technology A
- Product A, produced by technology B
- Product A, produced by technology C

Whereas in the second case, the activity indicator is just defined as product A without taking into account the technologies) used to produce it.

In determining benchmark levels, the choice between the two is very important as the following example shows. If sector activities are defined by the mix of processes, one can argue that steam reforming of natural gas to produce ammonia is a different activity than the partial oxidation using oil (or coal via gasification) to produce the same grade of ammonia. In that case, both activities should receive a different, technology-specific benchmark. If sector activities are defined by the mix of products, steam reforming and partial oxidation are just different processes to perform the same activity, i.e. the production of ammonia. In the former 'definition', the higher GHG emissions of partial oxidation are considered to be the result of differences in sector structure, in the latter this is just considered to be a matter of energy and GHG gas efficiency (text adapted from Phylipsen et al., 1998).

The objective of the EU ETS is to give incentives for clean, GHG-efficient technologies. Since the primary purpose of the EU ETS it to help achieving the emission reduction target in a cost-effective way, a benchmarking system should provide incentives for companies to select the least cost emission reduction options. If benchmarks for the same or for sufficiently homogenous products were differentiated by process, technology or fuel (see Section 4.6), this would create distortions in the price signal for individual technologies within a certain industrial sector.

If wrong incentives are created, companies may not necessarily invest in the most cost-efficient technologies and overall costs to achieve a given emission target would be higher. In terms of allocation to new projects, differentiating benchmarks by technology would be technology-specific subsidies. In this case, the benchmarking rules would mask the price signals for investments in new projects and for research and development efforts in carbon-saving technologies.

A single benchmark per product would thus provide the best incentives to invest in the most carbon-efficient technologies. A single benchmark would also be more transparent.

Applying a single uniform benchmark for all technologies will have distributional effects for existing installations. These distributional effects are in line with the polluter-pays-principle and with the aim of the EU ETS to promote GHG efficient technology as outlined above.

We will therefore use in this study product-specific benchmarks that are not distinguished by technology as outlined in the following allocation principle:

Recommended allocation principle 2:
Do not use technology-specific benchmarks for technologies producing the same product

In line with the above argumentation, we further recommend not to apply correction factors for parameters such as:

- Existing plants versus new plants. Using a different benchmark level for existing versus new installations results in intra-sectoral distortions and incentives to keep existing non-efficient technologies longer in operation. No differentiation will therefore be made between new and existing installations.
- Plant age. Generally speaking, old plants can be expected to be less carbon-efficient compared to new plants. Including age as correction factor in the benchmark (i.e. distinction between old and new plants) would not incentivise investments in new, cleaner technology which is in contradiction with the objective of the EU ETS scheme.
- Plant size. Large plants are generally more efficient than small ones for the production of the same product. There is no need to include correction factors for plant size for a given product, because one would like to give equal incentives for all plants to invest in more efficient plants.
- Raw material quality. Production sites with access to low quality raw materials only (e.g. limestone with high moisture content) should not be favoured compared to those sites with high quality raw materials inputs to avoid intra-sectoral distortions in the price signal. We therefore suggest not applying a correction factor for differences in raw material quality and to base the benchmark on good quality input materials.
- Climatic circumstances. Although climatic circumstances can have an impact on issues such as efficiency of boilers and heat demand of processes, these effects are in many industrial processes small and are difficult to quantify decisively. We therefore suggest not correcting for this.

Recommended allocation principle 3:
Do not differentiate between existing and new installations

Recommended allocation principle 4:
Do not apply corrections for plant age, plant size, raw material quality and climatic circumstances

A remaining issue related to the application of allocation principle 2 and 3 is the availability of secondary materials (scrap, recycled paper, glass cullet) that are available only in limited quantities and cannot always be fully used in view of product quality issues. We argue that benchmarks for each product should be based on a realistic share of secondary input material that can reasonably be obtained in view of availability and product quality issues and try to reflect this in the benchmark level where possible. Such a share needs to be determined for the EU as a whole to create a level playing field for all installations in the EU, i.e. no country-specific shares will be determined. We will discuss the application of this general line of reasoning in more detail in the sector chapters on Iron and Steel, Pulp and Paper and Glass.

4.5 Number of activity indicators to distinguish

An important aspect related to recommended allocation principle 2 is of course the definition of "the same product". In other words, for how many products separate benchmarks should be distinguished. Possible criteria that can be used to determine the number of products to distinguish are:

1. The availability of verifiable production data for the products that are distinguished. It is not feasible to distinguish between products if no production data are available based on an unambiguous and justifiable product classification taking into account e.g. the existence of statistical classification used for the collection of production data and clear (technical or non-technical) differences between products.
2. The difference in emission intensity between products. It can be doubted whether it is useful to distinguish between products if their emission intensity differs only marginally.
3. The substitutability between products. It is not in line with the defined allocation principle to have separate benchmarks for two products that are to a large extent substitutable.
4. The share of a product in the total emissions of a sector. It can be doubted whether separate benchmarks need to be developed for products that only contribute marginally to the emissions of a sector.
5. The need for a simple and transparent allocation system. One can argue that more benchmarks make the allocation methodology less simple and transparent. However, a counterargument is that, once a consistent and uniform allocation formula is used for all products, the number of products is not necessarily an issue affecting the overall transparency of the methodology or the system's complexity.

We regard the first criterion as a bottleneck criterion for determining the maximum number of products, whereas the remaining four criteria contain subjective elements that are open for discussion. With the exception of the first bottleneck criterion, we do not give a recommended allocation principle with respect to the number of products to distinguish:

Recommended allocation principle 5:
Only use separate benchmarks for different products if verifiable production data is available based on unambiguous and justifiable product classifications

Another important issue is whether separate benchmarks are possible and required for intermediate products from installations. We argue that it is necessary to have separate benchmarks for intermediate products for installations if there are installations that sell the relevant intermediate product to the market. Otherwise, installations only performing production processes up to a certain intermediate product or using a certain intermediate product as raw material, could not receive a benchmark-based allocation:

Recommended allocation principle 6:
Use separate benchmarks for intermediate products if these products are traded between installations

To ensure equal and thus fair treatment for all installations, the benchmark for the intermediate product should apply to all installations producing this product, including those installations not selling the intermediate product, but using it in an integrated process.

This contradicts the line of reasoning with respect to secondary raw materials as outlined above. Take as an example the situation of integrated versus non-integrated pulp and paper mills. If for an integrated pulp and paper mill the benchmark for paper would be based on a fixed amount of primary raw material (i.e. pulp) and secondary raw material (recycled paper) in line with the reasoning for secondary raw materials outlined above, the mill would not receive full allocation for the pulp it produces in case this is more than the benchmark amount of pulp required for the specific paper product.

If, on the other hand, the pulp would have been produced by an independent pulp producer receiving the full allocation, the ownership structure of the site would influence the total number of allowances[14]. For this reason, we do not specify a 'best practice share of primary versus secondary input material' for the pulp and paper and iron and steel sector (see Chapter 6 and 7)[15].

A side-issue related to the same topic is whether the benchmark for the intermediate products should be based on the stand-alone production or on the production in integrated processes. In line with allocation principle 2, we argue that the most energy-efficient technology (in many cases the integrated process) should be the basis for determining the benchmark level.

4.6 Basis for fuel mix benchmark levels

The fuel mix applied by industrial sectors in many cases shows substantial differences across the EU countries. Partly this has obvious and understandable reasons (e.g. no availability of natural gas), in other cases this is due to a range of factors (e.g. policies, number of new plants etc., possibility to use cheap solid fuels). We argue here that the price signal to shift to non-carbon intensive fuels should be equal to all installations in the EU, i.e. not to have fuel-specific benchmarks for

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[14] An alternative could be to already take the use of the pulp into account in the allocation, but this cannot be implemented from a practical point of view.

[15] For the glass industry, we do define a best practice share of cullet, because for glass there is no intermediate primary product which is traded.

individual installations or for individual countries to ensure that the fuel-shift incentive remains undistorted in the EU ETS. We therefore recommend the following allocation principle:

Recommended allocation principle 7:
Do not use fuel-specific benchmarks for individual installations or for installations in specific countries

A remaining issue is of course which fuel mix benchmark (t CO_2/TJ) to combine with the energy efficiency benchmark to determine an emission benchmark. We distinguish the following possibilities with respect to fuel mix choice:

1. The most GHG-efficient fuel mix that is currently applied at an industrial scale (by analogy with the chosen level for energy efficiency).
2. A comparison of the performance of existing installations. The fuel mix is chosen as the performance of e.g. the installations representing the 10% best installation, or as the average of these installations.
3. Idem, but the fuel mix is chosen as the performance of e.g. the installations in the 1, 2 or 3 best performing countries.
4. External reference based on a default sector-specific fuel mix (i.e. the dominant fuel of the sector).
5. External reference based on a default non-sector specific fuel (e.g. natural gas)

The first methodology has the advantage that it is consistent with the definition of the benchmark level for energy efficiency and would result in an emission benchmark that could be considered as referring to the most GHG-efficient technology. However, such a benchmark level might be strongly influenced by individual installations that are in specific situations regarding the fuel mix, e.g. nearby availability of cheap biomass resources (e.g. wastes). Contrary to energy efficiency of technology, fuel availability has a clear regional dimension and this regional dimension has a strong influence on the allocation in case this methodology (and to a lesser extent methodology 3) is used.

Methodologies 2 - 4 have the drawback that they are based on the actual fuel mix performance of the sector (which can be far worse than possible or close the best achievable) and that, via the correction factor, other sectors are influenced

Advantage of methodology 5 is that it is very simple to apply and as such adds to the transparency of the EU ETS allocation methodology. It is, however, disadvantageous for those sectors that currently strongly rely on carbon-intensive fuels (cement, iron and steel), sometimes for reasons that can be considered as inherent to the process (i.e. coke use in the blast furnace).

The choice for a single fuel mix has a strong political dimension, because it will have a strong distributional effect among Member States in the European Union. This was also stressed during the stakeholder meeting (Annex III). It will put Member States with a carbon-intensive fuel mix at a disadvantage. It is also related to the availability of certain fuels and sustainability issues related to the large-scale use of certain fuels (biomass). Given this strong political dimension, we do not give here a recommended allocation principle regarding the fuel mix to apply in the benchmark allocation methodology. For the time being, we assess the fuel mix of the four individual sectors mentioned and take the most dominant fossil fuel as default in determining the benchmark levels. For all four sectors, after the correction for the technology-specific fuel choices in the iron and steel and pulp production (see below), this results in natural gas being the fuel of choice to use in the benchmark (i.e. application of methodology 4 is equivalent to methodology 5). It should be stressed, however, that this will not necessarily be the case for all other sectors in the EU ETS (e.g. cement where coal is the dominant fuel, with increasing importance of biomass wastes).

In case the best practice process for a specific product contains a technology-specific fuel choice we recommend taking this into account in determining the benchmark. Examples from the products discussed in this report are the use of coke in the blast furnace and biomass resources in the production of pulp.

Recommended allocation principle 8:
Take technology-specific fuel choices into account in determining benchmarks

4.7 Activity levels

The choice on how to determine activity levels is equally important as the specific CO_2 emission benchmark level in determining the final allocation in accordance with Equation 1 (Section 4.1). The activity level is equal to the capacity of a certain installation to manufacture the product that is benchmarked multiplied with a certain capacity utilization rate.

For **existing installations**, the following three options can be distinguished in an ex-ante[16] allocation system to determine the activity level (adapted from Ecofys / Öko-Institut, 2008):

1. Historical production figures
2. Capacity, in combination with standard capacity utilization rates
3. Projected production based on market studies, maintenance schedules etc.

Historical production figures. The allowances in this case are distributed based on the production in a given historical year or the average of a number of historical years. The approach bears the risk that installations and / or sectors are being penalised or favoured by past circumstances that are not necessarily equal or similar in the trading period. This could partly be corrected for by using the average historical production over e.g. three years (2005 – 2007) to avoid that e.g. a non-representative maintenance stop in a given year has a large influence on the allocation. Using historical production for existing plants has as great advantage that only historical production data of the relevant products are required and no data on capacity. This is advantageous, because for existing facility, the concept of “capacity” is not well defined as was also confirmed during the stake-

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[16] The EU ETS is designed as an ex-ante allocation system as opposed to an ex-post allocation system where the actual production could play a role in the allocation.

holder meeting (see Annex 2). Initially, when a new facility starts operation, the "nameplate capacity" of the installations is often known and mentioned in e.g. environmental permits, but during operation, partial or full retrofitting and debottlenecking of installations take place, resulting in an actual capacity differing from the initial nameplate capacity. Capacity can furthermore depend on operation parameters, such as product quality (e.g. the specific weight of the paper produced).

Standard capacity utilization rates. In this methodology, plants are treated as if they are operated with equal capacity utilization rates which are considered as common and accurate for the sector at stake. This methodology has been used in several second National Allocation Plans mainly for new installations. It has the disadvantage, however, that data on capacity are required.

Projected production. Historical production figures may not reflect expected production levels for all installations or for all sectors. Installation and/or sector specific circumstances can affect the expected production level of an installation (e.g. strong expected production growth or decline, planned maintenance for installations etc.). In theory, specific market studies could be conducted to estimate realistic capacity utilization levels for a given sector or installation in the trading period to project future production, but in our opinion, any potential advantage is far outweighed by the subjective and arbitrary elements that are inherent to future production projections. In addition, as allocation would concern an 8 year trading period, a large part of the fluctuations can be expected to even out. Moreover, many companies operate multiple installations, which further reduces the need to assess installation specific factors.

Based on this, we therefore define the following allocation principle:

Recommended allocation principle 9:
Use historical production figures to allocate allowances to existing installations

This methodology thus requires the availability of historical production data (e.g. for the years 2005 – 2007) for all products that fall under a benchmark based allocation methodology. During the stakeholder meeting (Annex II), industrial representatives made clear that the availability of this data should, generally speaking, not be a major problem, but we recommend further assessing whether this is indeed the case in detailed pilot studies for some sectors. Production data for intermediate products are for example often missing in official statistical production databases such as the European-wide PRODCOM database (Neelis et al., 2007). In such assessment, it should also be checked how independent verification of the data could take place. Also the issue of confidentiality of these production data should be further assessed. When the data are used for allocation (e.g. in 2011), the production data used are already rather outdated (4 – 6 years), which might make it easier for companies to publicly share this information. Still, it should be studied further whether this is indeed the case for all sectors for which benchmarking is used.

For **new installations**, historical production can obviously not be used. For this reason, in an ex-ante system of allocation, an estimate for capacity utilization should be made. To do this in a transparent and uniform manner, the definition of capacity should have a sound and verifiable basis. We recommend addressing the issue of "capacity definition" in monitoring and verification guidelines for new installations under the EU ETS in close cooperation with industry. Capacity utilization factors differ significantly from sector to sector and from product to product. This is also acknowledged in the NAPs for phase I and II that use benchmarking for new installations (see overview in Chapter 2 and Annex I). In the NAPs for which specific information on this issue could be found (e.g. for the UK and Germany), sector-specific capacity utilization figures are applied, in many cases ranging between 80% and 95%.

We therefore recommend the following allocation principle:

Recommended allocation principle 10:
Use product-specific capacity utilization rates in combination with verifiable capacity data to allocate allowances to new installations

The above-mentioned NAPs for Germany and the UK can be a valuable source of information in determining relevant sector-specific capacity utilization factors. Another option could be to estimate for existing installations the capacity utilization rate based on 2005 – 2007 production and estimated total capacity and apply this capacity utilization also to new entrants. An interesting attempt to study load variations by sectors over time is done by ENTEC and NERA (2005) by studying variations in emissions over time, assuming constant capacity and no change in emission intensity. The maximum variation in load over the period 1998 – 2003 varied between 4% for aluminium and 59% for installations in the oil and gas industry with most sectors having a variation in load between 10% and 30%. These rather large values show that for existing installations, an average of historical production will yield a far more robust estimate of past production than focusing on a single year.

5 Allocation for Heat

5.1 Introduction

As already briefly touched upon in Section 3.2, a consistent treatment of all emissions resulting from the production of heat is necessary to ensure that:

1. Different types of ownership of the heat producing installations do not result in different allocations.
2. The heat produced in cogeneration units gets an equal treatment compared to other producers of heat (Article 10a of the Commission proposal for a revised directive).

Especially installations for the cogeneration of heat and power (CHP), but to a more limited extent also steam boilers and other heat producing equipment can have rather different ownership structures. Some of these installations are owned by the company that use the heat produced to support its primary activity. These “autoproducers” are defined in the annual joint EUROSTAT/IEA/UN electricity questionnaire (EUROSTAT/IEA/UN, 2008) as *undertakings that generate electricity and/or heat, wholly or partly for their own use as an activity which supports their primary activity.* Other installations, referred to as “main activity producers” are undertakings that generate electricity and/or heat for sale to third parties, *as their primary activity*. For a fair and consistent EU ETS, the heat produced by the installations should be treated equal, regardless whether it is produced by an auto- or main activity producer. This means that the allocation methodology should find a solution for heat crossing the boundary between different installations under the EU ETS. We will discuss this in Section 5.3.

A second issue, related to CHP installations is that they produce one product, electricity, for which no allowances will be allocated free of charge, and another product, heat, that partly might receive free allocation. The allocation methodology for these installations should thus distinguish emissions resulting from electricity production and heat production. We discuss this further in Section 5.2.

In Section 5.4, we discuss how a benchmark for heat production can also be used for sectors and production processes for which no output-based benchmark methodology is developed.

5.2 CHP – dividing emissions over heat and electricity

Cogeneration of Heat and Power (CHP) is a process generating simultaneously heat and power. The use of cogeneration maximises the fuel utilization defined as a ratio of the useful energy per unit of energy input and leads to a net reduction in primary energy use and GHG emissions compared to separate production. Most cogeneration is based on a local heat demand (e.g. an industrial facility, district heating network). CHP producers can be classified as autoproducers and as main activity producers as defined above. In 2002 autoproducers accounted for 45% of the cogenerated electricity at the EU level, whereas main activity producers represented 55% of the CHP electricity produced (Eurostat, 2007). CHP electricity generation in 2006 in the EU-27 amounted to 366 TWh and heat production to 863 TWh (Loesoenen, 2008).

The electric efficiency of CHP units is determined by the type of fuel used, the scale of the installation and the technology used. Table 3 shows typical technical usage characteristics of industrial Combined Heat and Power installations.

Table 3 Typical usage characteristics of industrial CHP installations (Hers et al., 2008 unless otherwise given)[17]

	Capacity MW_e	**Power to heat ratio**	**Overall fuel efficiency**
Large combined cycle	250	1.11	75%
Small combined cycle	80	0.40	84%
Large gas turbine	25	0.69	78%
Gas engine	2	0.84	90%
Steam turbine[1]	2 – 50	0.20	90%

[1] Data based on Ecofys expert opinion

In Article 10a of the Commission proposal for a revised directive, free allocation to any electricity production is ruled out. According to the same article, free allocation may, however, "be given to electricity generators in respect of heat through high-efficiency cogeneration … to ensure equal treatment with regard to other producers of heat." Emissions related to the production of CHP heat should thus be treated identically as those related to the heat produced in other plants to avoid a distortion of competition. In other words, CHP heat fed to the final user should not face more stringent allocation than an industrial boiler installation in the same host sector. This is consistent with the general objectives of EU legislation to encourage high efficiency CHP.

To allocate allowances to CHP heat, it is thus necessary to separate the fuel used to produce heat and the fuel used to produce power. Phylipsen et al. (1998) identify six methodologies to do this:

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[17] The study is used to calculate the cost-effectiveness of Dutch industrial CHP installations.

1. On the basis of the energy content of the products
2. On the basis of the exergy content of the products
3. On the basis of the economic value of the products
4. Allocation to heat based on a reference efficiency of stand-alone steam production in boilers, the remainder of the fuel use allocated to electricity
5. Allocation to electricity based on a reference efficiency of stand-alone power production, the remainder of the fuel use allocated to heat
6. Dividing the energy savings equally over the heat and power produced using a reference efficiency for both stand-alone heat and power production.

To ensure equal treatment for CHP heat compared to heat otherwise produced, one would like to allocate the fuel equivalent of the non-CHP production of heat also on the basis of heat produced in CHP plants. Out of the six methodologies listed above, the methodology that accomplishes this is the fourth, i.e. the fuel input allocated to the production of heat is based on the efficiency of an industrial reference boiler and the remainder of the fuel input is allocated to electricity production. The benefit of such a methodology for the CHP operators compared to separate generation of electricity is that the former will need fewer allowances for the electricity produced in the unit.

We visualize this in Table 4. In the table, we calculate the number of allowances necessary to cover the emissions for the heat produced in CHP units using a reference boiler efficiency of 90% and natural gas as fuel (emission factor of 56.1 t CO_2 / TJ) resulting in an allowance of 62.3 t CO_2 / TJ heat[18]. Using the power to heat ratios and overall efficiency given in Table 3 for typical existing industrial CHP units, this yields figures for the number of allowances required for the power production part of the CHP unit.

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[18] The energy content of steam is dependent on temperature and pressure level. To calculate the steam production in CHP units in TJ, one thus needs the production in tonnes of steam and the associated temperature and pressure levels.

Table 4 Allowances required for electricity production with free allocation to heat production based on reference efficiency. Indicate figures scaled to 1 TJ of fuel input, assuming typical Power to Heat ratios and efficiencies as given in Table 3

	Natural gas input (TJ)	**Power production (TJ)**[1]	**Heat production (TJ)**[1]	**Fuel allocation to heat (TJ)**[2]	**Fuel allocation to electricity (TJ)**[3]	**Allowances for heat (t CO_2 / TJ)**	**Allowance required for electricity (t CO_2 / TJ)**[4]	**Allowances required for electricity (t CO2 / MWh)**[5]
Large combined cycle	1	0.39	0.36	0.40	0.60	62.3	85.9	0.31
Small combined cycle	1	0.24	0.60	0.67	0.33	62.3	78.0	0.28
Large gas turbine	1	0.32	0.46	0.51	0.49	62.3	86.6	0.31
Gas engine	1	0.41	0.49	0.54	0.46	62.3	62.2	0.22
Steam turbine	1	0.15	0.75	0.83	0.17	62.3	62.2	0.22
Electricity only[6]							107	0.39

[1] This production of heat and power correspond to the power to heat ratio and overall efficiency given in Table 3.

[2] Based on heat production, 90% efficiency and natural gas as fuel

[3] Calculated as the total fuel input – the fuel allocated to heat

[4] Based on the power production, the fuel allocation to electricity and natural gas as fuel.

[5] Idem, expressed in a different unit

[6] Based on the performance of a natural gas power plants (see text for further explanation)

The reference boiler efficiency of 90% for natural gas used here corresponds with the reference value for separate production of electricity and heat mentioned in Commission Decision 2007/74/EC establishing harmonised efficiency reference values for separate production of electricity heat in the application of Directive 2004/8/EC on the promotion of cogeneration (EU, 2004; EC, 2007). The resulting required allowances for electricity production can be compared with the reference electricity generation efficiency for natural gas from the same sources. This reference is 52.5% for the period 2006 – 2011, resulting in emissions of 107 t CO_2 / TJ electricity. The table shows that typical industrial CHP units need to buy fewer allowances for the electricity output of their installations compared to this efficient gas operated power plant[19], if the proposed allocation based on heat production only is used.

5.3 Heat flows between installations

As discussed above, the EU ETS installation producing the heat in a CHP installation or an industrial boiler can be different than the EU ETS installation consuming the heat, due to a different ownership of the heat producing equipment.

This complicates the way in which the efficiency of heat consumption is to be taken into account.

We distinguish the following three principle methodologies to take into account the efficiency of heat consumption in the allowances associated with this heat.

1. Allocation of allowances to consumers of heat based on the benchmarked production and consumption of the heat.
2. Separate allocation rules for producers of heat (receiving allowances based on performance of heat producing equipment) and consumers of heat (receiving allowances based on benchmarked consumption of heat).
3. Allocation of allowances to producers based on the benchmarked production and consumption of the heat.

In Box 1, we give a calculation example to show how these allocation methodologies would work in practice for different ownership structures of the heat production and consuming installations. In each of the three methodologies, the total amount of allowances given for the heat involved is equal (Column 8, 12 and 16, Row F, I and L) to the amount of heat consumption according to the benchmark, divided by the reference efficiency (90%) and multiplied by the emission factor of natural gas (56 t CO_2 / TJ). The methodologies, however, differ in the way the allowances are distributed over the in this case two companies involved.

In the first methodology, the allowances for the heat producer (i.e. where the emissions occur) are given to the consumer of heat. This is not in line with the overall architecture of the ETS in which allocation takes place for direct emissions and would result in the need for transfer of allowances between installations. This can be seen by the difference between allocation and actual emissions (Cell G9 and H9 in the table in the box). It can therefore be discarded.

The second option allocates to the heat producer as if all heat were consumed efficiently, and allocates to the heat consumer taking into account the efficiency of heat consumption. Advantage of such a methodology is that the *consumer* of heat is benchmarked for the efficiency of *heat consumption* and the *producer* of heat is benchmarked for the efficiency of heat *production*. However,

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[19] This statement should not be interpreted as a concluding statement on the profitability of CHP plants under the ETS using this allocation methodology. Such an assessment requires much more detail and is far beyond the scope of this study.

if the heat consuming installation consumes more than the benchmark and gets the heat from another installation this could lead to "negative" allocations to heat consumers, i.e. a requirement to surrender allowances even in the absence of direct emissions (See Cell G12 in the example in the box), which is not consistent with the principle of allocation to the entity having the direct emissions.

The remaining option 3 is to take into account the efficiency of heat consumption and still allocate to the heat producer. Such a methodology has the drawback that the actual emitter (company B in situation B in the example in Box 1) is in its allocation “punished” for something he may not have under his own control (i.e. the fact that company A uses heat in an inefficient way), but has the advantage that the full allocation takes place to the entity which has the actual emissions, which is in line with the overall EU ETS architecture. From that perspective, it can thus be considered as the most feasible methodology.

However, the methodology requires for its application to installations with heat flows across the installation boundary that the actual heat consumption of all products that are covered via a product-based benchmark is known as well as the origin of this heat (i.e. from outside the installation boundary or from boilers inside the system boundary). It can be questioned whether this is feasible for all installations in view of data availability etc. We therefore recommend assessing in detail if and how such an allocation methodology would work out in practice. Such an assessment should include issues such as:

- The number of EU ETS installations for which cross-boundary heat flows are relevant (to asses the order of magnitude of this issue)
- The availability of all required data for all Member States and all installations.
- System boundary issues related to the consumption and production of heat (where does “production” stop and does “consumption” begin).

Box 1 Allocation for heat – different options

In the following table, we work out the three allocation options for the production of one unit of product X with the following characteristics:

Benchmark heat consumption: 6 TJ
Actual heat consumption: 8 TJ
Actual efficiency of heat production: 80%
Actual emission factor used of fuels in heat production: 56 t CO_2 / TJ (natural gas)
Benchmark efficiency of heat production: 90%
Benchmark emission factor for fuels in heat production: 56 t CO_2 / TJ (natural gas)

We distinguish three different types of heat production in relation to ownership:

Situation A: All heat is produced by company A producing product X (auto producer) – Row D-F
Situation B: All heat is produced by a utility company B – Row G-I
Situation C: Half of the heat is produced by company A and half by company B – Row J - L

In the table we distinguish between heat Consumption (C), Heat production (P) and Total (T) allowances and between actual Heat Consumption (letter A) and Benchmark Heat Consumption (BM).

Box 1(continued)

Table 5 Distribution of allowances for heat (assumed production of one unit) – possible solutions

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A		Consumption		Production	Emissions	Allowances - Method 1				Allowances - Method 2				Allowances - Method 3			
B		BM	Actual	Actual	Actual	Consumption	Production	Total	Delta	Consumption	Production	Total	Delta	Consumption	Production	Total	Delta
C		TJ	TJ	TJ	tonne	tonne	tonne	tonne	tonne	tonne	tonne	tonne	tnne	tonne	tonne	tonne	tonne
D	Company A	6	8	8	560	373	0	373	-187	-124	498	373	-187	0	373	373	-187
E	Company B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F	Total	6	8	8	560	373	0	373	-187	-124	498	373	-187	0	373	373	-187
G	Company A	6	8	0	0	373	0	373	373	-124	0	-124	373	0	0	0	0
H	Company B	0	0	8	560	0	0	0	-560	0	498	498	-560	0	373	373	-187
I	Total	6	8	8	560	373	0	373	-187	-124	498	373	-187	0	373	373	-187
J	Company A	6	8	4	280	373	0	373	93	-124	249	124	93	0	187	187	-93
K	Company B	0	0	4	280	0	0	0	-280	0	249	249	-280	0	187	187	-93
L	Total	6	8	8	560	373	0	373	-187	-124	498	373	-187	0	373	373	-187

5.4 Heat consumption by non-benchmarked products

A complication arises in situations, where heat is consumed by one or more processes for which at least for one process no individual benchmark is available. This may be possible for e.g. chemical and other speciality products which are manufactured by only a few installations under the EU ETS or for installations operating downstream process steps (see also the discussion in Section 3.2). In addition, this could also be the case for the wide range of different activities that are included as part of the "combustion installations" such as installations in the food, horticulture and other installations.

Determining the best practice may be impossible by a lack of data due to confidentiality reasons or because no peers for comparison are available. Such a situation needs to be tackled by allocation rules independent of the ownership structure of the heat supply (part of the consuming installation or outsourced). In cases where individual benchmarks exist, the efficiency of the consuming process is taken into account, while this can't be equally achieved by using only a benchmark for the heat production. In order to ensure fairness during allocation, a fall-back approach for "non-benchmarkable" processes needs to be provided.

The use of a reference benchmark efficiency for the production of heat (e.g. the suggested 90% efficiency for steam and hot water production based on natural gas mentioned in Commission Decision 2007/74/EC)[20] as used here also offers a starting point for the allocation to such processes. These products could be benchmarked based on the historical heat production in combination with a reference heat generation efficiency and reference fuel rather than via a benchmark based on the actual sector output. In addition, a reference efficiency improvement for a generic heat consuming process should be used in order to reflect improvement potential in those sectors.

Proposed allocation principle 11:
Use heat production benchmark combined with a generic efficiency improvement factor for heat consumption in processes where no output-based benchmark is developed

This allocation principle thus creates two different allocation mechanisms for free allocation:

1. One based on the product output of industrial sectors benchmarked by energy and fuel efficiency
2. One based on the conversion efficiency and fuel mix applied in heat production for those heat consuming processes for which no output-based benchmark is developed in combination with a generic efficiency improvement factor to reflect the improvement potential in the consuming process.

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[20] For direct use of fuels for heat applications (i.e. not via the intermediate production of steam or hot water) and for other heat transfer media (hot oil, air), also reference efficiencies could be defined, although this will in practice be more difficult, because the 'heat product' is more difficult to define. Alternatively, direct allocation based on the caloric value of the fuels used could be defined using a uniform fuel in accordance with allocation principle 7.

Justification of this choice is to make the benchmark-based allocation methodology feasible and to avoid a large amount of output benchmarks for types of installations for which only a few are included. The improvement factor suggested is key to maintaining a non-discriminatory, uniform approach to all ETS installations, including the potential to reduce emissions. One could think of the following options for such a factor:

- Based on an assessment of "implied" improvement factors calculated based on the difference between historical emissions and total allocation for all products that are benchmarked.
- Based on detailed technical analyses of improvement potential (e.g. by analysing the heat losses in heat distribution etc.)

Further work will be required to further assess for how many products such as generic approach is necessary (e.g. by assessing more in detail the processes included in the ETS as "combustion installations", see recommendation in Chapter 3) and to assess possible approaches towards the generic efficiency improvement factor.

6 Sector study: Iron and Steel

6.1 Sector description

Annex I of the existing directive on the European Emissions Trade Scheme (EU, 2003) lists activities which are part of the EU ETS. For the iron and steel industry the following activities of this list are of relevance[21]:

- Coke ovens
- Metal ore roasting or sintering installations
- Installations for the production of pig iron or steel (primary or secondary fusion) including continuous casting

For these activities, about 300 installations are included in the EU ETS. The Commission proposal for a revised directive (EC, 2008) characterises a further group of activities to be included as "Production and processing of ferrous metals (including ferro-alloys) where combustion installations with a rated thermal input exceeding 20 MW are operated, including rolling mills, re-heaters, annealing furnaces, smitheries, foundries, coating and pickling."

The inclusion of activities from primary production of iron and steel including continuous casting to further downstream activities of rolling, casting and smitheries means that the number of possibly concerned installations or enterprises is very large. According to Eurostat (2007b), there are some 6000 enterprises in the section "First processing of ferrous metals" and some 6500 enterprises in the section "Casting of metals". A part of these will not deal with ferrous metals and therefore not fall under the definition mentioned above. However the proposal for the amendment of the Emissions Trade Directive also covers installations for the production of non-ferrous metals. So, technically it can be expected that all of the enterprises in the section "Casting of metals" will be part of the Emissions Trading Scheme if they operate installations above the threshold capacity of 20 MW. Concerning the threshold capacity it can be assumed on the other hand that a considerable part of the enterprises will not operate installations of that size and hence will not be part of the system.

In view of the system boundary of the "iron and steel sector" in the proposed revised directive, for the purpose of this study, the production of pig iron and crude steel, the preceding processes of coke making, sintering and iron making as well as the following process of rolling and casting are all taken into account.

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[21] The activity 'combustion installations' is also of relevance, because they are also operated in the iron and steel industry.

The process of coke making is the conversion of coal to coke by heating of coal in absence of air (or oxygen) to drive out coke gases and other substances like tars. The process of sintering is the agglomeration of iron ores of different grain size together with additives to create a material feed for the blast furnace with improved permeability and reducibility.

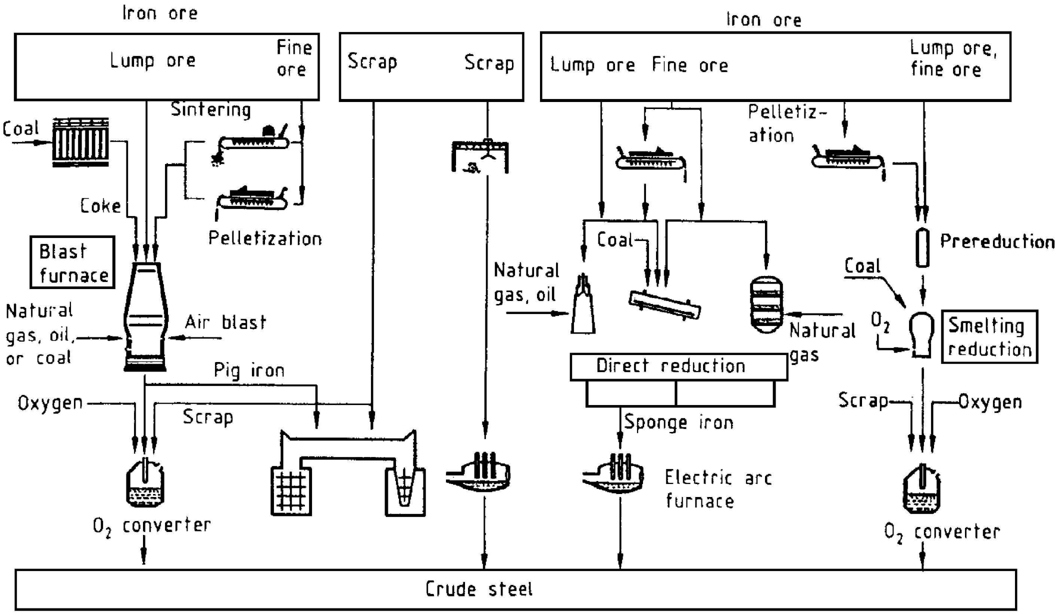
There are several routes for the production of crude steel (see Figure 1). When starting from iron ore, pig iron is most commonly produced in blast furnaces that are fed with sinter, coke and additives with a following conversion to steel in a blast oxygen furnace. Other steel conversion processes like the open hearth furnaces do not play a significant role any more in Europe. Alternatively to the blast furnace process, iron ore can also be converted into metallic iron in a direct reduction process. There are several technologies for the direct reduction of ores such as for example the MIDREX, HyL or the FASTMET process. The product yielded is often referred to as “direct reduced iron” (DRI) or “sponge iron”. According to the Best Available Techniques Reference Document for the Production of Iron and Steel (BREF I&S 2001), over 90% of the direct reduced iron is produced using natural gas. Within Europe, the amount of direct reduced iron production is very small compared to pig iron production (Table 6).

Table 6: Production of pig iron and direct reduced iron in EU-Member States in 2005 (IISI, 2008)

	Pig iron	**Direct reduced iron**
Austria	5444	
Belgium	7254	
Finland	3056	
France	12705	
Germany	28854	440
Italy	11423	
Netherlands	6031	
Spain	4160	
Sweden	3730	114
United Kingdom	10189	
Czech Republic	4627	
Hungary	1338	
Poland	4477	
Slovak Republic	3681	
Bulgaria	1081	
Romania	4098	
European Union (27)	112147	554

Next to the direct reduction processes there are also the smelting reduction processes in which iron ores are converted to pig iron. Examples for these are the COREX or the FINEX process where non-coking coals are used. These processes are not applied in Europe so far. The plant data published in IISI (1998) suggests that these processes do not offer advantages in terms of carbon dioxide emissions. The input of coal to smelt reduction processes is higher than the input of coke (or coke equivalents) to a blast furnace. The result of the energetic and emissions related assessment largely depends on how the large volume of exported energy-rich off gases from the process is valued.

Figure 1: Crude steel production methods. Source: Ullmann’s 1994



Alternatively, steel is made in electric arc furnaces where scrap is melted into crude steel. As already indicated in Figure 1, there are numerous possibilities to mix intermediate products like e.g. pig iron together with scrap and use the mixture as input to a steel making process. The specific process design including the choice of inputs depends on a set of factors like the desired quality of the product, the economics of the overall technological chain or the possibility to integrate the process also energetically into existing structures.

Crude steel is transformed into finished end-products via various rolling (hot rolling and cold rolling) and finishing steps (pickling, annealing, coating etc.).

Iron and steel products are also produced in foundries. *“Foundries melt ferrous metals and alloys and reshape them into product at or near their finished shape through the pouring and solidification of the molten metal or alloy into a mould”* (BREF foundries, 2005).

6.2 Product specific emission benchmarks

The application of several of the recommended allocation principles to the iron and steel industry is complex. Especially the principles not to apply technology specific benchmarks for technologies producing the same product (principle 2) and not to correct for plant age, plant size, raw material quality and climatic circumstances (principle 4) are complex to apply for the following reasons:

- The route to come from primary materials to end-products involves various process steps with a number of intermediate products that are traded between installations (important in view of recommended allocation principle 6[22]).
- The two main process routes for the production of crude steel (the primary route: basic oxygen furnace versus the secondary route: electric arc furnace) differ widely in emission intensity. The processes differ in input (scrap, pig iron) and in the type of products produced (discussed further below).

The situation overall is even more complex, because not only the reference product crude steel is a traded good but also the intermediary products like pig iron. With the high market share of integrated steel plants, the share of pig iron being traded is much smaller than the share being further processed in the same plant. Nevertheless, the overall amount of traded pig iron in the European Union reaches a volume of millions of tons and hence we see it as not negligible for the formulation of benchmarks.

For this reason, we suggest to have separate benchmark for the production of pig iron and a separate benchmark for the production of crude steel. A benchmark for pig iron should be based then like the benchmark for the steel making process on the most efficient technology available in order to be consistent with recommended allocation principle 1[23]. For the case of crude steel production this means that the somewhat different processes of the basic oxygen steelmaking and the electric arc steelmaking have to be compared with the result that electric arc processes have to be considered as the most efficient configuration.

The approach to have separate benchmarks for pig iron and steel is also advantageous in view of the application of recommended allocation principle 7[19]. Pig iron and the intermediate products in the production of pig iron (coke, sinter) are traded between installations and thus would require a separate benchmark to allow allocation to installations selling this intermediate product. Separate benchmarks are also required for hot rolling, cold rolling, various surface treatments and cast products from foundries, because these processes are (partly) done by non-integrated installations that will surpass the threshold value of 20 MW.

It is worthwhile mentioning that other solutions for benchmarking in the iron and steel sector can be imagined and have been evaluated. Of these, the simplest solution would be to define crude

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[22] Allocation principle 6: Use separate benchmarks for intermediate products if these products are traded between installations.

[23] Allocation principle 1: Base the benchmark level on the most energy efficient technology.

steel as product and to neglect any preceding intermediary products. This would be fully in accordance with allocation principle 2[24] to apply only a single benchmark for the production of crude steel. From a data point of view, this is a feasible approach, because publicly available statistics present aggregated crude steel production figures without further differentiation by process. Stakeholders from industry argue that with a growing steel market and with a usage cycle of steel in the order of four decades, enough scrap is in principle not available. Following to this reasoning a significant share of the steel is still in the phase of use, not ready for recycling and not all steel can thus be produced via the secondary electric arc furnace route. Furthermore, this approach would not deal adequately with the intermediary product pig iron. As a result we did not consider a single benchmark for the production of crude steel as a feasible option.

Alternatively we have investigated the option to further differentiate the products of the iron and steel sector by taking into account steel qualities. There is a wide range of steel types produced by European manufacturers. Differences consist in the metallurgical composition – the presence of impurities and of desired trace elements – or in the metallurgical structure of the material. Depending on the steel quality different products can be manufactured from a specific steel type. Generally, basic oxygen steel allows creating a wider variety of products as it is newly produced from iron ore and does not contain alloy elements that have been carried over from the scrap input. These alloy elements usually would not be desired in the newly made product. Different to this, electric arc steel made from scrap contains the alloy elements that are brought into the product with the scrap. They cannot be simply separated from the steel and hence electric arc steel usually is considered to be of lower quality than basic oxygen steel. Hence, basic oxygen steel usually goes into the products that require higher material qualities like e.g. sheets for car manufacturing. Electric arc steel is used more for products that are less sensitive to the material quality like e.g. concrete reinforcing bars. More generally speaking, the higher steel qualities are used more for flat steel products whereas the lower steel qualities are used more for the long products. If the correlation between long products / electric arc furnace route and flat products / basic oxygen furnace route were very good, it would be possible to distinguish two products to be benchmarked: flat products based on the primary route and long products based on the secondary route.

On a first glance the data on crude steel production by process and the data on the production of hot rolled suggest that in the European Union on a Member State level there is a good correlation the two process types and the two product types. A more thorough analysis of the correlation based on ten-year time-series from the Steel Statistical Yearbook shows, however, that the significant positive correlation only exists for most of the EU-15 Member States whereas it can not be observed for the new Member States. This finding that the correlation between product type and manufacturing process doesn’t exist in the new Member States fits to statements of industry representatives. They claimed that in the new Member States not only electric steel making but also oxygen steelmaking is applied for the production of long products. Further with the techniques like the addition of DRI there are options that also allow a substitution of basic oxygen steel with electric steel for the production of high-quality products. The low amount of direct reduced iron production indicates that the technical potential for electric arc processes in the making of flat product has not yet been exploited. This holds true, even if additional imports of DRI are assumed.

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[24] Allocation principle 2: Do not use technology-specific benchmarks for technologies producing the same product.

We regard a two-product benchmark approach for steel products (one for flat products based on the basic oxygen furnace route and one for long products based on the electric arc furnace route) as not feasible for the following reasons:

- There is not a sufficient correlation between long products and the electric arc furnace route on the one hand and flat products and the basic oxygen furnace on the other hand.
- Related to this: there are technical options to produce products from both groups with the two routes.
- The approach would not provide a solution for intermediary products.

As a result of the presented arguments, we therefore propose to have benchmarks for (at least) the following products:

- Coke
- Sinter
- Pig iron
- Crude steel
- Hot rolled steel
- Cold rolled steel
- Surface treated products from iron and steel – tinning and galvanizing
- Cast products from iron and steel foundries

Many of products listed here are intermediate products that occur in the production chain e.g. within an integrated steel plant. The benchmarks for these products should be applied in an additive manner to calculate the overall allocation for plants where more than one of these products is made within the production chain.

Industry representatives from the iron and steel industry argue that a separate benchmark for the production of stainless steel would be advisable. From a perspective of product types and qualities, stainless steel can certainly be viewed as a distinctly different product to ordinary steel. In how much the higher energy demand for stainless steel production leads to a distinct difference in emissions intensity in real production could, however, not be resolved within the scope of this study. One reason for the lack of data is the confidentiality of information on the qualities of the ferro-alloy used in the production of stainless steels. The production of stainless steel takes place via the EAF route with Argon Oxygen Decarburization and with Vacuum Oxygen Decarburization. Additional emissions compared to ordinary steel would originate from the decarburization.

Different to conventional carbon-steel production in electric arc furnaces, where scrap is the main raw material input, stainless steel production needs ferro-alloys (ferro-chrome, ferro-nickel and others) as input to introduce the alloy elements to the product. These ferro-alloys can have a carbon content of up to 4% to 6%. There is however a range of different carbon containing ferro-alloys depending on the origin of the ores and on the production method of the alloys.

A successful implementation of a benchmark system for these products thus requires the availability of production data for these products on the level of installations as well as data on the most efficient technologies (see below). This data is not publicly available, but consultations with stakeholders from the iron and steel industry suggest that the installations do have this information available (see also Chapter 10).

The level of information available on coating plants, foundries and smitheries that also fall under the auspicies of the directive is significantly lower. From a point of view of benchmarking, the wide variation of products and installation makes the situation even worse. We see it as virtually impossible to define products or product groups based on terms like “coated ferrous metal products” or “products from smitheries”. Viable solutions for products from these installations could be developed in direct co-operation with industry.

6.3 Most energy efficient technology

The average specific energy demand for steel making in the European Union varies greatly from as low as 4.2 GJ / t up to 23.2 GJ / tonne of crude steel (ODYSSEE database, 2008[25]). The primary cause for the observed differences is of course the process structure of basic oxygen steel making and electric arc steel making in the Member States. There are several sources of information for the best practice energy intensity and emissions intensity the products for which a benchmark needs to be developed. The Canadian Industry Programme for Energy Conservation (CIPEC, 2007) has published a study on the benchmarking of energy intensity of the Canadian steel industry. Price et al. (2007) have prepared a report on the world best practice energy intensity values for selected industrial sectors including also the iron and steel industry. Both of these studies make reference to the International Iron and Steel Institutes’ publication “Energy Use in the Iron and Steel Industry” (IISI, 1998). Although the study from IISI has been published some years ago, no more recent fundamental material could be identified that provides information on best practice on a scientifically accepted level. We therefore use this source to derive indicative benchmark values below.

Sintering

The sinter process energy and emissions data used for the derivation of a benchmark is shown in Table 7. The making of pellets is not taken into account as this product is most commonly produced at the sites of the mines and not at the sites of the iron and steel plants. So, pellets usually are imported into the European Union.

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[25] The ODYSSEE database is a source of information on energy use and energy efficiency indicators for the Member States of the European Union developed and updated on behalf of the European Commission by a consortium lead by Enerdata (www.odyssee-indicators.org).

Table 7: Most efficient sinter making technology (IISI, 1998)

Energy input	**Amount**
Ignition with gaseous fuel	17 MJ / tonne sinter
Sinter bed fuel	1094 MJ / tonne sinter
Balance	
Fuel use	1111 MJ / tonne sinter

Notes

Derived from the description of the AllTech Process for sinter plants in IISI (1998), p. 44

Pig iron

For the benchmarking of the iron making process, the generally employed approach is adapted to benchmark only CO_2 emissions occurring directly at the site. The adaptation is made due to the fact that the main carbon outflow from the blast furnace is the blast furnace gas. This gas is not emitted to the atmosphere but it contains carbon which is partly oxidised already. The use of blast furnace gas as fuel however requires special installations as it has a very low calorific value, which also leads to a very high emission factor in relation to the energy content. Due to the low calorific value, large volumes (and masses) of fuel gas have to be employed to yield a specific amount of energy. This means that adapted burners and installations for the transmission of the energy have to be in place. Given these restrictions there are basically three uses for blast furnace gas: the stoves in the blast furnaces, the under firing of coke oven plants and power plants on the site of integrated steel plants or nearby the plants that are adapted for blast furnace gas. The large volumes combined with the low pressure of the blast furnace gas make it hardly possible to store the gas. As a consequence any usage has to be more or less controlled by the supply of the fuel and not by process specific or market specific requirements.

In view of the circumstances described above we propose to benchmark the CO_2 emissions that are generated from the carbon (coke, coal or oil) input to the blast furnace at the site of the blast furnace and not at the site where product gases are used. This benchmark will take into account the inputs to the blast furnace and also the nature of the product gas that is still usable as a fuel. This means to take the coke and coal needs of a blast furnace with most efficient technology as a starting point as well as the amount of blast furnace gas produced in this furnace and the amount of fuel required for the stoves (Table 8). The methodology to come to an emission benchmark based on this data will be explained in the next section.

Table 8: Most efficient blast furnace operation (IISI, 1998)

Energy input	**Amount**
Stoves – fuel input	1442 MJ / tonne hot metal
Blast furnace: coke input	10827 MJ / tonne hot metal
coal input	3625 MJ / tonne hot metal
Blast furnace gas produced	- 4982 MJ / tonne hot metal
Balance	10912 MJ / tonne hot metal

Coke making

According to IISI (1998), the most efficient coke making technology requires energy inputs as described in Table 9. Coal input and coke, coke oven gas and other product production was taken from BREF I&S (2001). The coke making process inherently produces coke oven gas which has a slightly lower emission factor compared to natural gas. The methodology to come to an emission benchmark based on this data will be explained in the next section and is comparable to the methodology used for pig iron.

Table 9: Most efficient coke making technology (IISI, 1998)

Energy input	Amount
Fuel use for under firing	2618 MJ / tonne dry coke
Steam for by-product plants	290 MJ / tonne dry coke
Steam for coal moisture control process	302 MJ / tonne dry coke
Coke oven: coal input	40190 MJ / tonne dry coke
Coke oven gas production	-8080 MJ / tonne dry coke
Coke production	-27050 MJ / tonne dry coke
Other material products and waste	-4740 MJ / tonne dry coke
Balance	3530 MJ / tonne dry coke

Crude steel production

For steelmaking from inputs the most efficient technology with respect to CO_2 emissions is the melting of scrap and iron (usually in the form of direct reduced iron) in electric arc furnaces. The proposed benchmark for steelmaking is given in Table 10. The benchmark has been calculated based on a high input of scrap and a low input of DRI reflecting the situation of a low DRI production in Europe. The benchmark takes into account the input of carbon from electrodes and from the scrap and from additional slag forming products as well as the natural gas input.

Table 10: Most efficient electric arc furnace technology (IISI, 1998)

Energy input	Amount
Fuel input (natural gas)	148 MJ / tonne crude steel
Carbon from electrodes and scrap	11 kg / tonne crude steel
Carbon for slag formation	2.7 kg / tonne crude steel

Hot and cold rolling, tinplates and galvanising

The data for the calculation of a benchmark proposal for hot rolling is shown in Table 11, for cold rolling in Table 12, for tinning in Table 13 and for galvanizing in Table 14. In IISI (1998), two process lines for cold rolling are described; one for the production of cold rolled sheets and the other for the production of tinplate. There are differences in the thermal energy requirement within the two process lines. These are caused by different intermediary steps that need to be undertaken depending on the output and by the different thickness of the material usually produced in the two lines. With a difference of below 10 % between the two lines in the most efficient configuration described, the resulting total thermal energy demand of the two lines is quite comparable however. Therefore we don’t see the necessity for two distinct benchmarks. Galvanisation for surface coating is especially done with zinc. There are two process types, hot dip galvanization and electro galvanization. The hot dip galvanization produces higher resistance coatings but has higher direct CO_2 emissions compared to the electro galvanization process. Nevertheless we believe that a separate benchmark for hot dip galvanization is more appropriate as the product qualities are distinctly different.

Table 11: Most efficient hot rolling technology (IISI, 1998)

Energy input	**Amount**
Natural gas in reheating furnaces	820 MJ / tonne hot rolled product
Steam	37 MJ / tonne hot rolled product
Balance	857 MJ / tonne hot rolled product

Table 12: Most efficient cold rolling technology (IISI, 1998)

Energy input	**Amount**
Cold rolling for sheets	
Fuel for acid recovery and drying in pickle line	53 MJ / tonne cold rolled product
Steam in pickle line	47 MJ / tonne cold rolled product
Steam in tandem mill	25 MJ / tonne cold rolled product
Fuel for annealing	680 MJ / tonne cold rolled product
Balance	805 MJ / tonne cold rolled product
Cold rolling for tinplate*	
Fuel for acid recovery and drying in pickle line	*73 MJ / tonne cold rolled product*
Steam in pickle line	*47 MJ / tonne cold rolled product*
Steam in tandem mill	*35 MJ / tonne cold rolled product*
Steam in cleaning line for annealing	*173 MJ / tonne cold rolled product*
Fuel in cleaning line for annealing	*3 MJ / tonne cold rolled product*
Fuel for annealing	*550 MJ / tonne cold rolled product*
Balance	*881 MJ / tonne cold rolled product*

Notes

The data for cold rolling for tinplates is given for comparison only

Table 13: Most efficient tinning technology (IISI, 1998)

Energy input	**Amount**
Fuel for strip drying in tinning line	50 MJ / tonne product
Steam	235 MJ / tonne product
Balance	285 MJ / tonne product

Table 14: Most efficient galvanizing technology (IISI, 1998)

Energy input	**Amount**
Natural gas	750 MJ / tonne product
Steam	35 MJ / tonne product
Balance	785 MJ / tonne product

Iron and steel foundries

Besides the benchmarks for these products, for which data could be made available at least to some degree, also benchmarks would be needed for cast products from smitheries and foundries. The reference document on best available techniques for Smitheries and Foundries (BREF foundries, 2005) does not give an indication on the energy demand of most efficient technologies and neither on CO_2 emissions of most efficient technologies. The same holds for coating plants.

Direct reduced iron plants

As mentioned above, iron can not only be produced from iron ore with the blast furnace process but also with alternative routes. There is only one plant of industrial scale that produces iron from ores with one of these routes in Europe. The plant is located in Germany and applies the DRI process. The other production mentioned for Sweden comes from a research plant. IISI (1998, p. 179) gives energy demand reference data for a DRI plant applying the MIDREX process stating that a natural gas input of 300 Nm³/t of DRI was required. Based on an energy content of 36.3 MJ/Nm³, the plant creates CO_2 emissions of 0.61 tonnes per tonne DRI. This is considerably less than the blast furnace process. It is argued however that the DRI produced has a higher slag content and different share of trace metals than pig iron from the blast furnace route. The difference in quality makes it not comparable to the product pig iron. Although this position that was also raised by industry representatives can be debated we propose to apply a benchmark based on the MIDREX process (or a comparable process) only to DRI and not to pig iron.

6.4 Fuel mix and resulting emission benchmarks

As becomes clear from the overview given above, the iron and steel industry uses process-related fuels, resulting therefore in specific fuel-related CO_2 emissions of the processes. In the calculation of emission-benchmarks, we take into account these process-specific fuel related emissions (i.e. in coke making, pig iron making and crude steel making). We describe the approach for these processes below. For the remainder of the fuel use, we assume natural gas as the default fuel of choice.

For steam, we use the reference efficiency of 90% and natural gas as fuel as explained in Chapter 5.

Pig iron production

Starting point for the calculation of the emission benchmark is the CO_2 equivalent input of coal and coke in the blast furnace. In a second step we propose to deduct from this amount an amount of natural gas equal[26] to the blast furnace gas produced to take into account the usability of the blast furnace gas. This deduction is necessary in our view to stay consistent with the overall benchmarking approach, i.e. with the additionality of benchmarks for intermediate products. In integrated steel works, blast furnace gas is used for many upstream (like coke making) and downstream processes (rolling). These processes however are also applied in stand-alone configurations and there have to rely on alternative fuels like naturals gas. As a consequence, a benchmarking allocation for the products of these processes is necessary. In order to achieve an equal treatment of integrated and non-integrated plants, we see a deduction from the benchmark for blast furnace gas as a viable option. With the additional benchmark allocation for the upstream and downstream processes, an efficiently operated integrated steel plant should receive a reasonable allocation.

We also deduct the amount of carbon which is dissolved in the pig iron product. In a third step we account for the CO_2 emissions that occur at stoves.[27] The accounted equivalent amount of CO_2 for the stoves is based on a hypothetical use of natural gas even though in real world operations, the stoves usually are fed with blast furnace gas. Applying the most efficient freely available fuel for this benchmark is necessary as with this approach, the high emissions intensity of the blast furnace gas is covered in the first and second step. The resulting emission benchmark is given in Table 15.

Within the approach we propose, the equivalent amount of CO_2 deducted for its further usability is of crucial importance for the overall benchmark for iron making. Several ways could be followed to calculate the deducted amount:

1. Deduction based on the specific emissions intensity of fuels that are substituted by the blast furnace gas.
    a) Substitution of natural gas being the standard gaseous fuel; switching between natural gas and blast furnace gas seems to be the most easily feasible switch if a switch is possible at all. A deduction of 56 kgCO_2 / GJ would be made in this case.
    b) Substitution of hard coal based on the idea that in electricity generation power plants using blast furnace gas produce base load which is often supplied by coal fired power plants. A deduction of 94 kg CO_2 / GJ would be made in this case.
2. Deduction based on ratio of the energy content of the carbon monoxide in the blast furnace gas and the energy content of the carbon input from the coke and the injected coal.
3. Deduction based on the stoichiometric ratio of unbound electrons of the carbon monoxide and in the carbon input.

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[26] Equal in terms of its energy content (i.e. 4982 MJ / tonne, see Table 9)

[27] Viewing the stoves of a blast furnace as a separate side energy conversion process does certainly not reflect the view of metallurgists operating the real plants with a holistic approach across the entire installation. Still we believe this is a feasible approach for the accounting of separate energy and material conversion processes.

We consider the deduction based on the substitution of natural gas as reasonable approach with sufficient clarity. This solution reflects that natural gas is employed as alternative fuels if no other product gases from an integrated iron and steel plant are available. In our view, basing a deduction on the substitution effects in the electricity market is not realistically feasible for two reasons. First, the fuel mix for electricity generation varies greatly across the Member States. So no general rule can be derived for the whole of the EU. Second, the fact that electricity generation based on blast furnace gas can not be dispatched according to the requirements of the electricity market makes it not being comparable to generation from hard coal.

Table 15: Indicative CO_2 emission benchmark for pig iron production

Energy input	**Amount**
Blast furnace: coke input	1.165 t CO_2 / tonne hot metal
coal input	0.353 t CO_2 / tonne hot metal
Deduction for energy value of blast furnace gas	0.279 t CO_2 / tonne hot metal
Deduction: dissolved carbon	0.172 t CO_2 / tonne hot metal
Fuel use in stoves (based on natural gas)	0.081 t CO_2 / tonne hot metal
Total	1.147 t $CO_{2/}$/ tonne hot metal

Coke making

Coke making results in coke oven gas which has a lower emissions intensity than natural gas. In stand-alone coke oven plants, coke oven gas is used for the under firing of the coke oven batteries. Different to this, in integrated steel plants with an on-site coke oven plant, also blast furnace gas is used for the under firing. This low-calorific gas – although being usually considered as a fuel of very low value – is suitable for this purpose as it burns slowly and allows a more even distribution of heat across the walls of the coke oven chambers. We propose a method comparable to pig iron for coke ovens.

Starting point for the calculation of the emission benchmark is the CO_2 equivalent input of coal into the coke oven. In a second step we propose to deduct from this amount an amount of natural gas equal to the coke oven gas produced to take into account the usability of the coke oven gas.

We also deduct the amount of carbon which is embodied in the coke and other material products and waste. In a third step we account for the CO_2 emissions related to the energy use in the coke oven. The accounted equivalent amount of CO_2 is based on a hypothetical use of natural gas even though in real world operations, coke oven gas or blast furnace gas is used. Applying the most efficient freely available fuel for this benchmark is necessary as with this approach, the emission intensity of the coke oven gas is covered in the first and second step. The resulting emission benchmark is given in Table 16.

Table 16: Indicative CO_2 emission benchmark for coke making based on coke oven gas as fuel

Energy input	Amount
Coke oven: coal input	3.802 t CO_2 / tonne hot metal
Deduction for energy value of coke oven gas	0.453 t CO_2 / tonne hot metal
Deduction: carbon in coke and other material products	3.438 t CO_2 / tonne hot metal
Fuel use for under firing	0.147 t CO_2 / tonne hot metal
Steam use for by-product plants	0.016 t CO_2 / tonne hot metal
Steam for coal moisture process	0.016 t CO_2 / tonne hot metal
Total	**0.090 t $CO_{2/}$/ tonne dry coke**

Crude steel production

The inputs of carbon into the electric arc furnace relate to direct process related pure carbon source (electrodes). The CO_2 emissions from this carbon use are calculated based on the assumption of pure carbon (3.67 t CO_2 / tonne carbon). The associated emissions from the other important process route – basic oxygen steelmaking – are significantly higher due the oxidation of the carbon dissolved in the pig iron input. Consequently, we consider electric steelmaking as the most efficient technology with respect to emissions.

Summary of proposed benchmark values and remark on testing the feasibility

The default assumption for fuel and steam use and the process-specific fuel choice as discussed above result in the emission benchmark values as given in Table 17.

Table 17: Overview of indicative emission benchmark values for iron and steel production

Process	Product	Benchmark value
Coke making	Coke	0.090 t CO_2 per tonne
Sinter	Sintered ore	0.119 t CO_2 per tonne
Iron making	Pig iron	1.147 t CO_2 per tonne
Iron making	Direct reduced iron plants	0.610 t CO_2 per tonne
Steelmaking	Crude Steel	0.058 t CO_2 per tonne
Hot rolling	Hot rolled steel products	0.048 t CO_2 per tonne
Cold rolling	Cold rolled sheets and plates	0.046 t CO_2 per tonne
Tinning	Tinplate	0.018 t CO_2 per tonne
Galvanising	Galvanised steel products	0.046 t CO_2 per tonne

No structured data is available on the actual distribution of specific energy use and specific CO_2 emissions from the iron and steel industry. An assessment of the intra-sectoral distributional effect resulting from the proposed emission benchmarks can therefore not be made. Comparison with the

NAPs for which quantitative information on benchmarks for the iron and steel sector could be found per tonne of output (Annex 1-B) show that the proposed benchmark for EAF steel is a bit higher compared to the 10% best performing plants in Italy (0.05179) and lies at the lower side of the range used in the UK for new entrants (0.055 – 0.090). The benchmark for pig iron is far lower than the average European average for primary steel production used in Sweden (1.91 t CO_2 / tonne).

The proposed system for the processes with derived gases (coke and pig iron production) can be seen as advantageous with respect to the uniform treatment of carbon containing inputs and outputs and the use of carbon balance principles to come to an allocation. Still, the complexity of the method can be seen as a drawback. The calculation for coke ovens e.g. shows a large amount of 'carbon throughput' through the process which has a great effect on the resulting carbon balance. An alternative for coke ovens could be to base the benchmark on the most efficient fuel to be used in coke ovens, i.e. blast furnace gas. In that case, the carbon content of the produced coke oven gas does not need to be considered anymore. It is advisable to further discuss the approach suggested here for coke and pig iron production with the iron and steel industry also taking into account the actual mass, energy and carbon balances of the processes at stake.

6.5 Capacity utilization

The annual Community statistics for iron and steel also contain the annual statistics on capacity. These statistics are of considerable value for the derivation of activity indicators as they contain data for both, the maximum possible production and the actual production. Like for other type of data of the Community statistics for iron and steel, the confidentiality of data reduces the availability of information for several Member States and for several types of products and activities. Table 18 shows the data on capacity utilization for the year 2005 that could be derived from the annual Community statistics for iron and steel. Obviously, data from important steel producing Member States like the United Kingdom or Spain is completely unavailable and for other Member States like Czech Republic only very little part of the data is available. Nevertheless, with the Community statistics for iron and steel, a consistent database exists that possibly could be made available for the purpose of deriving realistic capacity utilization values.

Already from the publicly available data one can see considerable differences in the capacity utilization of the production facilities in the Member States in the year 2005. The differences range from 21 percentage points between highest and lowest utilization for the category of "Long products" to nearly 49 percentage points for electric steel. Already based on this incomplete dataset we can conclude that the application of a uniform average activity rate for a benchmarking-based allocation will have visible distributional effects among installations and among Member States' industries.

Table 18: Capacity utilization in the production of products in the Community iron and steel industry in the year 2005. Based on data from the annual Community statistics on iron and steel[28].

	Belgium	Czech Republic	Germany	Greece	France	Italy	Hungary	Poland
Coke	94%	-	97%	-	-	-	61%	-
Load preparation	82%	-	91%	-	-	-	109%	-
Pig iron and ferro-alloys	91%	-	89%	-	-	67%	98%	-
Crude steel	68%	-	85%	49%	81%	74%	81%	70%
Crude steel: electric	55%	90%	87%	49%	71%	78%	41%	78%
Crude steel used in continuous casting	58%	-	93%	49%	81%	74%	55%	83%
Products obtained directly by hot rolling	65%	-	81%	45%	78%	80%	87%	69%
Flat products	65%	-	84%	-	-	90%	98%	63%
Long products	65%	-	77%	64%	-	72%	56%	73%
Products obtained from hot rolling products (excluding coated products)	69%	-	83%	18%	88%	64%	66%	-
Products obtained from hot rolling products obtained by cold rolling	69%	-	83%	18%	88%	65%	72%	-
Coated products	79%	-	97%	70%	85%	72%	84%	-

6.6 Conclusions

- Separate benchmarks for pig iron production and crude steel products is the most feasible benchmark approach taking into account trade with intermediate products (e.g. pig iron), the distribution of products by quality and type over the primary and secondary steel production routes.
- Separate benchmarks for the intermediate products in the production of pig iron (coke, sinter) are necessary as these are also traded goods.
- The processing steps of ferrous metals (re-heaters, annealing furnaces, smitheries, foundries, coating and pickling) is also performed by independent installations, thus making it necessary to develop benchmarks for the products of these processing steps.
- The type of fuel used in coke ovens, the blast furnace and electric arc furnaces is process-specific. We propose to base the emission benchmark on this process-specific fuel use (see below) and to use natural gas as default fuel for the remaining fuel use.
- We suggest correcting the benchmark for coke and pig iron for the inherent production of derived gases in these processes. The correction is based on the difference in emission fac-

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[28] The annual Community statistics on the steel industry are produced by Eurostat on the basis of information provided by Member States. The production of the annual Community statistic on the steel industry is regulated by Regulation (EC) No 48/2004 of the European Parliament and of the Council of 5 December 2003 on the production of annual Community statistics on the steel industry for the reference years 2003-2009

tor between the default fuel of choice (natural gas) and the emission factor of blast furnace gas and coke oven gas respectively. This methodology avoids double counting with the benchmarks for downstream process using the derived gases.

- The poor availability of data and information on coating plants, foundries and smitheries made it impossible so far to derive proposals for benchmarks for the products from these activities. For these processes, either the fall-back options for heat use for non-covered products as touched upon in Chapter 5 could be used or best practice values can be determined in close cooperation with industry.

7 Sector study: Pulp and Paper

7.1 Sector description

The pulp and paper sector comprises a wide variety of manufacturing plants. Approximately 733 mills participated to the EU ETS in 2005 and are now registered in the Community Transaction Log. The production of pulp and paper can be classified into three main operations:

1. Pulp making
2. Recovered paper processing
3. Paper production

These main activities are supported by a number of associated activities such as power and steam generation, water treatment, waste handling and storage and handling of chemicals. Wood pulp production can be categorised into three types of production processes (descriptions from BREF P&P, 2001):

1. Kraft (sulphate) pulp. In this process, fibres are liberated from the wood matrix by dissolving in a chemical solution at a high temperature. Depending on the quality requirements with respect to brightness and brightness stability, bleaching might be applied.
2. Sulphite pulping. In this process, aqueous sulphur dioxide (SO_2) is used in the cooking process. The strength properties of sulphite pulp are generally less than that of kraft pulp, although for certain specialty sulphite pulps, properties might actually be better.
3. In mechanical pulping, the wood fibres are separated from each other by mechanical energy applied to the wood matrix. In semi-mechanical pulping, the wood is pre-softened with chemicals.

The production of fibre for papermaking (i.e. process 1 and 2, pulping or recovered paper processing) can be integrated or non-integrated with the paper making process.

In Table 19, production figures for pulp production in Europe are provided, for the total production and the production of market pulp, i.e. the pulp supplied to non-integrated or partially integrated paper mills. The use of secondary pulp amounted to 48.9 Mt.

Table 19 Total and market pulp production in Europe, 2006 (GHK, 2007 based on CEPI data)

Pulp production process	**Production (Mt)**	**Share (%)**	**Market pulp (Mt)**	**Share (%)**
Chemical pulp	28.3	65%	12.8	92%
Mechanical and semi-mechanical pulp	14.6	34%	1.1	8%
Other pulp	0.6	1%	0	0%
Total	43.5	100%	13.9	100%

Mechanical pulping is normally applied in integrated pulp and paper mills. This is also true for the processing and use of recovered paper. The other pulp types serve both integrated and non-integrated mills. Pulp production in Europe is concentrated in Finland (13.1 Mt), Sweden (12.2), Germany (2.9 Mt), France (2.5 Mt), Norway (2.3 Mt), Portugal (2.3 Mt), Spain (2.0 Mt) and Austria (1.9 Mt). Smaller amounts of pulp are produced in Italy, the Netherlands and the UK.

Pulp and paper production facilities can be classified according to the type of pulp production and whether they are integrated or not. This way of classifying is quite often used, e.g. in the BREF (BREF P&P, 2001), where the following classification is used:

1. Kraft pulp & paper mills.
2. Sulphite pulp & paper mills
3. Mechanical pulp & paper mills
4. Recycled fibre paper mills
5. Non-integrated paper mills

As additional sixth category, non-integrated pulp mills could be added, which are in the BREF classification categorised under the respective pulp and paper mills. There are many different products produced by the papermaking industry and various categorisations are in use. The Confederation of European Paper Industries (CEPI) breaks down the paper sector in six product groups (CEPI, 2008, between brackets the percentage of CEPI production in 2007)[29]:

1. Newsprint (11%)
2. Other Uncoated Graphics (18)
3. Coated graphics (20%)
4. Sanitary and household (6%)
5. Packaging (41%)
6. Other paper and board (4%)

This differentiation of types of products lies in their use and not in the process. The substitutability of a product between the six main groups is generally unlikely from a practical point of view. For example, the market for newsprint cannot be substituted with grades such as packaging or house-

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[29] http://www.cepi.org/DocShare/Common/GetFile.asp?PortalSource=1138&DocID=15560&mfd=off&pdoc=1

hold paper because their physical properties would not be appropriate. On the other hand, the other grades (e.g. coated/uncoated graphics) despite being of better quality are not only more energy intensive but also economically not convenient for that market.

7.2 Product-specific emission benchmarks

In view of a benchmarking effort along the allocation principles defined in Chapter 4, it would be most easy if specific products or product groups would always be produced via one of the six process routes specified above. This is, unfortunately, not the case. According to the BREF, "a certain product may be manufactured through various different processes… For instance, newsprint may be manufactured from several different pulp sources… As pulp and paper products are highly diverse and applied processes for the same product may vary greatly, many factors in production technology must be taken into account to guarantee a high level of environmental protection". The same becomes clear from Table 20 produced by GHK together with CEPI (GHK, 2007).

Table 20 Pulp and paper production processes and paper / board grades (GHK, 2007)

Grade	Fibres (average split)	Process	Production in 2006, kt
Newsprint	84% recycled, 16% virgin	Recycling or mechanical pulp	11244
Printing and writing	90% recycled 10% virgin		39073
Uncoated mechanical	Mainly recycled	Recycling or mechanical pulp	7460
Coated mechanical	Mainly recycled	Recycling or mechanical pulp	10306
Uncoated wood free	Mainly virgin	Chemical pulp	10715
Coated wood free	Mainly virgin	Chemical pulp	10592
Sanitary and households	51% recycled 49% virgin	Recycling or semi-mechanical pulp	6389
Total packaging			41056
Containerboard / case materials	91% recycled 9% virgin	Recycling or chemical pulp	24570
Carton board and other paper and board for packaging	40% recycled 60% virgin	Recycling or all kinds of pulp	12572
Wrappings	56% recycled 44% virgin	Recycling or all kinds of pulp	3914
Others			4469
Total			102231

The authors of that study stress that these are not official estimates and the table also shows some inconsistencies with the surrounding text, but still it becomes clear that the production processes for various types of paper are very diverse. The authors conclude from the table that "the bulk of total packaging would come from integrated recovered fibre processes. Graphic grades … also come mainly from integrated recovered fibre processes. Virgin pulp is used for carton board and sanitary and household products, but there is no way of splitting this by mechanical, thermo-mechanical of chemical pulping processes".

For the development of paper end-product based benchmarks (in line with the overall starting points as outlined in Chapter 4), it would thus be required to define a benchmark production process for each of the product groups considered out of the several production routes applied in practice. This includes the choice for the type of pulping process and the share of recycled fibre. The overview given above makes clear that it is difficult or even impossible to make such a decisive choice for one production route, especially if hundreds of products from the paper industry are grouped into only a limited (e.g. six) overall product categories. Different products in these aggregated product groups probably require a different share of virgin fibre inputs (e.g. because of quality issues) and might be produced from different types of pulp.

Further complicating factors in determining one benchmark process route for selected paper product categories include:

- Pulp is also a marketed product. In line with recommended allocation principle 6[30], a separate benchmark for pulp is thus required to be able to allocate allowances to installations selling pulp. An output-based benchmark for the total paper production process (assuming a certain best practice share of recycled input) is in contradiction with this allocation principle.
- The increased use of recycled fibre is beneficial from a resource point of view and also from a primary energy point of view as explained below. However, due to the use of biomass resources in the production of virgin pulp, the fossil CO_2 emissions from process routes starting with recovered fibre might be higher compared to an equivalent product made from virgin material. Allocations based on a CO_2 benchmark for integrated primary production might thus be disadvantageous for those mills using recycled fibre.
- The increased use of recycled paper has caused the location of industry to shift to large consumer centres, where recycled fibre is available (e.g. Germany). These industries do need inputs from virgin fibres as well, because without constant input from virgin fibres, recovered fibre quality would deteriorate rapidly. These recycled fibre based industries thus require market pulp produced by installations that are mainly located in countries with sufficient supply of wood material. Benchmarks fully based on integrated paper mills using a share of virgin pulp and a share of recycled fibre is not in line with this geographical distribution of the paper industry as described here, which can be regarded as beneficial from an overall resource efficiency point of view.

Based on the above, we conclude that it is in practice not possible to assess for each product group the 'best practice' share of fibre inputs and the corresponding 'best practice' process route. The

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[30] Allocation principle 6: Use separate benchmarks for intermediate products if these intermediate products are traded between installations.

suggested alternative is to have separate benchmark for pulp production, for recycled fibre production and for paper production and to base the emission benchmark on the most energy efficient processes.

7.3 Most energy efficient technology

In Table 21, we provide Best Practice specific heat consumption values for the non-integrated production of pulp and paper from two sources.

Table 21 Best practice specific heat consumption for non-integrated production of pulp and paper[31]

	Starzer (2004)[1]	Price et al. (2007)[2]
	Heat (GJ /t)	**Heat (GJ /t)**
Pulp		
Bleached kraft pulp[3]	*10 – 14*	*11.2*
Bleached sulphite pulp[3]	*16 – 18*	*16*
Thermo-mechanical pulp[4]		*0*
Recovered paper processing		0.3
Paper		
Uncoated fine paper	7 – 7.5	6.7
Coated fine paper	7 – 8	7.5
Tissue mill	5.5 – 7.5	6.9
Newsprint		5.1
Board		6.7
Kraftliner		5.9

[1] Based on BREF P&P (2001).

[2] Based on BREF P&P (2001), Karlsson et al. (2005), Francis et al. (2002).

[3] The heat demand can be met by energy recovery from black liquor and biomass residues combustion, see text for explanation.

[4] In thermo-mechanical pulping, part of the electricity used can be recovered in the form of hot water and steam, see text for explanation. The process has little heat demand and can export up to 5.5 GJ / tonne of pulp (Price et al., 2007)

The two sources are fairly consistent with each other. Both pulp making and paper making are energy-intensive processes. In the BREF P&P (2001), indicative breakdowns of energy consumption are given for a number of reference mills. For bleached kraft pulp making, major heat consuming process steps are the cooking process (~15%), evaporation (~30%) and pulp drying (~20%). The latter can partly be avoided in integrated pulp and paper mills. Furthermore, process integration of

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[31] Separate data on the "pulp" and "paper" part of integrated pulp and paper mills could not be found. These data could be somewhat lower, due to the overall process integration. In line with recommended allocation principle 1, the best practice energy performance of the integrated mill should be used.

the different processes may result in a further optimisation of the steam use on-site. Electricity use in pulp mills is divided over a large number of process steps (BREF P&P, 2001).

The chemical pulping processes (kraft pulp and sulphite pulp) can be net exporters of energy (electricity and/or heat). This export is the result of balancing energy demand in the process (as given in Table 21) and the energy recovered from the black liquor recovery process in which the lignin from the wood is combusted. The recovery process yields approximately 15 GJ / t pulp (Price et al., 2007) and also the bark is often used to produce process steam in additional boilers. The steam is used in the process (the heat demand of the process as indicated in Table 21 can be fully met) and the excess heat is used to generate electricity in steam turbines, making the process a net exporter of electricity[32]. The energy self-sufficiency of non-integrated sulphate pulp mills is confirmed in the BAT reference document for a 250 kt per year non-integrated mill.

Non-integrated thermo-mechanical pulping is also a net heat exporting process. The process allows the recovery of heat from the process in the form of hot water and steam, as only a fraction of the mechanical energy supplied to the process is actually used to separate the fibres in the wood.

The best practice data shown above thus support the conclusion that in the production of non-integrated wood pulp, no external fossil heat supply is required. This is supported by an analysis of the fuel mix used in the various pulp and paper producing countries (see below). A possible exception to this rule is the lime kiln which is an integral part of chemical pulping (kraft process). The recovery of pulping chemicals is essential for chemical pulping and lime recovery from precipitated calcium carbonate is part of the calcium loop (Miner and Upton, 2002). The process emissions resulting from this process are, contrary to normal lime production, from biomass origin as Miner and Upton (2002) show. For the fuel component, an amount equivalent to the benchmark for lime production could be used.

Energy use in the papermaking process is concentrated in the paper machine and is determined by the specific grade of paper to be produced and the fibre quality. Typical best practice values assume that an effective control system is in place, long nip (or shoe) presses are being used (except for tissue mills), condensate recovery and integration of the various steam and hot water flows in the mill (Price et al., 2007).

For the processing of recycled fibre, a small amount of fossil fuels is required. We suggest including an allocation of emission allowances to those installations using recycled fibre based on the actual historical use of recycled fibre.

The number of products included in Table 21 is determined by the availability of best practice specific energy consumption data from the two sources. They do not correspond entirely with the six product classification used by CEPI (i.e. speciality products are not included and board and kraftliner are separately identified). As can be seen, the specific heat consumption data are relatively close or even equal for some of the products distinguished. One can therefore argue that less benchmarks than the six distinguished here are required, e.g. if a certain threshold with respect to

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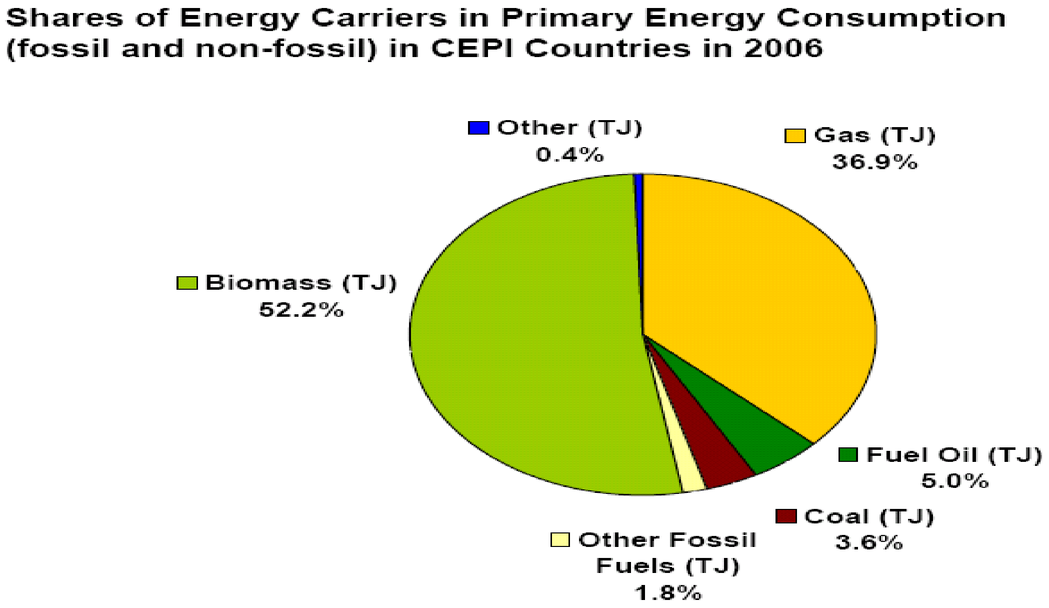
[32] The exact heat and electricity balance is very site-specific.

differences in specific energy consumption would be used (see for this and other criteria the discussion in Section 4.5). The six-product classification used by CEPI in their statistics is advantageous in view of recommended allocation principle 4, ensuring that verifiable production data are available based on a widely accepted classification and. If this six product classification would be used, it should also include an approach for specialty products produced in many cases by small specialty mills. For these specialty mills, a generic reference could be used, e.g. based on the highest benchmark for any of the other products. Alternatively, for this group of products, a benchmark based on the heat production only could be applied (Chapter 5). This would, however, result in a rather inconsistent allocation methodology within a relatively homogeneous sector and is therefore not recommended.

7.4 Fuel mix and resulting emission benchmarks

Figure 2 illustrates the fuel use in Europe in the paper, pulp and printing sector. The largest shares of fuel use are natural gas and primary solid biomass, together accounting for more than 80% of the sectors fuel use.

Figure 2 Fuel mix of CEPI[33] members



An analysis on a country-by-country basis (IEA, 2008) makes clear that solid primary biomass is a dominant fuel in those countries where large amounts of pulp are produced. In Finland and Sweden (the two main pulp producing countries), the share of primary solid biomass in the total fuel use in 2006 was 76% and 84% respectively. These data support the view that energy use in pulp

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[33] CEPI Members are Austria. Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom.

production can be assumed to be based on biomass energy sources and that natural gas is the dominant fuel in those parts of Europe where non-integrated paper mills are dominant (e.g. in Italy, the Netherlands, the UK and Germany where the share of natural gas in the total fuel use was 89 %, 71%, 81% and 80% respectively). We therefore suggest using biomass as fuel in pulp production (resulting in an effective benchmark of 0 t CO_2 / t pulp[34]) and natural gas as default fuel for paper production. The resulting benchmark values for paper are given in Table 22 assuming a 90% conversion efficiency in the production of heat. In practice, some drying processes also use hot air for drying and thus apply fuels for heat other than via steam boilers. Examples are Yankee cylinders and through-air drying used in tissue production (BREF P&P, 2001). It is unclear, however, to which extent the best practice specific energy consumption values in Table 21 correspond to steam or direct fuel use and we therefore use a 90% efficiency for the total heat demand.

Table 22 Indicative emission benchmark values for pulp and paper production (t CO_2 / t pulp or paper) based on specific heat consumption values from Table 21, assuming all heat used is steam produced with a 90% boiler efficiency and natural gas as fuel in paper and recovered fibre production and biomass in pulp production.

	Based on specific heat consumption from Starzer (2004))	**Based on specific heat consumption from Price et al. (2007)**
Pulp		
Bleached kraft pulp	0	0
Bleached sulphite pulp	0	0
Thermo-mechanical pulp		0
Recovered paper processing		0.02
Paper		
Uncoated fine paper	0.44 – 0.47	0.42
Coated fine paper	0.44 – 0.50	0.47
Tissue mill	0.34 – 0.47	0.39
Newsprint		0.32
Board		0.42
Kraftliner		0.37

The use of biomass for heat production in pulp making is an example of a process-specific fuel choice that is inherent to the production process that has to be taken into account in determining the benchmark, allocation principle 8). One could think of going one step further by correcting for the biomass-based heat that can be exported from the process in the benchmark for the heat consuming heat process (e.g. the paper in an integrated pulp and paper mill) or directly in the allocation for the pulp making (thus resulting in a negative allocation). This could in those cases result in a correction in the allocation for paper production. In view of recommended allocation principle

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[34] As explained, a possible exception could be made for the production of lime in kraft pulping.

7[35] and the choice for natural gas as default in paper production (assuming the non-integrated paper mills as reference in the fuel mix choice), we recommend not doing this[36]. The proposed benchmark approach is in this way advantageous for integrated pulp and paper mills that use biomass resources to meet the heat demand of the pulp and paper production process as indicated in Table 21.

Take as an example an integrated kraftliner plant using sulphate pulp. The best practice heat consumption for this integrated plant is between 14 and 18 GJ / tonne (Starzer, 2004)[37]. For each tonne of kraftliner, the plant would receive an allocation of 0.37 t CO_2 / t krafliner per year. If the plant would operate the paper mill in the integrated plant best practice, i.e. with a heat consumption of 5.9 GJ / tonne (Table 21) and would benefit from a steam export of 2 GJ / tonne from the pulp section, it would thus receive an excess allocation compared to the actual emissions resulting from the additional steam requirement of 3.9 GJ / tonne. This installation would thus benefit from the fact that they make use of biomass resources to produce heat that is available due to their integration with pulp making[38].

No structured data is available on the actual distribution of specific energy use and specific CO_2 emissions from the pulp and paper mills included in the EU ETS. An assessment of the intra-sectoral distributional effect resulting from the proposed emission benchmarks can therefore not be made. Comparison with the NAPs for which quantitative information on benchmarks for the paper sector could be found per tonne of output (Annex 1-B) show that the proposed benchmarks are a bit higher than the 10% best performing plants in Italy (0.37 for paper and 0.286 for board).

7.5 Capacity utilization

According to personal communication with the paper industry, there is little variation in load factors between paper mills producing the same product type. If demand for a certain paper grade declines all mills producing this grade temporarily lower production. This indicates that the variation in load between mills producing different grades of paper might differ substantially; depending on the market conditions for the grades and also that the variation in load factor over time might be significant. This is confirmed by ENTEC (2005) where the maximum variation in load factor between 1998 and 2003 for the UK pulp and paper industry was estimated at 39%. This supports the

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[35] Allocation principle 7: Do not use fuel-specific benchmarks for individual installations or for installations in specific countries.

[36] In addition, such a correction would also require determining exactly the amount of heat export from the different types of pulp. Since this e.g. requires choices on the “benchmark” technology for heat export (e.g. in the form of electricity or as heat) and on the “benchmark” use of e.g. bark from tree, it would make the methodology more complex compared to the rather simple proposed zero allocation for pulp production approach suggested here. In addition, it also brings back into the discussion the question how much pulp the paper making should use in the benchmark case, which is in practice not possible (see Section 7.2).

[37] Please note that this is lower that the sum of the non-integrated processes as indicated in Table 21, which yields a total heat use of 16 – 20 GJ / tonne. The difference is probably due to the fact that pulp drying is not required. Since we propose zero allocation for pulp making without deduction for heat export, the inclusion or exclusion of pulp drying in the benchmark for pulp becomes irrelevant.

[38] The advantage resulting from the integration thus lies in the availability of biomass resources, not in lower specific heat consumption for the paper production, which should be based on the most energy efficient process, in line with allocation principle 1.

conclusion that the product-specific capacity utilization factor should be used in the allocation for new entrants in the pulp and paper industry.

7.6 Conclusions

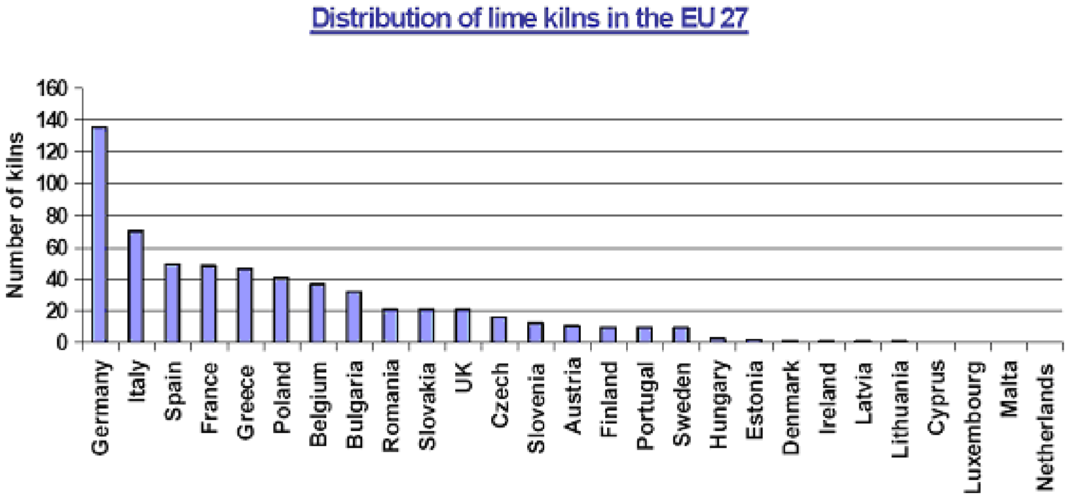
- The structure of the pulp and paper industry (both recycled and virgin fibre are required, similar grades are produced via multiple process routes) support the use of separate benchmarks for pulp and paper making.
- Available data indicate that non-integrated market pulp can be produced without the input of fossil fuels. This suggests that a 0 t CO_2 / t pulp benchmark is an appropriate benchmark. An exception could be made for the lime kiln in kraft pulping process.
- For integrated recycled fibre installations and for non-integrated paper mills, natural gas is the dominant fuel in use.
- Using available best practice specific heat consumption, this could result in a specific CO_2 emission benchmark of 0.02 t CO_2 / t recovered paper pulp produced between 0.32 and 0.50 t CO_2 / t paper (depending on the grade).
- The suggested methodology provides a reasonable allocation for non-integrated paper mills using recycled fibre or market pulp and rewards CO_2 efficient integrated operation.
- The limited data on capacity utilization available indicates that the use of standard load factors for all paper grades is not applicable for the pulp and paper industry, because load factors might differ widely between paper grades.

8 Sector study: Lime

8.1 Sector description

The European lime industry is scattered among Member States (see Figure 3) and comprises over 100 companies which operate in total about 600 kilns at 210 sites[39].

Figure 3 Distribution of lime kilns in the EU 27 (EULA, 2008)



In 2006, the non captive lime production (lime not produced for internal use in integrated industrial facilities) in Europe was around 28.4 Mt (CIBA, 2007). Lime is used in a wide variety of applications in the iron and steel, chemical, paper and pharmaceutical industry (BREF CLM, 2007). Direct CO_2 emissions from lime making occur in the calcination of limestone. This step involves burning calcium carbonate and/or magnesium carbonate in kilns at temperatures between 900ºC and 1200ºC. The chemical reaction is as follows and CO_2 is produced as a result of the decomposition of the raw material:

$$CaCO_3 \text{ (limestone)} \rightarrow CaO \text{ (lime)} + \mathbf{CO_2}$$
$$CaCO_3 \cdot MgCO_3 \text{ (dolomite)} \rightarrow CaO \cdot MgO \text{ (dolime)} + \mathbf{2CO_2}$$

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[39] European Lime Association (EuLA): http://www.ima-europe.eu

The process emissions due to calcination are constant and determined by the chemical reactions given above. These process emissions are equal to 0.785 t CO_2 per tonne of lime and 0.913 tonne of CO_2 per tonne of dolime.

To generate the necessary energy for the above-mentioned chemical reactions, fuels are burned. The combustion CO_2 emissions are the second source of CO_2 emissions in the lime industry.

The lime and cement industry Best Available Techniques Reference Document (BREF CLM, 2007 – draft) and EULA, the European Lime Association, distinguish six types of kiln in this industry, which in turn can be grouped into two main categories: horizontal kilns and vertical kilns. The six categories are:

1. Horizontal - Long rotary kiln – LRK
2. Horizontal - Rotary kiln with pre-heater - PRK
3. Vertical - Parallel flow regenerative kiln - PFRK
4. Vertical - Annular shaft kiln - ASK
5. Vertical - Mixed feed shaft kiln -MFSK
6. Vertical - Other kiln - OK (single shaft kiln, double inclined shaft kiln, multi chamber shaft kiln, travelling grade shaft kiln, top-shaped kiln, gas suspension, calcination kiln, rotating hearth kiln)

Table 23 Number of lime kilns by kiln type in the EU + Croatia, Norway, Switzerland and Turkey (CIBA, 2007)

Kiln type	Number
PRK	21
LRK	25
Total horizontal kilns	**46**
PFRK	158
ASK	74
MFSK	116
OK	203
Total vertical kilns	**551**
Total	**597**

8.2 Product-specific benchmarks

According to the lime industry, the industry faces a number of constraints that influence the choice of kiln technology which can be used in a particular situation and thus, via the specific fuel consumption, also the CO_2 emissions (EULA, 2008):

1. The raw material (limestone and dolomite) characteristics;
2. Fuel availability.

3. The final product specifications which depend on the client;

1. The type of limestone is an important factor in the kiln selection in relation with:

   - Granulometry
   - Softness or thermal behaviour

   Vertical kilns typically process medium to large pebble limestone with sizes > 30 mm, whereas horizontal kilns process small to medium pebble limestone, generally > 6 mm and < 40 mm. Also soft limestone that is subject to thermal degradation may not be suitable for calcination in vertical kilns, but may be calcined in certain types of horizontal or other kilns. (EULA, 2008). As discussed in Section 4.4, we argue that intra-sectoral distortions in the carbon price signal resulting from correction factors based on low-quality raw materials should be avoided and therefore we propose not to have separate benchmarks based on different limestone qualities (allocation principle 4[40]). Industry stakeholders argue that for an overall sustainable use of the limestone resources, the use of horizontal kilns (able to process small pebble sizes and soft limestone) cannot be avoided. So far, no convincing quantitative proof was given that starting from good quality limestone resources and taking into account alternative applications of fine pebble size limestone, horizontal kilns would be required. For this reason, we do not propose technology-specific benchmarks for lime based on this argument.

2. Some kiln types cannot technically burn certain types of fuels. The MFSK (> 20% of European kilns) for example cannot use gaseous fuels (EULA, 2008). According to recommended allocation principle 7[41], we propose not to have fuel-specific benchmarks for processes producing the same product to avoid intra-sectoral distortions in the carbon price signal. As explained below, we propose using natural gas as fuel and therefore do not penalise kiln types that cannot use high-sulphur fuels, i.e. oil based fuels.

3. In terms of lime quality, reactivity is the main reference, determined via a standard reactivity test. Each type of lime has a reactivity, which in turn, is governed by the requirements of the application. The reactivity depends on the limestone feed material, the type of kiln and the fuel used. A general principle is the higher the temperature, the lower the reactivity, but this is also dependent on the geological origin of the limestone. The product specification therefore does not have a direct link to kiln efficiency or specific energy use, but is more related to choice of kiln (EULA, 2008). According to EULA (2008), the requirements of lime qualities are laid down specifically in national as well as in European standards, but also in direct agreements between manufacturers and costumers. No overview is yet available specifying which lime grades can not be produced by the more efficient vertical kilns. Furthermore, according to the stakeholders from the lime industry there is no intra-sector agreement on a lime product classification. It can therefore be doubted whether a benchmark-based allocation based on more than one type of lime product is feasible in view of recommended allocation

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[40] Allocation principle 4: Do not apply corrections for plant age, plant size, raw material quality and climatic circumstances.

[41] Allocation principle 7: Do not use fuel-specific benchmarks for individual installations or for installations in specific countries.

principle 5[42]. An exception is the production of dead-burnt dolime with a very low reactivity. This is a clearly identified separate product, requiring a higher specific energy use, because higher temperatures are required in the kiln (sintering).

Based on the above considerations, we propose to have a single benchmark for lime production and an additional benchmark for dead-burnt dolime production. The benchmark for lime production for fuel combustion emissions can also be applied to captive lime production in industries such as the pulp and paper and sugar industry. For these sectors, the origin of the CO_2 from the calcination reaction is important to determine whether allowances are also given for the process emissions. In the pulp and paper industry, for example, the process emissions are from biomass origin as explained in the previous chapter.

8.3 Most energy efficient technology

The six kiln types differ significantly in energy consumption as is shown in Table 24.

Table 24 Typical specific fuel consumption for lime kilns (BREF CLM, 2007 - draft)

Kiln type	Specific heat consumption (GJ / tonne of lime)
PRK	5.1 – 7.8
LRK	6.4 – 9.2
PFRK	3.6 – 4.2
ASK	3.8 – 4.6
MFSK	3.8 – 4.7
OK	3.5 – 7.0

In the special case of dolime production, specific heat consumption equals 6.5 – 13 GJ / tonne of dolime.

The overview shows that the vertical kilns have a lower specific energy consumption compared to the horizontal kilns. This is confirmed in a detailed benchmarking effort conducted by the lime industry, which we discuss in the next section.

8.4 Fuel mix and resulting emission benchmarks

The lime industry developed a global allocation model for the lime industry based on benchmarking (CIBA, 2007). The model is based on a survey of non-captive lime kilns in the EU-27 + Norway, Switzerland, Turkey and Croatia) and covers over 90% if the lime kilns. The CIBA benchmark study unfortunately does not consider separately the fuel efficiency of the various kiln types

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[42] Allocation principle 5: Only use separate benchmarks for different products if verifiable production data for these products is available based on unambiguous and justifiable product classifications.

(i.e. the specific fuel consumption) and the fuel mix applied in these kiln types, but directly reports specific emission values.

The report gives two types of specific CO_2 benchmark values:

- Method A: Average specific CO_2 emissions
- Method B: Lower 10% of specific CO_2 emissions

Biomass energy use is taken into account using the corresponding energy amount from the conventional fossil fuel mix arguing that Europe's renewable energy policy will create a shortfall in the supply of wood from EU forests. Based on the data, EULA proposes to sort out the 6 kiln types into two main kiln categories, i.e. horizontal kilns and vertical kilns. With the latter, a separate treatment should apply to the mixed feed shaft kilns as it is technically not possible to use natural gas in these kilns.

Table 25 Benchmark values for the lime industry according to CIBA (2007)

Kiln type	Specific combustion emissions – Method A (tonne CO_2 / tonne of lime)	Specific combustion emissions – Method B (tonne CO_2 / tonne of lime)
PRK	0.483	0.243
LRK	0.708	0.556
PFRK	0.249	0.189
ASK	0.269	0.216
MFSK	0.401	0.313
OK	0.291	0.210
Horizontal kilns	0.573	0.273
Vertical kilns	0.275	0.200
Vertical kilns without MFSK	0.257	0.190

In the CIBA report, the following fossil fuel mix is given:

Table 26 fuel use in the lime industry in 2005 (CIBA, 2007)

Fuel	**Fraction**
Natural gas	47%
Solids	45%
Liquid fuels	8%

Also, the use 7.6 PJ of waste fuel and 2.3 PJ of biomass is reported that is used in lime kilns. However, gas has the largest share in consumption in this sector followed by solids and liquid fuels. In Table 27, we give the distribution of fossil fuel use by type of kiln, taken from the draft BREF (BREF CLM, 2007 - draft).

Table 27 Types of fuels by kiln types in 203 in the EU-25, % (BREF CLM, 2007 - draft)

Fuel	LRK	PRK	ASK	PFRK	MSFK	OK
Gas (fossil)	3	26	69	64	0	51
Solid (fossil)	81	60	6	20	100	32
Liquid (fossil)	1	3	14	10	0	10
Waste (fossil and biomass)	14	11	11	3	0	7
Biomass	0	0	0	3	0	0

This overview confirms that natural gas cannot be used in mixed feed shaft kilns (MFSK) and that gaseous and solid fuels are the dominant fuel types. No overview by country is available, but based on this overview, we conclude that natural gas is a non carbon-intensive fuel that is widely used as fuel in the lime industry and can as such be a suitable basis for determining the best practice fuel mix for the lime sector. In Table 28, we calculate specific CO_2 fuel combustion emissions for lime making by combing the lower value for specific heat consumption reported in the BAT reference document with the fuel emission factor of natural gas (56.1 kg CO / GJ). As a reference, we give the specific combustion emission range given in the BREF and the 10% benchmark as given in the CIBA benchmark study.

Table 28 Indicative CO_2 emission benchmark for the combustion of fossil fuels in lime production (t CO_2 / t lime) based on lowest specific heat consumption mentioned and ranges from the BREF CLM (2007 - draft) and 10% benchmark from CIBA (2007)

Kiln type	Natural gas as fuel, lower energy use from range in given in Table 24	Specific combustion emission range given by BREF CLM (2007 – draft)	10% benchmark CIBA (2007), Table 25
PRK	0.286	0.269 – 0.617	0.243
LRK	0.359	0.365 – 1.062	0.556
PFRK	0.202	0.202 – 0.425	0.189
ASK	0.213	0.224 – 0.464	0.216
MFSK	0.213	0.224 – 0.708	0.313
OK	0.196	0.224 – 0.508	0.210
Dead-burnt dolime	0.365		

In addition to these fuel combustion emissions, the production of lime and dolime results in specific process emissions of 0.785 t CO_2 per tonne lime and 0.913 t CO_2 per tonne dolime as a result of the chemical reaction. It is important to note that these process emissions are thus responsible for approximately three quarters of the CO_2 emissions in the lime industry.

Comparison with the average emissions of lime kilns as indicated in Table 25 shows that a fuel emission benchmark of about 0.2 t CO_2 / tonne lime would likely result in a shortage of allowances for many lime kilns in the EU, but is a realistic value when comparing with the best performing units in the EU. A total benchmark of 0.985 t CO_2/t lime is slightly below the value used in the UK for new entrants producing high calcium lime (1.00 t CO_2 / tonne), high calcium lime for the steel industry (1.09 t CO_2 / t) and ultra pure lime (1.31 t CO_2 / t). The total benchmark for dead-burnt dolime of 1.278 t CO_2 / t is also lower compared to the total benchmark range used for dolime in the UK (1.33 – 1.91 t CO_2 / t) (Annex 1-B)

8.5 Capacity utilization

Data on capacity utilization is not available. EULA (2008) states that "the lime industry being a capital intensive sector, the producers are without doubts working close to maximum capacity in order to maximize yields of their investments with nevertheless some spare capacity to guarantee the necessary flexibility to face potential market demand". However, the ENTEC-NERA study assessing benchmarks for the UK ETS allocation states that for lime, the variation in load is high, e.g. compared to cement, because variation in utilization depends on which markets are supplied by individual sites. Lime products serve distinct end users. A key factor is whether sites supply the steel industry which has significantly increased demand recently. These statements are confirmed by two analyses:

1. In the New Entrants reserve approach used in the first National Allocation Plan for the UK, a standard capacity utilization rate of 95% for 330 planned operating days is assumed. When these rates are applied using technology and fuel-specific benchmarks, the ratio of calculated emissions over actual emission ranged from 70% to 155% at 4 of the 7 sites analysed.
2. Based on actual production and capacity, the actual number of operating days was calculated for the 7 UK lime kilns, assuming a capacity utilization rate of 95%. The number of operating days calculated ranged from 32 to 324 days.

These analyses indicate that capacity utilization varies widely between kilns and that this variation is driven by the multiple markets that lime kilns serve. Standard capacity utilization rates for new entrants might therefore not directly be applicable to the lime industry.

8.6 Conclusions

- The CIBA benchmark study has demonstrated that a simple and transparent benchmark system can be developed for the lime sector, based on a very solid data basis (coverage > 90%).

- Following the recommended allocation principles outlined in Chapter 4 (i.e. no technology-specific benchmarks, no corrections for feedstock quality and a single fuel mix assumption), we propose a single benchmark for lime production based on best-practice vertical or other kiln technology using natural gas as fuel.
- Using the data sources available, this could result in a specific CO_2 emission benchmark around 0.2 t CO_2/t lime for fuel combustion in lime and dolime production.
- For dead-burned dolime production (having a much lower reactivity), higher temperatures in the kiln are required (sintering), requiring a higher specific energy use. Based on the data from the BAT reference document, specific CO_2 emissions from fuel combustion of 0.365 t CO_2 / t dolime might be applicable.
- In addition to the fuel combustion emissions, the production of lime and dolime results in specific process emissions of 0.785 t CO_2 / t lime (lime) and 0.913 t CO_2 / t dolime (dolime).
- According to EULA, product quality issues might limit the use of certain kiln types under the most efficient conditions. If this could be further differentiated and specified using internationally accepted lime quality standards in combination with data on the production of lime qualities by kiln type, additional benchmarks might be justified, comparable to the one proposed here for dead burnt dolime. However, the benchmark should in that case be specified by type of lime product rather than only by production technology.
- It is recommended to further extend the CIBA benchmark study to include separate specific energy use data and fuel mix data for the derivation of CO_2 emission benchmarks.
- The analyses on capacity utilization for the UK lime industry indicate that capacity utilization varies widely between kilns and that this variation is driven by the multiple markets that lime kilns serve. Standard capacity utilization rates for new entrants might therefore not directly be applicable to the lime industry.

9 Sector study: Glass

9.1 Sector description

The products of the glass industry usually are divided into three or four categories with the first two being container glass and flat glass. If only three categories are used all other types of glass products are summarised as other glass or specialty glass. If four categories are used, fibre glass is treated separately from the specialty glass. From a general perspective, the product mix of the glass industry is very diverse. The biggest range of products can be found in the category of specialty glass that covers also products like hand made glass jewellery or optical glasses. In terms of production volume, container glass and flat glass are by far the most important products. With a production of 21 million tons of container glass and 9.7 million tons of flat glass in 2005, these two categories made up some 90 % of the EU-27 production of 34.2 million tonnes of glass (Data from CPIV, 2008). The largest glass production volume can be found in Germany, France and Italy (see Table 29)

Table 29: Glass production in Germany, France and Italy in 2005 according to CPIV. Data in tonnes

	Germany	France	Italy
Flat Glass	1,550,993	1,098,465	1,183,310
Container Glass	3,908,431	3,798,384	3,543,333
Domestic Glass	328,289	401,738	173,176
Fibres	888,369	229,409	129,958
Other Glass	155,090	41,234	100,000

Container Glass

Products of the container glass industry on the one hand are bottles for beverages and wide neck jars for industrial purposes which are considered as commodities. On the other hand higher value containers for medicines and perfumes are produced.

Within the container glass manufacturing industry the “pack to melt” ratio is a measure of the quality of the production process. It is the ratio of the tonnage of container glassware packed for shipment to customers to the tonnage melted in the furnace. The pack to melt ratio varies between up to 94% for containers for beverages and foodstuff and around 70% for flaconnage.

According to the BREF, more than 50 % of the container glass production comes from the ten largest producers in the European Union. These are at least partly subsidiaries of larger international companies. So, depending of the perspective, the concentration in the container glass industry is even higher. For 1997, the BREF document lists 140 installations with 295 furnaces. In 2008 the European Container Glass Federation represents 57 producers in 22 Member States (FEVE, 2008).

Flat Glass

In 1997 there have been 40 float glass tanks in the EU producing 6.9 million tonnes in the EU 15 of that time. In 2005, there were 56 float glass tanks in the EU-27 (BREF Glass, 2008 - draft, p. 12). The BREF gives an indication of the regional distribution of these float glass tanks across the Member States. 85% of the production capacity of these tanks is located in Germany, France, Italy, Belgium, United Kingdom and Spain (p. 11). The majority of rolled glass is produced as patterned glass or wired glass. Float glass goes mainly into the building industry (75% to 85% of the output) and into the car manufacturing industry (15 to 25 % of the output).

There are four companies that control about 80 % of the market for flat glass products (Pilkington, Saint-Gobain, Asahi with its European subsidiary AGC Flat Glass Europe and Guardian with its European subsidiaries). The high degree of industry concentration in the flat glass market leads to the effect that most of the relevant data on production volumes and input of energy carriers is publicly not available due to confidentiality reasons.

Table 30: Float glass tanks in EU Member States and associated shares in EU production in 2005 (BREF Glass, 2008 – draft)

	Number of float glass tanks	**Share in EU production**
Germany	11	19.6
France	7	12.5
Italy	7	12.5
Belgium	7	12.5
United Kingdom	5	8.9
Spain	5	8.9
Poland	3	5.4
Czech Republic	2	3.6
Luxembourg	2	3.6
Finland	1	1.8
Netherlands	1	1.8
Portugal	1	1.8
Sweden	1	1.8
Hungary	1	1.8
Romania	1	1.8
Bulgaria	1	1.7

Continuous Filament Fibre

Continuous filament fibres are especially used for the production of composite materials like fibre-reinforced plastics. Glass wool usually is categorized in another product group. Continuous filament fibre is generally manufactured from a glass melt in cross-fired recuperative furnaces that are employing fossil fuels to supply the melting energy. As the production volume of continuous filament fibre is lower than that of the large bulk materials (container glass, flat glass), smaller furnaces are used and the use of regenerative furnaces is not advisable. Most commonly, an E glass[43] formulation is used for continuous filament fibre. With a low electrical conductivity of E glass, electrical melting is not seen as efficient process for continuous filament fibre.

Technologies for the Manufacturing of Glass

Corresponding to the wide range of products, there is also a wide range of production techniques that vary from small electrically heated furnaces to large cross-fired regenerative furnaces e.g. in the flat glass manufacturing industry. The application of a specific technology depends on several influencing factors such as the required furnace capacity, the chemical formulation of the glass, the choice and prices of fuels, the existing infrastructure and the environmental performance (BREF glass, 2001, p. 36). The BREF gives an estimation of the EU15 furnace types in 1997 (see Table 31). The data given does not allow differentiating amongst the different products of the glass industry.

Furnaces for the production of glass are usually constructed to continuously melt large volumes of glass. The uninterrupted operation period can last up to twelve years. According to the industry representatives the tendency in the glass industry and especially in the flat glass industry is to increase the operational life time to 15 to 18 years. It has been further stated that under normal circumstances, the replacement of a glass furnace at the end of its lifetime is done on the foundations of the preceding installation. The replacement hence is mainly a rebuilding of the refractory walls of the furnace with a comparable geometry.

The output of furnaces has a wide range from 20 tonnes of glass per day to more than 600 tonnes per day. Generally, the large installations with a capacity of more than 500 t/day use cross-fired regenerative furnaces. For medium-sized installations with a capacity in the range of 100 to 500 t/day end-fired recuperative unit melters are the most common choice but also cross-fired regenerative, recuperative unit melters, and in some cases oxyfuel or electric melters may also be used.

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[43] E glass has a chemical composition that is largely free of alkaline elements. The formulations usually can still be characterised as boro-silicon glass.

Table 31: Estimates on the types of furnaces in the EU15 in 1997. Taken from BREF Glass, 2001, p. 36

Type of furnace	Number of units	Melting capacity (kt/y)	Average melting capacity (t/d)
End-fired	265	13 100	135
Cross-fired	170	15 300	250
Electric	100	1 100	30
Oxygen	30	1 200	110
Others	335	4 300	35
Total	**900**	**35 000**	**110**

Regenerative furnaces are named after the form of the applied heat recovery system. The burners are usually placed in or below the combustion air/waste gas ports. The purpose of this design is to achieve a preheating of the air by the waste gases prior to combustion. There are two types of regenerative furnaces, cross-fired and end-fired. According to the BREF Glass (2001), all of the float glass furnaces are of the cross-fired regenerative design. Regenerative furnaces allow preheat temperatures of up to 1400° C and thus high thermal efficiencies.

In recuperative furnaces the heat recovery from the waste gases and the pre-heating of the combustion air is performed indirectly by a continuous counter flow of the two gas streams through a heat exchanger. This design is used for smaller furnaces. The preheat temperatures of recuperative furnaces is usually limited to 800°C as metallic heat exchangers don’t allow higher temperatures. The lower recovery temperatures compared to regenerative furnaces leads to a lower heat recovery rate. This could be compensated by further recovery systems on the waste gases for the preheating of input materials or for steam production.

Oxyfuel melting is based on the combustion of the fuels with mostly pure oxygen instead of combustion air. Although this technology requires the energy intensive production of pure oxygen it is still beneficial as it reduces the volume of waste gases by about two thirds and avoids the heating of the nitrogen contained in the air. Oxyfuel melters do not apply heat recovery systems.

Electric furnaces are built as a box shaped container lined with refractory materials. Electrodes are inserted usually from the bottom side of the furnace. The energy is provided through resistive heating as the current flows through the molten glass. Electric melting is used in smaller units as the thermal efficiency of fossil fuel fired furnaces decreases with unit size. According to the BREF Glass (2001), the thermal efficiency of electric furnaces is two to three times higher than that of fossil fuel fired furnaces.

Apart from these furnace types there are also furnaces with combined fossil fuel and electric melting, furnaces for discontinuous batch melting and furnaces with special melter design. The addition of electric boosting to fossil fuel fired furnaces is done to increase the output capacity and to meet fluctuating demand. Discontinuous batch melting and special designs are applied for smaller production volumes.

9.2 Product-specific benchmarks

A crucial point for the derivation of benchmarks is the definition of products that can be clearly differentiated from each other. This in mind we see as a workable approach to base a benchmark-based allocation methodology on four groups of products:

- Container glass
- Flat glass
- Continuous filament fibre
- *Specialty glass*

These broad groups of products do certainly not fully reflect the wide variety in products that are made in the glass industry. In discussions with members from the associations of glass manufacturers (amongst others associations of manufacturers of flat glass, container glass, continuous filament fibre and tableware), it was pointed out that a benchmarking approach with only three or four product groups would not be seen as sufficiently differentiated by the industry stakeholders. According to industry the differences in product qualities and types resulted in significant differences in energy demand for production and thus also in significant differences in emissions. They for example suggested further categories of tableware glass and flaconnage. The latter is a further differentiation of container glass and covers vessels for perfumes or for medical purposes.

Although these proposed groups would each incorporate a diversity of individual products we see serious advantages in using a more limited number of product groups. A main point is the clear differentiation of products that would avoid ambiguities on which benchmark to apply for a product (i.e. allocation principle 5[44]). Further, the general lack of available data on energy demand of glass furnaces makes it hardly possible to even judge the differences in emissions intensity of these groups; not speaking of the identification of appropriate most efficient technologies (see below).

A benchmark allocation methodology based on these four product groups would for existing installations require historical production data. In the glass industry statistics, two types of data can be used. One is glass melted, which is the actual output coming directly from the glass furnace. The other is glass packed and shipped, which is always a lower amount than the glass melted due to losses in the post processing. Any lost material can be recycled as internal cullet. In times of low markets that make a capacity reduction necessary, internal recycling of cullet can increase. Applying a benchmark on the glass packed and shipped would put a slightly higher emphasis on energy and emissions efficiency. This is the case because installations operating inefficiently and hence having a low ratio of melted to packed and shipped glass could compare themselves directly to the reference ratio of melted to packed and shipped glass. The industry stakeholders clearly preferred to base benchmarks on the glass melted as this amount is under rigorous monitoring from the manufacturers. Although the practicability of a benchmark based on melted glass could be higher we suggest using packed glass as activity indicator because of the higher emphasis on emissions efficiency.

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[44] Allocation principle 5: Only use separate benchmarks for different products if verifiable production data is available based on accepted product classifications.

The use of cullet rather than mineral raw materials is a highly effective measure of reducing CO_2 emissions from glass manufacture. With respect to the effects on energy and emissions efficiency, the IEA (2007) study points out that increased recycling is a good means of reducing energy consumption as the energy demand for the endothermic chemical reactions of the glass formation is saved, the melting point of cullet is lower than that of mineral raw materials and the mass of cullet per unit of output is 20% lower. The study gives as general rule that a reduction by 2.5 to 3% of the furnace energy demand can be achieved per 10% of extra cullet input in the glass making process (from 5.2 to 4.0 GJ/t for the range 0 – 100% cullet). Beyond the direct effect on the energy demand and CO_2 emissions a higher cullet use rate contributes to a reduced demand for soda. Some 18% of soda is added to sand as primary raw material for the glass making process. The addition of cullet reduces the demand for soda and lime, and thereby reduces process emissions (non-energetic emissions). In line with the general approach indicated in Section 4.4, we base the benchmark for each product on a realistic share of cullet that can reasonable be obtained in view of availability and product quality issues.

9.3 Most energy efficient technology

Cullet use

Cullet can be used to a higher degree in the manufacture of container glass than in the manufacture of flat glass. Flat glass products require higher material qualities which can only be reached with a higher proportion of mineral raw materials. Although the use of cullet constitutes a very efficient opportunity for emissions reduction especially for container glass production, the collection rate of cullet is varying considerably across the European Union. The collection rates ranging from less than 10% to more than 90% clearly indicates that there is ample room for a higher use of cullets at least from the side of secondary material inputs. Nevertheless, industry representatives pointed out that the availability of cullet is a crucial factor for individual plants that is strongly influenced by local and regional factors[45].

Within the research work for this study, we have not been able to verify the extent of limiting effects on cullet availability based on statistical data. Still, we are of the opinion that with increasing market pull, induced by environmental policies and other mechanisms, a functional supra-regional cullet market will evolve if it does not exist already. We also believe that counter-effective recycling policies should be further developed in order to foster the use of cullet in the glass industry.

The available data do not give specific examples of best available techniques with respect to cullet use. For container glass, we assume a cullet share of 85% of cullet, for flat glass, a share of 10%.

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[45] One key issue mentioned are the existing policies on recycling of used materials in the Member States. In the United Kingdom obligations on recycling of packaging materials could be fulfilled by providing unsorted cullet to the construction industry as material for road construction. This would reduce the amount of available cullet for the glass manufacturing industry in the United Kingdom. Further, the quality requirements with respect to sorting of different glass colours implemented by the recycling policies are also influencing the availability of high quality cullet for the glass manufacturing industry.

For continuous filament fibre, no use of cullet will be assumed as for this type of products, only raw materials can be used.

Specific energy use

With respect to the energy demand, the BREF states that the actual requirements experienced in the various sectors vary widely from about 3.5 to over 40 GJ/tonne. The large variation is a result of different furnace designs as well as scale and method of operation and quality requirement of the product. However already in 1997, the majority of glass was produced in large furnaces and the energy requirement for melting is generally below 8 GJ/tonne. Given the high importance of fossil fuels in the glass sector (see below), the emissions intensity of glass production is directly linked to the energy intensity of production.

The BREF indicates that in general, the energy necessary for melting glass accounts for over 75 % of the total energy requirements of glass manufacture. For the manufacture of container glass, the typical energy distribution is as follows: furnace 79 %, forehearth 6 %, compressed air 4 %, lehr[46] 2 %, and others 6 %. Although there are wide differences between sectors and individual plants, the example for container glass could be considered as broadly indicative for the industry. The continuous filament fibre is seen as the main exception to this generalisation as there the fiberising operation and the curing oven also consume major amounts of energy.

In Table 32, the theoretical energy requirements for the melting of glass according to the BREF glass (2001) are given. Obviously the theoretical demand for the formulations of flat glass and container glass is the highest. The main differences between the real processes however originate from the efficiency of the process design and are not caused by the theoretical energy demand values.

Table 32: Theoretical energy requirement for the melting of common glass compositions (BREF glass, 2001)

	Soda-Lime (Flat/Container Glass) GJ/tonne	**Borosilicate (8 % B_2O_3) GJ/tonne**	**Crystal Glass (19 % PbO) GJ/tonne**
Theoretical energy requirement	2.68	2.25	2.25

According to IEA, 2007, in practice, the average energy use varies between 5.75 – 9.0 GJ/tonne. Hence it is between 2 times and 4 times as high as the theoretical minimum energy demand. Beerkens and Limpt (2001) investigated 123 container glass furnaces and 23 float glass furnaces in Europe and in the United States. Their analysis showed a energy intensity of 4 – 10 GJ/t of container glass and 5 – 8.5 GJ/t of flat glass. Main influencing factors on the energy intensity were the size and technology of the furnace and the share of cullet used. The major energy losses occur as structural heat losses (20 to 25% of the input, 0.85 GJ/t), and losses through the heat content of the

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[46] A lehr is used to slowly cool down glass products under controlled conditions. The operation may require additional heat energy in order to avoid a temperature drop taking place too fast.

flue gases (25 to 35% of the input, 1.18 GJ/t). According to IEA (2007, p. 169), oxy-fuel furnaces with cullet pre-heating now offer the most energy efficient furnace technology.

Although there is exemplary data on good practices with respect to energy demand of glass production, the BREF document on glass manufacturing does not specifically state data on best available techniques on this issue. Therefore, at the current state of the analysis, we use examples stated in the BREF document with the highest efficiency as indications of a possible most efficient technology. Electricity is only used for smaller batch processes or boosting in larger furnaces.

Table 33: Examples of efficient technologies for glass manufacture. Data from BREF glass (2001)

Glass type	**Furnace type**	**Share of cullet**	**Fuel**	**Melting energy demand**
Container glass	Unit melter oxy-fuel	65%	Gas	3.35 GJ / tonne
Flat glass	Cross fired regenerative furnace	-	Oil	5.40 GJ / tonne
Continuous filament fibre	Cross-fired recuperative	-	Gas	8.75 GJ / tonne

We correct the melting energy for the share of cullet assumed to be best practice (85% for container glass, 10% for flat glass and 0% for continuous filament fibre). We thereby assume the rule of thumb with relation to associated energy savings given in the previous section, 3% savings for each 10% increase in cullet use). This result in a deduction of 6% for container glass and 3% for flat glass compared to the values given in Table 33.

We further correct for the additional non-furnace related energy demand. Technically a detailed analysis of each post-processing step could be done to identify the most efficient solutions with respect to emissions. Given the dominance of the energy demand and associated emissions from the furnace, we recommend, however, to use a uniform factor for this energy use. The melting energy makes up some 79% of the total energy demand in container glass production (BREF glass 2001 p. 86) and some 83 % in the flat glass production. We also assume a share of 79% in filament fibre production. Taking this into account and assuming a share of 5% of the total energy demand being met with electricity, an indicative total energy demand from fossil fuels and can be derived.

Table 34: Derivation of best practice specific energy use in glass manufacturing based on energy use information from the BREF Glass (2001)

Glass type	**Melting Energy demand corrected for maximum use of cullet**	**Total energy demand**	**Fossil share of energy demand (95%)**
Container glass	3.10 GJ/t	3.92 GJ/t	3.73 GJ/t
Flat glass	5.24 GJ/t	6.31 GJ/t	6.00 GJ/t
Continuous filament fibre	8.75 GJ/t	10.94 GJ/t	10.40 GJ/t

The heterogeneity of the remaining product group of specialty glasses does not allow deriving a benchmark based on a real product. In order to find a solution also for this group, we propose to apply a generic value derived from a reference product, replacing a benchmark.

9.4 Fuel mix and resulting emission benchmarks

The overall scarcity of publicly available actual data on the glass industry makes it difficult to give a comprehensive overview of the fuel mix in this industry. The ODYSSEE database provides information for seven Member States (see Figure 4). With large glass producing Member States like Italy not being represented in the database, the information on the fuel mix can not be viewed as fully representative. However it seems likely based on this limited information, that natural gas has replaced oil products as predominant fuel. This indicates that the trend already discussed in the BREF document has continued. Compare BREF (2001, p 36-37) where oil products are still given a more important role with a rising importance of natural gas.

Figure 4: Energy use in the glass industry in seven EU Member States in 2005. Data: ODYSSEE database[47]

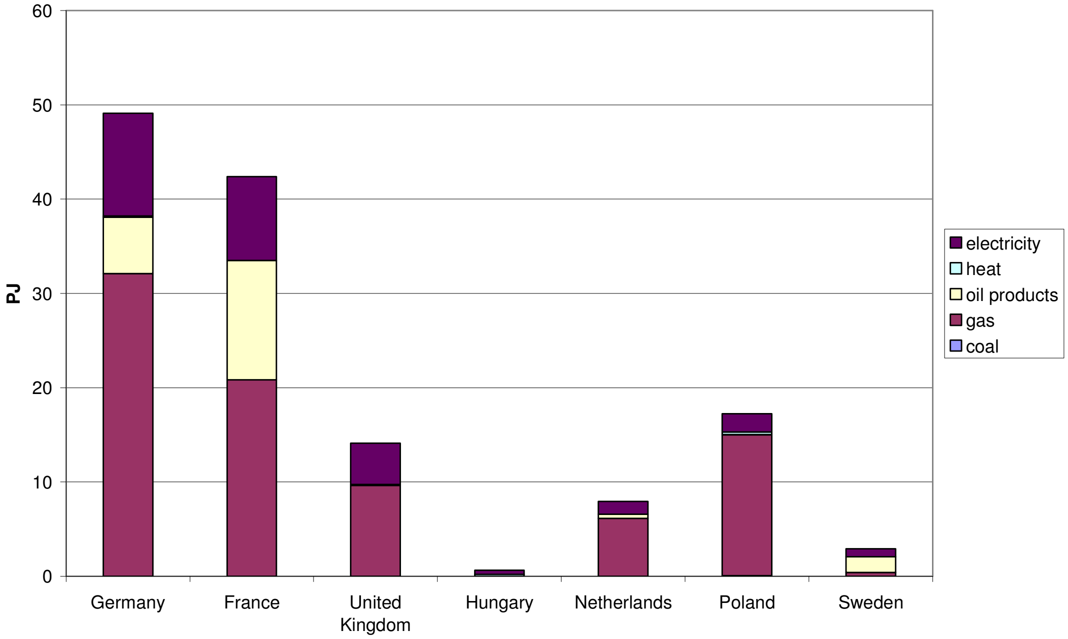
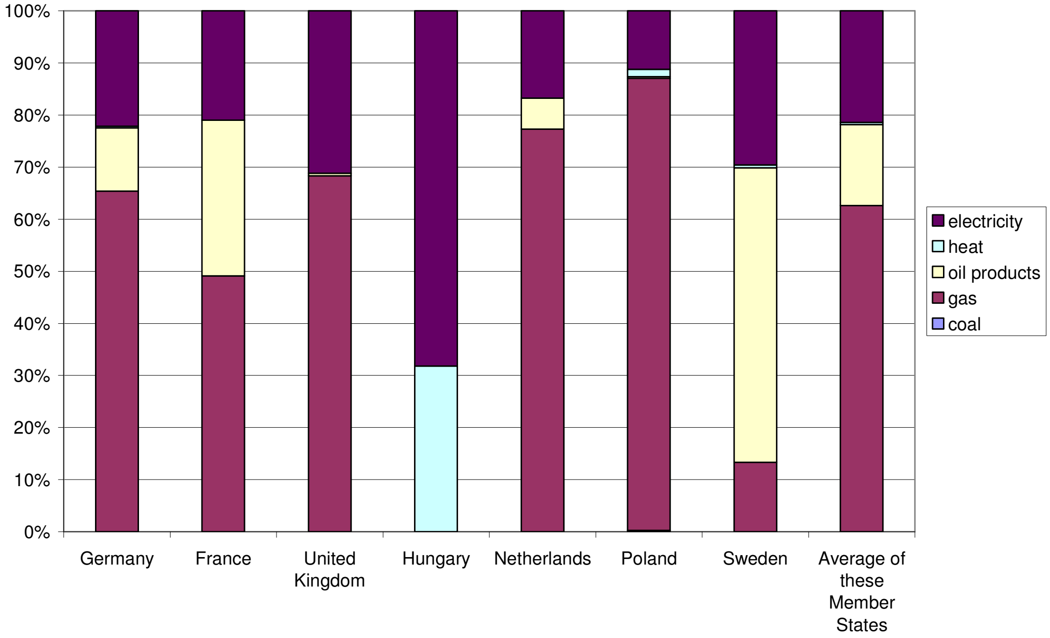


Figure 5: Relative share of the energy inputs in seven EU Member States



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[47] The ODYSSEE database gives "heat" as energy source without further details on the sources how the heat is generated. Apart from the case of Hungary, where "heat" has a significant share in the fuel mix, it can be considered as negligible.

In discussions with industry representatives, technical advantages of using heavy fuel oil have been claimed. As this fuel burns with a more luminous flame than natural gas, a deeper transmission of radiative heat into the mass of glass in the furnace could be reached. This, according to the stakeholders, leads to better results with respect to energy efficiency. Nevertheless the benchmarks should be based on the use of natural gas as this fuels leads to a better performance with respect to emissions.

Using Natural Gas as fuel, the fossil fuel use indicated in Figure 5, can be translated into the following indicative CO_2 emission benchmarks for melted glass:

Container glass: 0.209 tonne CO_2 / tonne melted glass
Flat glass: 0.336 tonne CO_2 / tonne melted glass
Continuous filament fibre: 0.582 tonne CO_2 / tonne melted glass

Further CO_2 emissions occur due to the decarbonisation of the carbonate raw material in the process input (mainly Na_2CO_3, $CaCO_3$ and $MgCO_3$). In case of a high share of cullet use as assumed for the most efficient technologies for container glass production, the decarbonisation plays a very minor role (some 0.016 t CO_2/t of melted glass when one fifth of the new raw material of 15% of the melt is assumed to be made up from carbonates). This is different for flat glass, where the raw materials play the dominant role. Assuming that the mineral raw material is made up of 13 % of soda, of 5 % of limestone and of 3 % of dolomite, the decarbonisation will result in an additional CO_2 emission of 0.088 t CO_2/t of melted flat glass. For continuous filament fibre, assuming a formulation of 1 % of soda, 10 % of limestone and 10 % of dolomite, the additional raw material related emission would amount to some 0.120 t CO_2/t of melted glass.

Finally, the packed to melt ration has to be taken into account to obtain an indicative benchmark for packed glass. Based on the information from the BREF glass (2001), the estimations for packed to melt ratios can be made but further investigations are necessary to obtain more reliable data on this matter:

Container glass: 90%, yielding a benchmark of 0.250 tonne CO_2 / tonne packed glass
Flat glass: 70%, yielding a benchmark of 0.606 tonne CO_2 / tonne packed glass
Continuous filament fibre: 70%, yielding a benchmark of 1.003 tonne CO_2 / tonne packed product

No structured data is available on the actual distribution of specific energy use and specific CO_2 emissions from glass industry in Europe. An assessment of the intra-sectoral distributional effect resulting from the proposed emission benchmarks can therefore not be made. Comparison with the NAPs for which quantitative information on benchmarks for the glass sector could be found per tonne of output (Annex 1-B) show that the proposed benchmarks for container glass (0.250 t CO_2 / tonne including process emissions) are lower than the ones used in the NAP for phase II by Germany and Luxemburg (0.28), Italy (0.30) and the UK (0.33). For flat glass, the allowance of 0.606 t CO_2 / tonne (including process emissions) is in the same order of magnitude as the one used in Luxemburg and Germany (0.51), Italy (0.64) and the UK (0.55). It should be noted, however, that in these figures, it is not always clear whether process emissions are included or excluded and whether the values refer to net or gross production of glass. These aspects should be studied further in order to make a fair comparison of benchmark values.

9.5 Capacity utilization

Statistical data on capacity utilization could not be made available. The high degree of concentration of the glass industry to very few large companies indicates that the application of a uniform capacity utilization rate would not necessarily create intolerable distributional effects on a enterprise level. The generally experienced problems with activity indicators makes using historical production levels for the derivation of an allocation level from the benchmarks the most promising alternative.

9.6 Conclusions

- The structure of the glass industry supports the formulation of three separate benchmarks for the container glass production, for the flat glass production and for the continuous filament fibre production and a generic reference for the (specialty) products not covered with these benchmarks.
- Natural gas is the dominant fuel followed by oil products with an apparent growth of the share of natural gas in the recent years.
- Specific data on the energy demand for most efficient technologies for glass making has not been found in the literature yet. Using examples of the most efficient technologies as found in literature results in a CO_2 emission benchmark for fuel combustion of 0.209 t CO_2/t melted container glass, of 0.336 t CO_2/t of melted flat glass and of 0.582 t CO_2/t melted continuous filament fibre.
- In addition to these fuel emissions, the best practice production of one tonne of melted container glass (with high share of cullet) results in process emissions of 0.016 t CO_2, and in 0.088 t CO_2 per tonne of melted flat glass and 0.120 t CO_2 per tonne of melted continuous filament fibre.
- The data for melted glass has to be corrected by the packed to melt ratio to result benchmarks for the final product.
- The lack of verifiable data on emissions levels of most efficient technologies proves the need to further undertake investigations and examine the outcome of the revision process of the BREF document on glass manufacturing.

10 Conclusions and outline for further work

The application of the allocation principles to the four example product gruops shows that a transparent and applicable benchmark-based allocation methodology can be developed and that no a-priori bottlenecks exist in developing such methodology. It is clear, though, that within the scope of this project no approach is developed that is fully ready for implementation. To come to a fully harmonised free allocation methodology based on benchmarking, we can envision the following important steps:

1. **Comprehensive definition of products for which benchmarks can be applied and their link to sector classification**
2. **Application of recommended allocation principles to all these products**
3. **Set-up of stakeholder involvement process**
4. **Detailed assessment of data requirements and pilots to test data availability**

Comprehensive definition of products to which benchmarks can be applied

In Section 3.2, we already gave an overview of the next steps that could be made to get for all installations under the EU ETS an overview of the type of products produced by these installations and their link to sector classification and the classification into Annex I activities:

1. Further categorization of the installations included in the EU ETS only via the Annex I activity “combustion installation” into their <u>main activities</u> to get detailed overview of the type of industrial activities included via the Annex I activity “combustion installations”.
2. Based on the EU-wide used PRODCOM and other product classifications, preparation of an overview of the products produced by all installations under the EU ETS. Such an overview, which should ideally also include the industrial sector classification of the installation involved as well as the categorization into the Annex I activity, will provide insight into the degree of overlap of certain products between various industrial sectors. Special attention in the preparation of such an overview should be given to intermediate products of installations that might not well be covered in product classifications and to “products” that might not be covered as part of the PRODCOM such as “district heating”.
3. Development of an output-based benchmark in line with the criteria outlined in this study and of fall-back approaches for those products where an output-based benchmark is not feasible or difficult to realise (see below).

Application of recommended allocation principles to all products

For reasons of equal treatment to all installations, the aim should be to develop reasonable benchmarks for the products of as many installations as possible, following the allocation principles developed in this study. For those products that cannot be covered via an output-based benchmark, because of the limited amount of producing installations and/or difficulties in convincingly establishing the output of the installation, the fallback option as outlined in allocation principle 11[48] could be used or other possible fallback approaches[49]. Based on the current list of specified industrial activities in Annex-I, this would require the further[50] development of benchmarks for:

- The various products produced by installations in the activity “combustion installations”
- The products of mineral oil refineries[51]
- Production of aluminium
- Production and processing of other non-ferrous metals
- Production of cement clinker[51]
- Production of ceramics
- Production of rock wool and stone wool
- Chemical industry (as specified in Annex-I)

Below, we discuss issues related to data availability to come to a benchmark-based allocation methodology.

Set-up of industrial stakeholder involvement process

To further elaborate the suggested benchmark-based approaches, involvement from industry stakeholders is indispensable, especially to:

- Establish best practice energy efficiency levels as suggested in Section 4.3. As we recommend there, it would be advantageous for each of the products being benchmarked to compare the actual specific energy consumption of all installations in the EU ETS producing this product. Such a comparison not only ‘automatically’ yields the best performing installations (regarding specific energy consumption), but also gives insight into the intersectoral distributional effects of the proposed allocation methodology.
- Assess whether the required data for application of the allocation methodology can be made available.

In addition, the input from other stakeholders such NGOs, academia and social groups is necessary in the development of a balanced and well-accepted harmonized methodology. Last, but not least, active involvement from the EU Member States is required. It is recommended to work out in detail such a stakeholder involvement process and start as soon as possible with the involvement of the various stakeholders, especially in view of the rather short timeframe in which the allocation methodology should be developed.

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[48] Allocation principle 11: Use heat production benchmark combined with a generic efficiency improvement factor for heat consumption in processes for which no output-based benchmark is developed.

[49] Another fallback approach could be to somehow use directly the historical emissions for those installations.

[50] In addition to the four sectors covered in this report.

[51] Covered by the pilot study by Ecofys and the Ökö institute (2008).

Data requirements and pilots to test data availability and allocation rules

A major issue related to the feasibility of any benchmark-based allocation methodology is the availability of the required data to apply the allocation methodology. The current study has been based on easily available public data on e.g. best practice energy efficiency values. Before actual emission benchmark values could be set and a benchmark-based allocation methodology could be applied, it will be required to analyse more in detail:

- The availability of all data required for all sectors, all products and all Member States.
- The quality of the required data and the possibility for (independent) verification and monitoring
- The confidentiality of the data and the resulting need for an independent entity governing the data without disclosing details

We conclude that we do not see any a-priori bottleneck issues regarding the required data, although the actual feasibility of acquiring all data in the short timeframe available should be further studied.

We try to present a schematic overview of these issues in Table 35, following the content of this report. In the first column we categorize the data into three categories

1. Data needs related to establishing the benchmarks (product definition, BM values)
2. Data needs related to defining the activity levels and the resulting total allocation
3. Data needs related to distributional and other effects related to the proposed methodology

Table 35 Overview of data needs

	Data need	**Why**	**Availability and issues related**
1	Overview of products produced by EU ETS installations	-To identify the products and sectors that are included in the EU ETS - To identify for which installations, product-based benchmarks could apply (general)	- Production data available via e.g. PRODCOM database and industry associations - Availability of production data for intermediate products might be a problem (e.g. lime in the pulp industry)

	Data need	Why	Availability and issues related
1/3	Best Practice specific energy consumption values for products included via product-based benchmark	Required to apply allocation principle 1 (Section 4.3)	- Available from various sources (BREFs, industrial data collection efforts) - Can also be assessed via analysis of actual specific energy consumption values of ETS installations - For each sector, a suitable approach should be developed in close consultation with industry. - Independent verification necessary to ensure equal treatment of sectors
1/3	Actual specific energy consumption values for EU ETS installations	- To identify "best practice plant" operating and estimate intra-sectoral distributional effects	- Data are available from operators, but it can be doubted whether operators are willing to deliver without formal legal requirements - For complex sectors (multiple products), actual specific energy consumption can only be determined after clear rules are established - Timing issue
2	Historical production data	Required to calculate allocation (Section 4.7)	- Production data available via e.g. PRODCOM database, via other production data collection systems and directly from operators - Need for independent verification and quality checks. - Bottleneck criterion (allocation principle 4): data need to be available based on accepted product classification. - Intermediate products might be problematic, but should be available from operators - Timing issue

	Data need	Why	Availability and issues related
2	Production of heat and power	To separate emissions from CHP installations to heat and power produced (Chapter 5), and to use heat output in the sectors without benchmark	- Available from operators - Further work required on definition of heat production (measured where, use of which steam tables etc.)
2	For installations with heat flows over the system boundary: consumption of heat per product by origin	To apply methodology for heat as described in Section 5.3	- Available from operators - Further work required on definition of heat consumption (measured where, direct heat vs. steam etc.) - Basically, a rather detailed heat balance for these installations is required. - Recommended to test quickly whether this is feasible (e.g. tests for all pulp and paper mills)
1	Fuel mix for the production of specific products	To identify suitable fuel mix to apply for the emission benchmark, depending on the chosen allocation principle	- Available from public statistics for some sectors - For smaller subsector available via operators
2	Capacity definition	To apply allocation methodology to new entrants	Need for sound and verifiable definition of capacity in order to calculate capacity utilization rate
2	Sector-specific capacity utilization factors	To apply allocation methodology to new entrants	Could be based on estimate for historical utilization for 2005 -2007 of existing installations, on market studies and on approaches followed in National Allocation Plans

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Abbreviations

ASK	Annular Shaft Kiln
BAT	Best Available Technique
BREF	Best Available Technique Reference document
CHP	Combined Heat and Power
CEFIC	European Chemical Industry Council
CEPI	Confederation of European Paper Industries
CPIV	Standing Committee of the European Glass Industries
CSI	Cement Sustainability Initiative
DRI	Direct Reduced Iron
EAA	European Aluminium Association
ECCP	European Climate Change Program
ETD	Greenhouse Gas Emission allowance Trading Directive
ETS	Emission Trading Scheme
EU	European Union
EU ETS	European Union Emission Trading Scheme
EULA	European Lime Association
GHG	Greenhouse Gas
GNR	Getting the Numbers Right
IEA	International Energy Agency
IFIEC	International Federation of Industrial Energy Consumers
IPPC	Integrated Pollution Prevention and Control
LRK	Long rotary kiln
MFSK	Mixed Feed Shaft Kiln
MS	Member State
NACE	Classification of Economic Activities in the European Community
NAP	National Allocation Plan
OK	Other Kiln
PFRK	Parallel flow regenerative kiln
PRK	Pre-heater rotary kiln
PRODCOM	PRODuction COMmunautaire, EU product classification
PVC	Polyvinylchloride
WBCSD	World Business Council for Sustainable Development

Annex I Benchmarking in NAP for Phase II

Appendix I – A: Overview tables

The tables below summarize the information that could be found in the National Allocation Plans. Source are the National Allocation Plans and (parts of) internal European Commission English translations. Missing information was not specified in the National Allocation Plans.

A: Allowance
BAT = Best Available Technique
CCGT = Combined Cycle Gas Turbine
Elec = Electricity
HE = Historical Emissions
HP = Historical Production
IPPC = Integrated Pollution Prevention and Control

Benchmark	**AT (Austria)**
Valid for	Electricity (existing and new plants) Industry (new plants)
Basic formula used	-
Sectors included	-
Benchmark level	BAT
Data used for benchmark level	Electricity: 350 t CO_2/GWh, Heat: 175 t CO_2/GWh (with upper and lower caps for the potential factor (i.e. a measure for the ratio allocated to historical emissions)
Basis for activity level	Existing plants: Historical Production
Monitoring mechanism	-
Other remarks	-

Benchmark	**BE – W (Belgium Wallonia)**
Valid for	Electricity (existing and new plants) Industry (new plants only)
Basic formula used	Electricity: $A=HP_{elec}*400$
Sectors included	-
Benchmark level	Electricity (all): 400 t CO_2/GWh electricity Industry (new): BAT (BREF)
Data used for benchmark level	CCGT for the electricity production Industry: non specified
Basis for activity level	Electricity (existing): Historical production All (new): planned capacity and estimate (installed capacity times technology-specific load factor)
Monitoring mechanism	-
Other remarks	BAT as in BREF mentioned as basis for new entrants

Benchmark	**BE-F (Belgium Flanders)**
Valid for	Industry: existing and new plants Electricity: existing and new plants
Basic formula used	Electricity (existing): A=HPelec*359 Industry (existing): A= HE*factor based on benchmarking
Sectors included	Electricity Industry: all (over a certain threshold)
Benchmark level	Electricity: (new and existing plants): 359 t CO2/GWh electricity Industry: (existing): based on global best practice Industry (new): BAT
Data used for benchmark level	CCGT for the electricity production Benchmark covenant for the industry based on BAT (worldwide surveying).
Basis for activity level	Electricity (existing): standardised load factor for each technology/fuel Industry (existing): Historical emissions All (new): installed capacity times technology-specific load factor
Monitoring mechanism	own benchmarking agency
Other remarks	-

Benchmark	**(BG) Bulgaria**
Valid for	Electricity (new entrants only) Industry (new entrants only)
Basic formula used	-
Sectors included	-
Benchmark level	Electricity: 350t CO2/GWh Industry: BAT (not specified)
Data used for benchmark level	Electricity: CCGT
Basis for activity level	All (new entrants): IPPC permit and business plan
Monitoring mechanism	-
Other remarks	-

Benchmark	**(CY) Cyprus**
Valid for	Electricity (new entrants only) Industry (new entrants only)
Basic formula used	BAT energy consumption * Stated capacity * Fuel factor
Sectors included	-
Benchmark level	-
Data used for benchmark level	BAT (BREF)
Basis for activity level	All (new entrants): Stated capacity
Monitoring mechanism	-
Other remarks	-

Benchmark	**(CZ) Czech Republic**
Valid for	Electricity (public utility new entrants only)
Basic formula used	-
Sectors included	-
Benchmark level	CHP generated electricity: 430t CO2/GWh 7t CO2/GWh for district heating
Data used for benchmark level	REZZO database
Basis for activity level	-
Monitoring mechanism	-
Other remarks	-

Benchmark	**(DE) Germany**
Valid for	Energy sector (new entrants and existing installations) Industry (new entrants only)
Basic formula used	All (new entrants): A = standardised utilization*stated capacity*BM Electricity (existing): A = average production level in 2002-2005* BM
Sectors included	Electricity / Hot water / Steam Industry specific: Clinker / Recipient glass Flat glass / Clay bricks (2 types) / Roof tiles (2 types) Non-specified industry: BAT
Benchmark level	Electricity: 750 t CO2/GWh coal generated; 350t CO2/GWh natural gas generated Industry: see German NAP2 Annex 3; BAT for non-specified sectors
Data used for benchmark level	Own figures
Basis for activity level	All (new): 36 Standardised value (see German NAP2 Annex 4) Electricity (existing): historical production
Monitoring mechanism	-
Other remarks	-

Benchmark	**(DK) Denmark**
Valid for	Electricity sector (new entrants only) Industry sector (new entrants only)
Basic formula used	Direct: CO_2 per capacity installed (e.g. X CO_2e allowances per “tonne capacity per hour”)
Sectors included	See Denmark NAP2 Chapter 11.3
Benchmark level	Electricity: 1185tCO2/MWelec +359tCO2/MWheat Industry: own figures based on BAT and adjusted.
Data used for benchmark level	Unknown
Basis for activity level	All (new): Standard factors
Monitoring mechanism	-
Other remarks	-

Benchmark	(EL) Greece
Valid for	Electricity (new entrants only) Industry (new entrants only)
Basic formula used	-
Sectors included	-
Benchmark level	BAT for energy and based on fuel type
Data used for benchmark level	BAT (BREF)
Basis for activity level	All (new): Stated Activity level
Monitoring mechanism	-
Other remarks	-

Benchmark	(ES) Spain
Valid for	Electricity sector (existing plants and new entrants) Industry (only new entrants)
Type of benchmark	CO_2
Basic formula used	-
Sectors included	-
Benchmark level	Electricity: BAT (own value) Industry: BAT (BREF)
Data used for benchmark level	-
Basis for activity level	Electricity (all): standard factor Industry (new): estimate (capacity and average utilization factors in 2005)
Monitoring mechanism	-
Other remarks	-

Benchmark	(FR) France
Valid for	Electricity sector (existing plants and new entrants) Industry: new entrants and large N_2O emitting chemical plants
Basic formula used	-
Sectors included	-
Benchmark level	Coal power generation: 950tCO2/GWh Industry: N_2O emitters: national sectoral average New entrants CO_2 emitters: BAT (with least emitting fuel)
Data used for benchmark level	Own data for N_2O emitters
Basis for activity level	All (existing and new): forecasted production
Monitoring mechanism	-
Other remarks	-

Benchmark	(HU) Hungary
Valid for	Electricity sector (existing and new plants) Industry (new plants and existing cement plants)
Basic formula used	-

Sectors included	Electricity generation > 50MW Industry: existing cement plants / Lime industry All new entrants
Benchmark level	Electricity (existing): BAT (technology differentiated) Industry (existing): Cement plants: BAT (BREF) Lime sector : Sectoral average All (new): BAT (BREF)
Data used for benchmark level	BAT based on IPPC for cement plants. Lime industry allocation distributed as share of production (=average BM) based on the phase 1 data.
Basis for activity level	All (existing plants): Historical production All (new): Forecasted production
Monitoring mechanism	-
Other remarks	-

Benchmark	**(IE) Ireland**
Valid for	Electricity sector (new or recent plants; existing CHP plants) Industry (new or recent cement or lime plants)
Basic formula used	-
Sectors included	3 (Power generation, cement, lime)
Benchmark level	Electricity sector : CCGT for the electricity share of CHP plants Industry: BAT (non-specified)
Data used for benchmark level	Benchmarks developed by ICF
Basis for activity level	Existing recent plants: historical production Remainder: projected production
Monitoring mechanism	-
Other remarks	-

Benchmark	**(IT) Italy**
Valid for	Electricity sector (existing and new entrants) Industry (existing and new entrants)
Basic formula used	
Sectors included	Electricity sector (existing and new entrants) Industry: Existing plants: pulp & paper / glass / electric furnaces New entrants: all
Benchmark level	Electricity (existing and new): 350 t CO_2/GWh heat produced by cogeneration Industry (existing): Based on own data and with numbers given for 10th and 90th percentile (complex calculation). Industry (new): BAT (own)
Data used for benchmark level	-
Basis for activity level	All (existing): historical production Industry (new): forecasted production
Monitoring mechanism	-
Other remarks	-

Benchmark	(LT) Lithuania
Valid for	Electricity sector (new entrants only) Industry (new entrants only)
Basic formula used	Direct: CO_2 per capacity installed (e.g. X CO_2e allowances per “tonne capacity per hour”)
Sectors included	Electricity / heat / glass / ceramic / pilp and paper / mineral oil products / cement and lime / steel and cast iron
Benchmark level	Electricity (new): 2500 allowances per MW capacity. Heat: 600 allowances per MW capacity. Industry (new) own figures
Data used for benchmark level	-
Basis for activity level	-
Monitoring mechanism	-
Other remarks	-

Benchmark	(LU) Luxembourg
Valid for	Electricity sector (new entrants only) Industry (new entrants only)
Basic formula used	A=Utilization*Activity level*BM
Sectors included	Electricity / hot water / process steam / cement clinker / flat glass / container glass / clay bricks / roof tiles
Benchmark level	Electricity: 365 t CO_2/GWh Industry: conform NAP2 Table 8
Data used for benchmark level	Study
Basis for activity level	All (new): Standardised factors
Monitoring mechanism	-
Other remarks	-

Benchmark	(LV) Latvia
Valid for	Electricity sector (new entrants only) Industry (new entrants only)
Basic formula used	
Sectors included	Electricity sector (new entrants only) Industry (new entrants only)
Number of benchmarks	
Benchmark level	Electricity (new): 80% fuel utilization factor for coal based cogeneration. 40% efficiency for coal based generation. 85% fuel utilization factor for natural gas based cogeneration. 50% efficiency for natural gas based generation
Data used for benchmark level	Based on the methodology and figures from 2004/156/EC
Basis for activity level	All (new): Estimate based on the technical capacity and the market
Monitoring mechanism	
Other remarks	

Benchmark	**(MT) Malta**
Valid for	Electricity sector (new entrants only) Industry (new entrants only)
Basic formula used	-
Sectors included	-
Benchmark level	BAT for the type of fuel/generation
Data used for benchmark level	BAT (BREF)
Basis for activity level	-
Monitoring mechanism	-
Other remarks	-

Benchmark	**(NL) The Netherlands**
Valid for	Electricity sector (existing and new entrants) Industry sector (new entrants and existing plants taking part in the BM covenant)
Basic formula used	Existing plants: A=Historical emissions*Relative energy efficiency
Sectors included	Power generation CO_2 Industrial sectors CO_2 (all) Nitric acid production N2O
Benchmark level	Electricity(all): Fuel specific Nitric acid (all): 1.8kg N2O/t. Industry (new): BAT Industry (existing) : index based on the relative energy efficiency
Data used for benchmark level	Distance to the BAT on a worldwide basis
Basis for activity level	All (existing): Historic production level*growth rate All (new): standardised factors
Monitoring mechanism	Dutch Benchmarking Verification Agency
Other remarks	The Netherlands benchmarks a very large number of processes and is the only country in the EU to have accumulated such a long experience in benchmarking.

Benchmark	**(PL) Poland**
Valid for	Electricity sector (new entrants and existing plants) Industry (new entrants and existing plants)
Type of benchmark	Electricity sector: SOx emissions based Industry: CO_2
Basic formula used	-
Sectors included	Electricity and CHP Industrial sectors: Refining / Coking / Iron & Steel Cement / Lime / Paper / Glass / Ceramic / Chemical Sugar
Benchmark level	Industry (all): New plants: KASHUE (own procedure) Existing plants: calculated based on national data and negotiated on a sectoral basis.
Data used for benchmark level	Industry: own data
Basis for activity level	Industry (existing): Historical production & production forecast Industry (new): permit & production forecast
Monitoring mechanism	-
Other remarks	-

Benchmark	**(RO) Romania**
Valid for	Electricity sector (new entrants only) Industry sector (new entrants only)
Basic formula used	-
Sectors included	-
Benchmark level	BAT (non-specified)
Data used for benchmark level	-
Basis for activity level	All (new): production forecast
Monitoring mechanism	-
Other remarks	-

Benchmark	**(SI) Slovenia**
Valid for	Electricity sector (new entrants and existing plants) Industry (only new plants)
Basic formula used	-
Sectors included	-
Benchmark level	Electricity (existing): Fuel specific benchmark. Electricity (new): 0.2tCO$_2$/MWh heat; 0.35tCO$_2$/MWh electricity Industry (new): BAT (BREF).
Data used for benchmark level	-
Basis for activity level	All (existing): Historical production
Monitoring mechanism	-
Other remarks	-

Benchmark	**(SK) Slovakia**
Valid for	Electricity (existing plants) Industry (existing cement plants)
Basic formula used	Historic average – no further information
Sectors included	-
Benchmark level	Cement: 0.64 tCO$_2$e/t grey cement (1.1 for white cements)
Data used for benchmark level	All (existing): Historical emissions and production levels.
Basis for activity level	-
Monitoring mechanism	-
Other remarks	-

Benchmark	**(SE) Sweden**
Valid for	Electricity sector (recent and new plants) Industry (only primary steel – existing installations)
Basic formula used	-
Sectors included	-
Benchmark level	Electricity (new) 337tCO2/GWh electricity and 118tCO2/GWh heat Steel (existing): 1.91 t CO2 / t steel ingot
Data used for benchmark level	Electricity: Own BAT Steel: EU wide average
Basis for activity level	All (existing): historical production Industry (existing): production forecast
Monitoring mechanism	-
Other remarks	-

Benchmark	**(UK) United Kingdom**
Valid for	Large electricity producers (new and existing) Industry (new entrants)
Basic formula used	Complete calculation spreadsheets available in a transparent manner. (See Annexes to UK NAP2)
Sectors included	-
Benchmark level	All: Own calculated levels, close to BAT.
Data used for benchmark level	Benchmarks established through several studies.
Basis for activity level	Electricity (existing): historical levels All (new): standardised factor
Monitoring mechanism	-
Other remarks	The UK is the only country having provided a large transparent and detailed benchmarking effort.

Appendix I – B: Quantitative figures on emission benchmarks from the National Allocation Plans (abbreviations given at the end of the appendix)

Table 36 Selected Benchmarks for CO_2 emissions from National Allocation Plans

	DE	DK	IT	LT	LU	Other	UK
	A=C*U*EF				A=C*U*EF		
Cement	0.315[1]; 0.285[2]; 0.275[3] tCO_2/t.o. clinker + 0.53 t process emissions[4] U: 7500/8760	5469/t.c.h. of grey cement 7764/t.c. of white cement per hour		7104/t.c.h. of grey cement[5] 9000/t.c.h. of white cement[6]	0.280 t CO_2/t.o. clinker + process emissions U:7500/8760	0.28 tCO2/ t.o. cement (fuel emissions only) (Slovenia) 0.64 tCO2/ t.o. grey cement (Slovakia) 0.64 tCO2/ t.o. white cement	6439/t.c.h. clinker A=U*EF*C U=0.95*330/365=0.859 EF=0.856 t CO_2/t clinker[7]
Hard burnt brick	0.115 tCO_2/t.o.				0.095 tCO_2/t.o.		Product differentiated
	U: 7500/8760				U:7500/8760		Product differentiated

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[1] For plants with 3 stage preheaters

[2] For plants with 4 stage preheaters

[3] For plants with 5/6 stage preheaters

[4] Agreed upon between the German government and the industry (see VDZ 2005"Development of CO2 benchmarks for cement clinker production within the EU ETS in Germany")

[5] Based on 296tCO_2/t of grey cement per unit of formal capacity (most likely expressed in t.p.d.)

[6] Based on 375tCO_2/t of white cement per unit of formal capacity (most likely expressed in t.p.d.)

[7] Based on process emissions of 0.532tCO_2/t clinker

Liming brick	0.065 tCO_2/t.o. 7500/8760						
Roof tile (H Shape)	0.130 tCO_2/t.o. 7500/8760				0.150 tCO_2/t.o. U:7500/8760		0.139 tCO_2/t.o.
Roof tile (U Shape)	0.158 tCO_2/t.o. 7500/8760						
Glass (container)	0.280 tCO_2/t.o. U: 8000/8760	1191/t.c.h. glass	0.30 tCO_2/t.o.[8]	1704/t.c.h. of glass products[9]	0.280 tCO_2/t.o. U:7500/8760		EF=0.3315tCO_2/t.o. U=0.85 Efficiency adjustment factor=0.955 Scope of scheme adjustment factor=1.04 *(assumptions used)*[10]
Glass (flat)	0.510 tCO_2/t.o. U: 8000/8760		0.6411 tCO_2/t.o.		0.510 tCO_2/t.o. U:7500/8760		EF=0.5534tCO_2/t.o. Efficiency adjustment factor=0.955 Scope of scheme adjustment factor=1.04 U=0.85 *(assumptions used)*[11]

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[8] As found in table 5.3 of the courtesy translation for the top 10%

[9] Based on 71tCO_2/t of glass product per unit of formal capacity (most likely expressed in t.p.d.)

[10] Emissions for the UK glass sector take a zero load factor into account

[11] Emissions for the UK glass sector take a zero load factor into account

Mineral wool and insulating substances		344/m^3c light clinker per hour 2130/t.c.h. light wool		U:7500/8760	Differentiated according to the installations involved. U=0.91
Glass wool		1153/t.c.h.	1824/t.c.h. of fiberglass[12]	U:7500/8760	
Ceramics		704/t.c.h. fired goods	1056/t.c.h. of combusted ceramic products[13]	U:7500/8760	
Lime/chalk/limestone	U:7500/8760	7499/t.c.h. lump lime per hour 6949/t.c.h. burnt lime per hour 304/t dried bentonite per hour	8760/t.c.h. of lime[14]	U:7500/8760	Product differentiated Range from 7524/t.c.h. (high calcium lime) to 14145/t.c. for dead burnt dolomitic[15] U=(330/365)*0.95
Gypsum		4024/m^2c plasterboard per hour			Further differentiated

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[12] Based on 76CO_2/t of fiberglass per unit of formal capacity (most likely expressed in t.p.d.)

[13] Based on 44tCO_2/t of combusted ceramic products per unit of formal capacity (most likely expressed in t.p.d.)

[14] Based on 365tCO_2/t of lime per unit of formal capacity (most likely expressed in t.p.d.)

[15] See table 5

Lime in the sugar industry	U:2500/8760				U:2500/8760	
Pulp and paper	U:8000/8760 (pulp, paper & cardboard)	196/ t.c.h. (recycled paper for) pulp 2679/t.c.h. pulp for paper	Pulp: 0.308 t CO_2/t.o. Paper: 0.370 t.CO_2/t.o. Cardboard:0.286 t CO_2/t.o.	384/t.c.h. of cellulose, produced from wood or other fibrous material[16] 2048/t.c.h. of paper, producing paper and cellulose[17]	U:7500/8760	Based on the rated thermal capacity from manufacturer specifications (no standard product benchmarking).[18]
refining and distilling of mineral-oil products	U:8000/8760	724/ t.c.h. refined finished products		1104/t.c.h. of oil products[19]	U:7500/8760	A=C[20]*SEC[21]*U*EF/1000 With: U:0.95 EF=0.358tCO_2/MWh for catalytic cracking units EF=0.211tCO_2/MWh for other unit SEC=0.3MWh fuel/t net throughput (for all products)

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[16] Based on 16tCO_2/t of cellulose, produced from wood or other fibrous material per unit of formal capacity (most likely expressed in t.p.d.)

[17] Based on 128tCO_2/t of paper, producing paper and cellulose per unit of formal capacity (most likely expressed in t.p.d.)

[18] See specific spreadsheet for the availability, utilization and efficiency factor

[19] Based on 46tCO_2/t of oil products per unit of formal capacity (most likely expressed in t.p.d.)

[20] Capacity in tones per annum.

[21] Benchmark specific energy consumption from the unit as given by the Solomon certificate (in kWh fuel/t throughput).

Steam cracker							7328tCO_2/t.c.h. ethylene
Onshore gas compressor calculation							Based on the shaft output and the heat rate at 100%, 75% and 50% load.(see table 2)
Onshore Gas LNG import terminal							U:0.56 A=EF*U*193 t CO_2 per t.c.h. throughput
Offshore installations							Differentiated
Metal founding	U:8300/8760	196/t.c.h. of pig iron		3600/t.c.h.[22]	U:7500/8760		
Production of cast iron from EAF			0.1098 t CO_2/t.o.				From 0.055 to 0.090 t CO_2 per t.c. liquid steel per year[23]. U: 0.85[24] or 0.79[25]
Steel from EAF			0.05179 t CO_2/t.o.				
Steel from ore (primary steel)						1.91 tCO_2/t.o. steel ingot[26] U: n.a. (Sweden)	Calculation of allowances for integrated steel mills based on the product mix and the processes involved. U: 0.92 (applies to all)[27]
Coking plants	U:8300/8760				U:7500/8760		
Sintering plants	U:8300/8760				U:7500/8760		

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[22] Based on 150tCO_2/t of steel and cast iron production per unit of formal capacity (most likely expressed in t.p.d.)

[23] Based on the "EU ETS Phase II New Entrants" report

[24] For EAF plants producing only "plain low carbon steel"

[25] For EAF plants not only producing "plain low carbon steel".

[26] Based on a European level of steelworks with integrated cogeneration. Data from CITL, International Iron and Steel Institute (IISI) and the European Blast Furnace Committee (EBFC)

[27] Factors used for the calculation available in the spreadsheet "Integrated Steel Data", recovered from: http://www.defra.gov.uk/environment/climatechange/trading/eu/phase2/pdf/nap-appendix-d1-new-entrant-benchmark-spreadsheet.xls

Table 37 Benchmarks for further products in Denmark

Product type	Benchmark emissions (tCO_2/ product)
Greenhouses	0.096/m²
Evaporating and drying saline solutions	34/t.c.h. dry salt 412/t.c.h. undry salt
Dry milk based products	2198/t.c.h. milk powder per hour 3435/t.c.h. protein per hour
Feedstuff (for animals)	20/t.c.h. feedstuff per hour
Meal powder	343/t.c.h flesh and bone meal
Green pellets and green meal	798/t.c.h. green pellets and green meal
Pectine and emulsifier	1766/t.c.h. pectine 638/t.c.h. emulsifier
Distillation of alcohol	491/m³c pure alcohol per hour (o)
Drying and evaporation of pulp and paper	0/t.c.h. pulp
Raw materials for fish oil and fishmeal production	343 /t.c.h. raw materials for fish oil and fishmeal production
Beet- and cane sugar	684/t.c.h. beet sugar
Starch	76/t.c.h. of potato flour 1805/t.c.h. of potato protein powder
Drying an roasting of malt	424/t.c.h. malt

Table 38 Benchmarks for lime emissions in the UK

Product type	Benchmark emissions (tCO_2/t lime product)
High calcium lime	1.00
High calcium lime – Size specific for steel sector	1.09
High calcium lime – ultra pure	1.31
Light burnt dolomitic	1.33
Dead burnt dolomitic (Dolofrit)	1.91
Dead burnt dolomitic (Dolopel)	1.88
Precipitated calcium carbonate – lime kiln	0.20
Precipitated calcium carbonate – product drier	0.08

t.c.h.: tonnes of capacity per hour
t.o.: tonnes of output
m³c: m³ capacity
m²c: m² capacity
tpd: tonnes per day
U: utilization factor (without unit)
EF: emission factor
C: capacity
A: Allowances (in tonnes CO_2e / year)
(o): reference to a real output

Appendix I – C: Selected heat consumption levels mentioned in the relevant BREFs

Activity	Specific heat consumption. Where the value is mentioned in the BAT conclusion chapter of the BREF, this is indicated with an *, in other cases the values are taken from the "typical emission and consumption levels" chapter
BREF CLM (2001)	
Production of cement clinker	2900-3200 MJ / t of clinker (5 stage pre-heater and precalciner), 3000 MJ / t of clinker* for new installations
Production of lime	3600-4200 MJ / t of lime (parallel-flow regenerative shaft kiln)
BREF glass (2001)	
Production of container glass	3.2-12.2GJ / t (Melting only, including boosting). Most plants in the range of 4.5…7GJ/t
Production of container glass	5.5 to 8.0 GJ /t (Melting only) SEC for the process generally lower than 8.0 GJ
Glass fibre	15.9.0GJ / t…27.7 GJ / t (does not include nor the heat of the stack neither the energy from utilities)
Glass wool	11 to 22 GJ / t
Stone and slag wool	7 to 18 GJ / t
BREF P&P (2001)	
Selection of values	
Non-integrated bleached kraft pulp	10 – 14 GJ / t*
Integrated bleached kraft pulp and uncoated fine paper	14 – 20 GJ / t*
Integrated kraftliner, unbleached	14 – 17.5 GJ / t*
Integrated sack-paper, unbleached	14 – 23 GJ / t*
Non-integrated bleached sulphite pulp	16 – 18 GJ / t*
Integrated bleached sulphite pulp and coated fine paper	17 – 23 GJ / t*
Integrated bleached sulphite pulp and uncoated fine paper	18 – 24 GJ / t*
Integrated mechanical pulp paper production	-1.3 – 13 GJ / t* (depending on type)
Test liner from recovered paper	6 – 6.5 GJ / t*
Carton board from recovered paper	8 - 9 GJ / t*
Newsprint from recovered paper	4 – 6.5 GJ / t*
Tissue from recovered paper	7 – 12 GJ / t*
BREF ceramics (2007)	
Masonry bricks	1.02-1.87 GJ / t
Facing bricks	2.87 GJ / t
Roof tiles	1.97…2.93 GJ / t
BREF refineries (2003)	
Main processes only	
Total energy consumption in refineries	1.7 to 5.4 GJ / t of crude oil processed

Activity	**Specific heat consumption. Where the value is mentioned in the BAT conclusion chapter of the BREF, this is indicated with an *, in other cases the values are taken from the "typical emission and consumption levels" chapter**
Coking process in refineries	800-1200 MJ / t
Primary distillation	400 – 680 MJ / t
	400 – 800 MJ / t
BREF I&S (2001)	
Selection of values	
Iron making – Direct reduction	10.5 GJ / t
	12.6 GJ / t
Iron making – BF route	17-18 GJ / t

Annex II Match between Annex I activities and the NACE classification

The industrial activities separately identified in Annex I of the Commission proposal for a revised directive could in principle be related to the NACE (rev 1.1) classification of industrial activities used in the European Union[79]. In the NACE classification, industrial activities are classified using a 4-digit level classification. In Table 39, we compare the Annex I of the proposed revised directive with the corresponding NACE (rev 1.1.) four digit classification numbers. Industrial activities included in the ETS only because of the operation of combustion installations are not listed. These could be found in principle in all sectors of manufacturing, but also in agriculture (e.g. greenhouses) and services (universities, hospitals, big office buildings etc.).

Table 39 Categories of activities under the amended Annex I of the Commission proposal for a revised EU ETS and corresponding NACE codes

Annex I activities	NACE code	Description
Mineral oil refineries	2320	Manufacture of refined petroleum products
Coke ovens	2310	Manufacture of coke oven products
Metal ore (including sulphide ore) roasting or sintering installations	2710	Manufacture of basic iron and steel
Installations for the production of pig iron or steel (primary or secondary fusion)	2710	Manufacture of basic iron and steel
Production and processing of ferrous metals (including ferro-alloys), including rolling mills, reheaters, annealing furnaces, smitheries, foundries coating and pickling	2710	Manufacture of basic iron and steel
	272	Manufacture of tubes¹
	273	Other first processing of iron and steel²
	2751	Casting of iron
	2752	Casting of steel
Production of aluminium (primary and secondary)	2742	Aluminium production
Production and processing of non-ferrous metals, including production of alloys, refining, foundry casting etc.	2741	Precious metals production
	2743	Lead, zinc and tin production

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[79] The new updated NACE 2 is coming into use more and more.

Annex I activities	**NACE code**	**Description**
	2744	Copper production
	2745	Other non-ferrous metal production
	2753	Casting of light metals
	2754	Casting of other non-ferrous metals
Installations for the production of cement clinker in rotary kilns or lime including the calcination of dolomite and magnesite	2651	Manufacture of cement
	2652	Manufacture of lime
	2653	Manufacture of plaster
Installations for the manufacture of glass including glass fibre	261	Manufacture of glass and glass products[3]
Installations for the manufacture of ceramic products by firing	262	Manufacture of non-refractory ceramic goods other than for construction purposes; manufacture of refractory ceramic products[4]
	2630	Manufacture of ceramic tiles and flags
	2640	Manufacture of bricks, tiles and construction products, in baked clay
Installation for the manufacture of rock wool or stone wool	2682	Manufacture of other non-metallic mineral products
Installation for the drying or calcination of gypsum or for the production of plaster boards and other gypsum products	2682	Manufacture of other non-metallic mineral products, not elsewhere classified
Production of carbon black	241	Manufacture of basic chemicals[5]
Production of nitric acid	241	Manufacture of basic chemicals[5]
Production of adipic acid	241	Manufacture of basic chemicals[5]
Production of glyoxal and glyoxilic acid	241	Manufacture of basic chemicals[5]
Production of ammonia	241	Manufacture of basic chemicals[5]
Production of basic organic chemicals by cracking, reforming, partial or full oxidation or by similar processes	241	Manufacture of basic chemicals[5]
Production of hydrogen (H_2) and synthesis gas by reforming or partial oxidation	241	Manufacture of basic chemicals[5]
Production of soda ash (Na2CO3) and sodium bicarbonate (NaHCO3)	241	Manufacture of basic chemicals[5]
Production of pulp from timber or other fibrous materials	211	Manufacture of pulp
Production of paper and board	211	Manufacture of pulp, paper and paperboard

[1] 2721 cast iron tubes, 2722 steel tubes

[2] 2731 cold drawing, 2732 cold rolling of narrow strip, 2733 cold forming or folding, 2734 wire drawing

[3] 2611 flat glass, 2612 shaping and processing of flat glass, 2613 hollow glass, 2614 glass fibres, 2615 other glass

[4] 2621 ceramic household and ornamental articles, 2622 ceramic sanitary fixtures, 2623 ceramic insulators and insulating fittings, 2624 other technical ceramic products, 2625 ceramic products, 2626 refractory ceramic products

[5] 2411 industrial gases, 2412 Dyes and pigments, 2413 inorganic basic chemicals, 2414 organic basic chemicals, 2415 fertilizers and nitrogen compounds, 2416 plastics in primary forms, 2417 synthetic rubber in primary forms

Annex III Summary stakeholder meeting

On 2 July 2008, a second interim report of this study was presented to stakeholders from the four selected industrial sectors iron and steel, pulp and paper, lime and glass. The attendants did not receive the interim report before the meeting, but received a power point presentation highlighting the recommended allocation principles (Chapter 4) and the key design choices per sector (Chapter 6 – 9) in the form in which they were included in the second interim report. At the meeting, this presentation was given.

In addition to the stakeholder meeting, there have been various interactions with representatives from the four sectors.

Below is a brief summary of the stakeholder meeting:

- Several industry representatives stressed the importance of the correction factor in relation to the acceptability of stringent (e.g. Best Available Techniques and a low-carbon fuel mix) emission benchmarks.
- There was consensus on the use of historical production data in the allocation for existing installations rather than allocation based on capacity and capacity utilization factors, also because the parameter 'capacity' is not well defined for existing installations.
- The availability of the required production data to apply a product-benchmark based allocation methodology is not regarded a major problem. Confidentiality issues related to this data might also be limited, because the data are already outdated at the moment they are used.
- All industry representatives stressed that using a single fuel mix for all installations producing a certain product has a strong distributional effect between Member States and for this reason has a strong fuel policy related dimension. Representatives from the iron and steel sector disagreed with the benchmark approach based on two-end products (flat and long). In this final report, the approach using benchmarks for two end-products is not used anymore.
- They announced that the sector was in the course of developing its own approach. The BREF for Iron and Steel contains only indicative figures and can therefore not directly be used.
- Representatives from the pulp and paper industry agreed with the allocation principles as a 'first line of thinking' and with the principle idea of having separate benchmarks for pulp, recycled paper processing and paper production. They stressed that the number of products to distinguish should be open for discussion once the allocation formula remains the same and that many specific choices are still to be made. The BREF for Pulp and Paper is regarded a useful document that should at least be used as a reference in determining best practice benchmark values.

- Representatives from the glass industry indicated that the number of products to distinguish should be open for discussion. A simple allocation mechanism should still correct for fuel mix (see also general remarks made by all representatives) and share of cullet. The glass industry currently undertakes benchmarking efforts that could be a useful contribution to the process.
- Representatives from the lime industry indicated a preference for technology rather than product-specific benchmarks and for using industry average rather than best available technique as reference. They indicated that the need to process limestone efficiently (e.g. both large and small pebbles and also limestone of different quality) makes it impossible to produce all lime with the most efficient vertical kiln technology. From ongoing benchmarking efforts, there is a lot of information available on the performance of lime kilns in the EU.