In 2011, DG Climate Action contracted a consortium of consultants to assist it in the preliminary work for the preparation of the methodology for the determination of the new carbon leakage list valid for 2015-2019. The work was carried out in 2011-2012.

This resulting report is here published for information purposes only. It is a useful overview of the policy landscape and clarifies some practical and technical details. It has to be noted that the proposed methodologies are by no means binding for the Commission. They constitute preliminary mapping work which could serve as a basis for input to the methodology used to determine the new list. The criteria for the new list remain the same as detailed in the ETS Directive. Where some discretion is possible; the assumptions will be subject to an Impact Assessment.

This study is a property of the Commission, but it does not constitute a Commission document. It cannot be quoted as expressing Commission position.

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sustainable energy for everyone

Support to the Commission for the determination of the list of sectors and subsectors deemed to be exposed to a significant risk of carbon leakage for the years 2015-2019 (EU Emission Trading System)

Final report

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1 Introduction

The aim of the EU Emissions Trading Scheme (ETS) is to reduce the greenhouse gas emissions of the European Union in an effective and cost efficient way. The scheme has been revised and extended since its start in 2005. The EU ETS is worldwide unique in terms of activities and emissions covered, as it includes emissions from combustion installations and from industrial processes.

While the first and second trading period (2005 - 2012) were largely characterised by free allocation to industry sectors, the 2009 revised directive states that from 2013 onwards auctioning should be the basic principle for allocation. This requirement also introduces the concept of carbon leakage: the risk that companies move outside Europe due to increased costs, thus leaking emissions outside of the EU cap, possibly producing there at lower efficiencies. The EU ETS has provoked considerable debate about the existence of carbon leakage.

Carbon leakage can be quantified in terms of a leakage rate, which is calculated as the increase in foreign emissions divided by the decrease in domestic emissions due to the climate policy considered. The term indicates the share of emission reductions that are 'lost' as a consequence of carbon leakage. There are several channels of sector-led carbon leakage initiated by uneven carbon constraints, which include (Reinaud, 2008)[1]:

- **Short term competitiveness channel**: 'Where carbon constrained industrial products lose international market shares to the benefit of unconstrained competitors'.
- **Investment channel**: 'Where differences in returns on capital associated with unilateral mitigation action provide incentives for firms to relocate capital to countries with less stringent climate policies'.
- **Fossil fuel price channel**: 'Where reduction in global energy prices due to reduced energy demand in climate constrained countries triggers higher energy demand and CO_2 emissions elsewhere, all things being equal'.

Carbon leakage via these channels may be associated with a detrimental impact on the competitiveness of firms covered by the EU ETS and may undermine its environmental integrity. However, the impact on international competitiveness and the resulting risk and extent of carbon leakage is not uniform and further depends upon other factors, such as trade regulations, transport costs, quality of the product, market position (monopoly, oligopoly), company structure (multinational vs. national firm), employment policy and costs. In light of these factors, producers may well be able to pass through their climate policy induced costs without losing a significant market share. The fossil fuel price channel is independent of competitiveness or location concerns and only has an environmental effect. To reduce distortions in competitiveness, two preventative measures are examined in the literature, free allocation and border measures. Both

[1] Reinaud, J. (2008): Issues behind competitiveness and carbon leakage. Focus on Heavy Industry. OECD/IEA Information Paper.

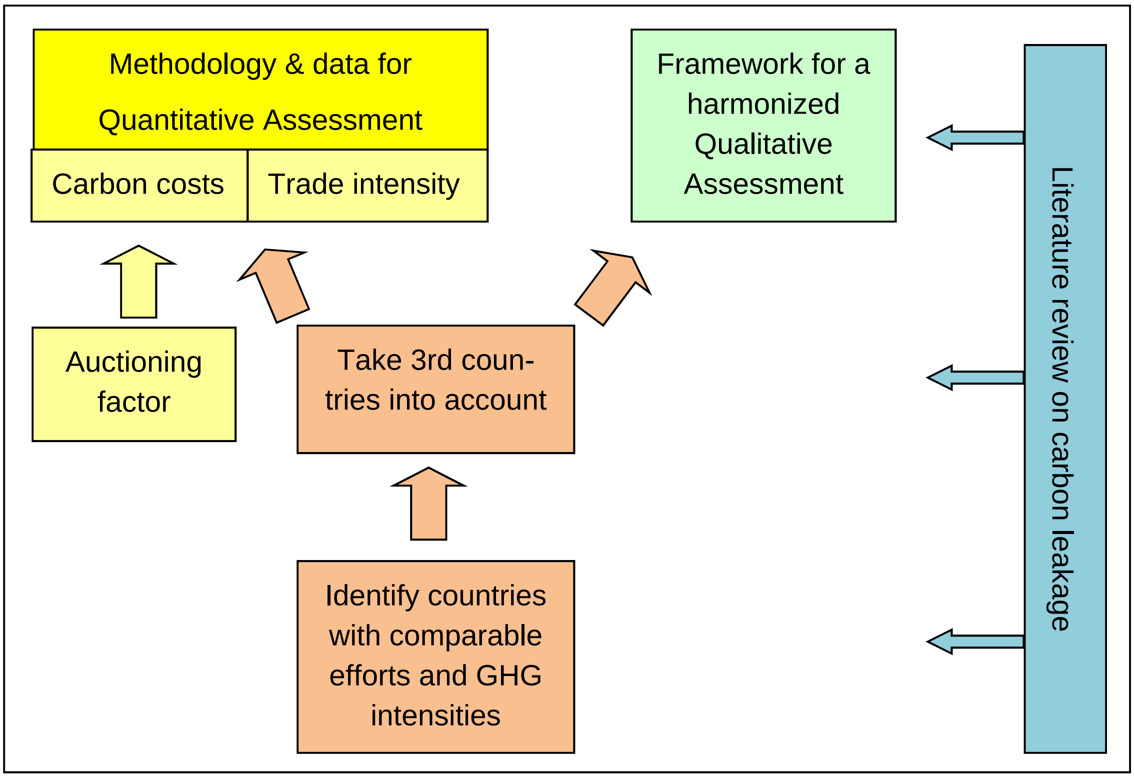
have been assessed to reduce the risk of carbon leakage, however, their mechanisms and the extent of their economic effects differ.

The Commission is required to determine a list of sectors or sub-sectors deemed to be exposed to a significant risk of carbon leakage. The list of sectors at risk of carbon leakage is based on a quantitative analysis which may be supplemented by a qualitative assessment for specific sectors. The sectors on this carbon leakage list are entitled to receive full free allocation based on a benchmarking scheme compared to sectors not at risk of carbon leakage that receive a lower and decreasing share of their benchmark emissions. This implies that in the sectors at risk of carbon leakage the most efficient installations receive for free the amount of allowances required to cover their emissions. In 2009, the Commission established the general methodology on the occasion of the first carbon leakage list, which applies for the years 2013 and 2014. To determine the second list, which will apply for the years 2015-2019, the Commission will need to take into account updated information. The aim of the work carried out under Service Contract No 07.1201/2011/599024/SER/CLIMA.C2 is to provide support to the Commission in preparing the general revision of the list of sectors or sub-sectors that are deemed to be exposed to a significant risk of carbon leakage both in terms of qualitative and quantitative assessment and to monitor research activities in this area. This report provides the final report of the project. It is organised around four research areas (see colour coding in Figure 1).

A **methodology for the update of the quantitative assessment** is developed and data sources needed to calculate trade intensity and induced carbon cost by the implementation of the EU ETS were scrutinized. Two methods to derive sector-specific auctioning factors are elaborated in order to quantify the amount of allowances industrial sectors need to purchase on average if not deemed to be exposed (see chapter 2).

The **qualitative assessment** of sectors deemed at risk of carbon leakage may supplement the quantitative assessment of sectors which are not sufficiently represented in the quantitative assessment or considered to be borderline cases. A proposal for a harmonised framework for qualitative assessments is elaborated in chapter 3.

Figure 1: Overview of the work areas covered by the project



With respect to **international considerations**, the carbon leakage list shall be determined after taking into account the extent to which third countries firmly commit to reducing greenhouse gas emissions in the relevant sectors and the extent to which they show comparable carbon efficiency to that of the EU. Chapter 4 provides an extensive assessment of the commitments of key countries and their carbon efficiency and develops ways to reflect those commitments in the carbon leakage assessment.

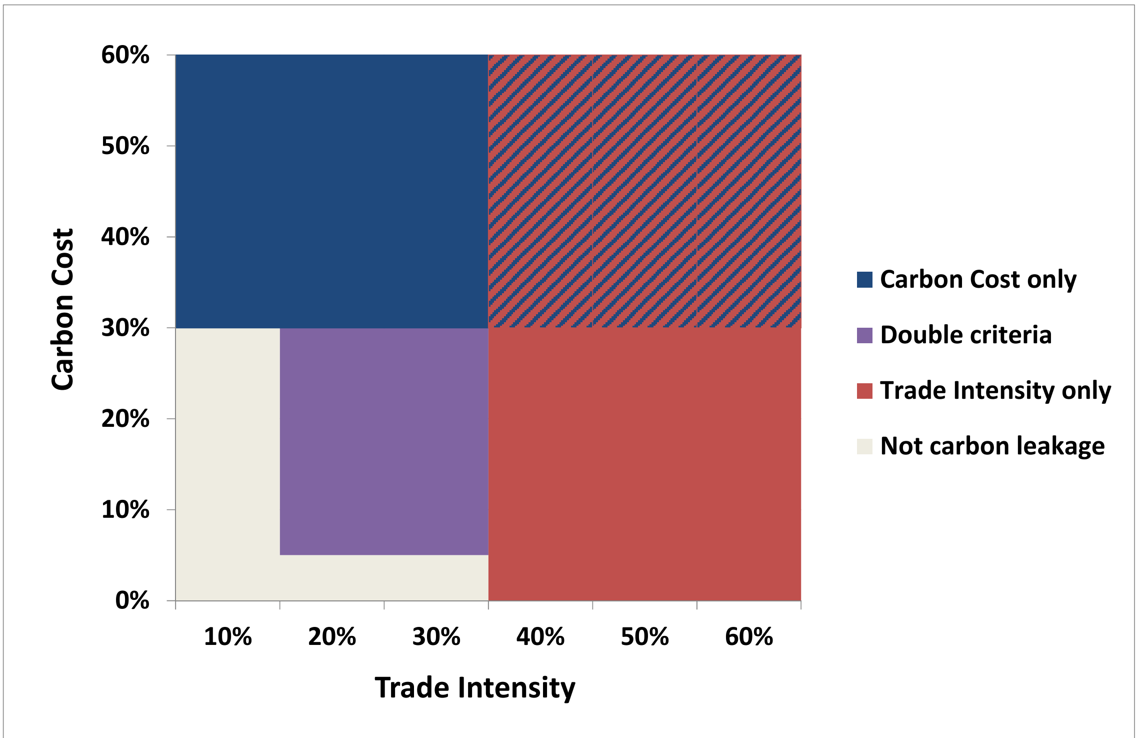
The work is accompanied by a **literature survey** on studies and other relevant information with regards to competitiveness effects and the risk of carbon leakage. Both the methodologies applied in the literature and the results obtained with these methodologies are discussed and if possible compared to each other (see chapter 5).

The findings are summarised in chapter 6. The detailed reports are to be found in the Annexes (see overview in chapter 7).

2 Methodology and data for the quantitative carbon leakage assessment

The revised EU ETS directive establishes two quantitative indicators which should be assessed to evaluate the risk of carbon leakage: Trade Intensity and additional cost induced by the implementation of the EU ETS (induced carbon cost – ICC). Sectors are included in the list if induced carbon costs are above 5% and trade intensity above 10% or either of them is above 30% (see Figure 2 below). For sectors not qualifying according to the quantitative criteria, a qualitative assessment might be carried out (see chapter 3).

Figure 2 Indicators for the quantitative carbon leakage assessment



Note: Coloured areas depict a significant risk of carbon leakage according to the provisions in the EU ETS Directive.

The analysis builds on the experiences made in the first assessment carried out in 2009 and valid for the years 2013-2014. It aims at providing the Commission with an overview how the quantitative carbon leakage assessment can be updated and which data sources are required concentrates on the improvement of those aspects which posed difficulties in the past.

The potential data sources required for the quantitative assessment are evaluated according to their quality. Quality criteria include:

- Availability, also for future updates of the carbon leakage list;
- Reliability, therefore verified or official data is given preference; and

- Consistency: as few sources as possible to avoid gaps/double counting.

Trade Intensity

Trade Intensity is defined as the ratio of imports and exports in relation to the domestic market (EU turnover + imports). The indicator of Trade Intensity is calculated using the following formula:

$$TradeIntensity = \frac{Imports + Exports}{Turnover + Imports}$$

Therefore information on the value of trade (imports and exports) and turnover is required. Turnover represents the domestic production within the EU.

For the trade intensity indicator it is recommended to keep the approach of the first carbon leakage assessment and use the same data sources. Trade and production data is provided by Eurostat in the Comext data base in the Statistical classification of products by activity (CPA), which has the same numerical codes at 4-digit level as the Statistical Classification of Economic Activities in the European Community (NACE). Where gaps in production data occur, Eurostat Structural Business Statistics (SBS) turnover data can be used, which is reported using NACE classification.

The Comext data can be used to carry out the trade intensity assessment at a very disaggregated level, moving beyond the 3-to 4-digit level required by the directive. This is not recommended as a general approach because it might produce misleading results for intermediate products which are not consistently valuated and reported. Furthermore the number of installations falling under the ETS directive may be very small and therefore not representative when moving to a very detailed level of assessment.

Induced carbon cost

The indicator of induced carbon cost is the sum of direct and indirect additional costs induced by the implementation of the emissions trading scheme, calculated as a proportion of value added in the sector:

$$InducedCarbonCost = \frac{DirectCosts + IndirectCosts}{GVA}$$

$$= \frac{(DirectEmissions * AuctioningFactor + ElectricityCons. * EmissionFactor) * CarbonPrice}{GVA}$$

Direct costs are the product of emissions covered by the ETS for which the installations receive no free allocation and the carbon price. They are expressed as the product of direct emissions and the share to be purchased (auctioning factor). Indirect emissions result from the increase of electricity prices due to the ETS. This is assessed using the average emission factor of electricity production and an estimated carbon price. Data sources should thus include data on direct and indirect emissions, auctioning factor, GVA and carbon price; several data sources have to be tapped to collect the required information.

Direct Emissions

For all industrial sectors covered by the ETS directive already in the base period; direct emissions (energy as well as process related) can be based on the values reported in the EU ETS registry (Community Transaction Log (CITL) and its successor European Union Transaction Log (EUTL)). Direct emissions of activities entering the EU ETS from 2013 onwards can be based on the application for free allocation (National Implementation Measures – NIMs). The NIMs can also provide the statistical classification codes (NACE) for individual installations.

Indirect Emissions

Indirect emissions are computed by multiplying the net electricity purchased from the grid for own use with a CO_2 emission factor for electricity. There is no European source for electricity purchased by industrial sectors for own consumption. In the last assessment Member States were asked to collaborate in the data gathering exercise and Eurostat assisted the Commission in calculating the value respecting confidentiality concerns. This approach is recommended to be followed again.

There are several approaches to calculate the CO_2 emission factor for electricity: average emissions of total generation; of fossil electricity generation only; the marginal electricity generation and marginal built capacities. For the purpose of the Carbon Leakage assessment it is recommended to employ the average emissions of total generation in the base period; the other approaches cannot reflect the effects of increasing renewable energy generation on electricity prices and their CO_2-component. The emission factor can be based on IEA statistics or can be calculated based on Eurostat and EU GHG inventory data. The fuel input to CHP plants has to be attributed to electricity and heat in order to be able to calculate an electricity only emission factor.

Auctioning factor

The Auctioning Factor (AF) represents the share of direct emissions for which a sector needs to buy allowances on the market if it was not exposed to a significant risk of carbon leakage. In the previous carbon leakage assessment for 2013-2014, a generic industry-wide value of 75% has been used.

In the project two methodologies to determine sector-specific auctioning factors were explored: called the “non-public NIM” method and the “product benchmark” method. The advantage of a sector-specific value is the higher accuracy and higher transparency of the auctioning factor. These advantages come at the cost of a higher effort to determine the value. Regardless of which method is chosen, the typical auctioning factor for sectors covered by product benchmarks would be in the range of 50% to 70%.

The *non-public NIM method* uses data from the non-public NIM files which Member States have submitted to the European Commission for the purpose of determining the amount of free allocation to ETS installations in the course of 2011-2012. In principle these files contain information on allocation, emissions, relevant NACE codes per (sub)installation and heat flows. This method could theoretically yield a high level of accuracy, it is designed to correct for emissions related to imported or exported heat. It depends to a large degree on the completeness and the correctness of the data which may not always have been well-verified; which may be especially concerning the NACE code an issue. Repairing each flaw on a case-by-case basis will be very labour intensive and may require focussing attention to the largest sectors and installations.

The *product benchmark method* makes use of information on emissions and allocation that is available in the product benchmark curves. A complexity in this method is that product benchmarks need to be matched with NACE codes and especially the cases where multiple product benchmarks are applicable in one NACE sector. In addition, a fallback auctioning factor needs to be developed for those NACE sectors not covered by a product benchmark. The product benchmark method will therefore probably be more time consuming than the NIM method, while it will yield results of equal or less robustness. Multiple issues have been identified in the product benchmark method, and more could arise along the process of executing it (the devil is in the details), especially for complex sectors. It is recommended to pursue the non-public NIM methodology.

Gross value added (GVA) data

GVA data is reported by Eurostat in the Structural Business Statistics. Of all data sources presented, this is the data which is published with the longest time lag; only three years after the reporting year final values are provided, preliminary values are available a year earlier. It may thus determine the base period which is defined in the EU ETS directive as the “three most recent years”.

Carbon price

The carbon price is the only component in the last carbon leakage assessment which is not based on historical data but on a projection for the period of application of the carbon leakage list. The CO_2-price assumed in the first carbon leakage list has – for a number of reasons which could not be foreseen at the moment the projection was elaborated – shown to be substantially higher than is realistically to be expected for 2013 and 2014. There may be certain legal constraints on the use of carbon price, which are not assessed in this report. For the case that no such legal constraints apply, some suggestions on carbon price to be used have been developed. The carbon price could be based on a) historic data (EUA prices in the base period or current future prices), b) short term economic forecasts or c) projections resulting from energy-economic modelling. As currently many fundamental decisions for the functioning of the carbon market are expected, it is recommended to base the carbon price on forecasts elaborated towards end of 2013/beginning of 2014 and which cover explicitly the years of validity of the second carbon leakage list.

3 Framework for a harmonized qualitative assessment

There might be industrial sectors which do not meet the quantitative thresholds, but are nevertheless exposed to carbon leakage - e.g. sectors being just below the thresholds or sectors for which statistics are absent or of poor quality. Therefore the EU ETS directive enables the Commission supplement the carbon leakage list based on qualitative arguments. However, decisions based on qualitative arguments (hence: without strict thresholds) can always be questioned. To reduce the arbitrariness in the decisions the Commission requested the consortium to propose a harmonised and structured framework as the basis for potential future qualitative assessments.

In the amended ETS Directive (paragraph 17 of article 10a), three criteria are mentioned as being relevant in the qualitative assessment:

> *(a) the extent to which it is possible for individual installations in the sector or subsector concerned to reduce emission levels or electricity consumption, including, as appropriate, the increase in production costs that the related investment may entail, for instance on the basis of the most efficient techniques;*
>
> *(b) current and projected market characteristics, including when trade exposure or direct and indirect cost increase rates are close to one of the thresholds mentioned in paragraph 16;*
>
> *(c) profit margins as a potential indicator of long-run investment or relocation decisions.*

Over the past years, the Commission has supplemented the list with sectors deemed to be exposed to carbon leakage with six sectors, based on combinations of the above-mentioned criteria.

The consortium has reviewed all criteria that have been used in the past. After consultation with the Commission, this long-list of indicators has been assessed and reduced to a list with nine indicators, which are viewed as the most important indicators to be assessed within a qualitative assessment. The nine indicators have been structured in a three step approach, inspired by the three criteria mentioned in the ETS Directive.

Step 1: The extent to which a sector will be exposed to carbon cost

The first part of the qualitative assessment would provide a further interpretation of the quantitative carbon cost ratio. Its aim is to determine the amount of carbon costs the sector actually faces. In the quantitative assessment this has been assessed already on the basis of direct emissions and indirect emissions from electricity consumption. In this step, this assessment is extended and refined by taking into account:

- <u>Abatement potential and associated costs</u>: Quantification of "the extent to which it is possible for individual installations in the sector or subsector concerned to reduce emission levels or electricity consumption, including, as appropriate, the increase in production costs that the relevant investment may entail, for instance on the basis of most efficient techniques".

- (In)direct carbon costs from suppliers: (In)direct costs from raw materials from supplier sectors (upstream), which are likely to be passed through to the sector being assessed. Also emission related costs from third party heat generation can be regarded in this respect. Indirect costs from electricity consumption are not intended here, as these are already included in the induced carbon cost ratio.

The first indicator may have a reducing effect on the carbon cost exposure. The second indicator may have an increasing effect on the carbon cost exposure.

Sectors that, after taking into account these indicators, still have a sufficiently high carbon cost exposure could proceed to the next step in the assessment, otherwise the carbon cost (relative to gross value added) are deemed as not significant enough for the sector to lead to a significant risk of carbon leakage.

Step 2: The extent to which a sector is able to pass these costs on to its customers

Whether or not a sector is able to pass these carbon costs on in market prices depends on various market characteristics which are assessed in this second step. The relevant market characteristics are:

- Bargaining power of sector in value chain: an assessment of the bargaining power of a sector within its value chain by looking at the market concentration and industry structure. This directly influences the ability of a sector to pass through costs.
- Import intensity: a metric for the strength of exposure to international markets and world prices, which influences the ability to pass through costs. Import intensity is to be determined by looking at the ratio of imports relative to turnover, and the development of this ratio over time. The import intensity should also be seen in conjunction with the export specialisation position, preferably over time.
- Export specialisation position: a metric for robustness a sectors net export position over time, influencing the ability to pass through costs without risking to loose export markets. Export specialisation position is to be determined by looking at the development of the trade surplus (exports minus imports) of a sector over time and/or ratio of exports relative to turnover over time. The export specialisation position should also be seen in conjunction with the import intensity position over time.
- Transportability: Transport costs in relation to product value, as metric for the "local/regional" nature of a sector's market. Alternatively, since transport costs are closely related to the weight of products, transportability can be assessed by looking at the product's weight-to-value ratio as a proxy.
- Homogeneity of produce: A metric for degree of price competition, influencing the ability for producers to pass costs through. Homogeneous goods are physically identical, or at least seen as such by the buyer of the goods, and it is therefore difficult for a producer to distinguish themselves. Homogeneous prod-

ucts compete more on price and substitution of homogenous products from one producer by those of another producer is easier than in the case of highly differentiated products.

If the combined picture of these indicators provides an indication that carbon costs are hard to pass through and the sector thus needs to absorb most of it themselves, the sector could proceed to the next step of the assessment. Otherwise there is no need to go to the next step, even if carbon costs (step 1) are relatively high, since the sector can pass through a large part of the costs to its customers and is not – or to a limited extent only - affected by the costs itself.

Step 3: The extent to which the inability to pass on costs is likely to result in carbon leakage

Even if carbon costs faced by the sector are high (step 1) and the ability to pass these costs through is low (step 2), there would be no significant risk of carbon leakage if the sector can either absorb these costs e.g. because of sufficiently high profit margins, or if substitution of the product overall leads to a lower carbon footprint.

- Cost absorption potential: an indication of absorption capacity of additional carbon costs for a sector by looking at profit margins. This indicator could be determined by assessing two elements:
    1. Profit margins: High profit margins can indicate the ability for a sector to absorb the costs without problems. Low profit margins can indicate lack of such ability (and can also provide an indication for strong competition of the market with low cost pass-through ability).
    2. The share of additional carbon costs as % of profit margins. This provides a direct relation between profit margin and the additional carbon costs faced by a sector and indicates the extent of impact and hence the risk of lower future (inward) investments, of relocation or of shutting-down.
- Carbon intensity of likely substitutes: This indicator assesses the carbon intensity of tradable substitutes, both from within EU and from non-EU, having the same functionality, which is relevant *if* it has been established that there is indeed a significant substitution risk.

The interrelation between the three assessment steps is depicted schematically in the picture below.

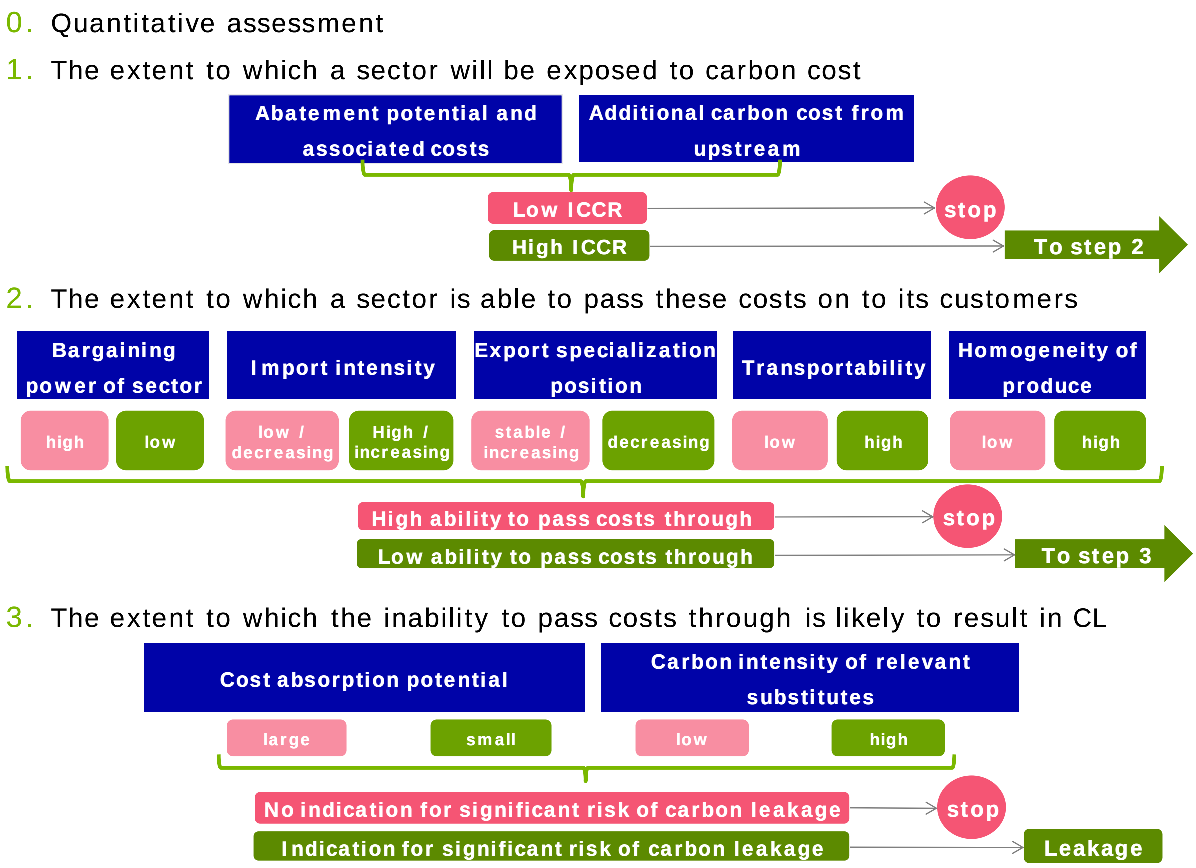


Figure 3 Visual representation of staged qualitative assessment

A sector could thus be in one the following stylised situations:

- Case A: Low carbon costs (step 1)
  - ⇨ If these costs are relatively low, there is no need to proceed to the next steps
  - ⇨ There are **no indications** for a significant risk of exposure to carbon leakage
- Case B: High carbon costs (step 1) + High ability to pass costs through (step 2)
  - ⇨ Even though carbon costs are high, the sector can pass them through
  - ⇨ There are **no indications** for a significant risk of exposure to carbon leakage
- Case C: High carbon costs (step 1) + Low ability to pass costs through (step 2) + Low extent to which this could lead to carbon leakage (step 3)
  - ⇨ Even though carbon costs are high and ability of the sector to pass costs through is low, the sector could potentially absorb the costs

- ⇨ There are **no indications** for a risk of exposure to carbon leakage

- Case D: High carbon costs (step 1) + Low ability to pass costs through (step 2) + High extent to which this could lead to carbon leakage (step 3)
  - ⇨ Carbon costs are high, the ability of the sector to pass costs through is low and the extent to which the sector can absorb this is low
  - ⇨ There are clear indications that this sector is exposed to a **significant risk of carbon leakage**

A summarising overview of each of the indicators under step 1, 2 and 3 is provided in the tables below.

Table 1 *Schematic overview of indicators determining* ***Step 1****: (in)direct costs of carbon faced by sector*

Indicator	Indication of low impact on induced carbon cost	Indication of high impact on induced carbon cost
Abatement potential and associated costs	Low	High
Indirect carbon costs from suppliers	High	Low

Table 2 *Schematic overview of indicators determining* ***Step 2****: ability of sector to pass costs through*

Indicator	Indication for low ability to pass costs through	Indication for high ability to pass costs through
Bargaining power of sector in value chain	Low	High
Import intensity	High / increasing	Low / decreasing
Export specialisation position	Decreasing	Stable / Increasing
Transportability	High	Low
Homogeneity of produce	High	Low

*Table 3 Schematic overview of indicators determining **Step 3**: extent to which this could lead to carbon leakage*

Indicator	Indication for high risk to carbon leakage	Indication for low risk to carbon leakage
Cost absorption potential	Small	Large
Carbon intensity of relevant substitutes	High	Low

4 International considerations and inclusion of third countries efforts into the calculation

The carbon leakage provisions included in the Emissions Trading Directive (Directive 2003/87/EC) aim to protect European producers from a competitive disadvantage compared to producers in countries without carbon constraints. Article 10a (18(1)) of the Emissions Trading Directive states that the carbon leakage list shall be determined after taking into account

> *"a) the extent to which third countries representing a decisive share of global production firmly commit to reducing GHG emissions in the relevant sectors to an extent comparable to that of the EU and within the same timeframe, and*
>
> *b) the extent to which carbon efficiency in these countries is comparable to the EU".*

It is important to gain a thorough understanding not only of the extent that third countries show comparable efforts and carbon efficiencies but also of the ways these commitments and efficiencies can be taken into account in determining the carbon leakage list.

Within this context, the study carried out aims to

i) analyse the commitments of countries outside the EU27, so-called third countries, to reducing greenhouse gas emissions;

ii) analyse the greenhouse gas efficiencies of relevant industrial sectors in third countries compared to the EU; and

iii) elaborate and assess methodologies for taking into account the commitments of these third countries.

4.1 GHG mitigation efforts and GHG intensities

In a first step, a set of countries for further investigation is selected based on the share of total industrial emissions relative to global emissions. The largest share is found for China, USA, India, the Russian Federation, Japan, South Korea, Indonesia, South Africa, Canada, Australia, and Brazil. These countries are taken for an in-depth analysis in terms of their implemented climate policies and their respective greenhouse gas efficiency.

West-Pacific countries are moving strongly forward

The assessment of commitments and policies which are developed and implemented by third countries to limit industrial greenhouse gas emissions is based on a thorough qualitative review of industrial energy and climate policies. Climate commitments have been based on up to date information in the Climate Action Tracker. National industrial energy and climate policies have been collected using amongst others the Institute for Industrial Productivity (IIP) database on industrial efficiency policies and the IEA policy and measures database on Energy Efficiency. In addition, country-specific sources have been used to find details of national GHG policy measures.

For each of the eleven selected countries, we identified the most important policies, which are then assessed in more detail regarding type of policy, level of stringency, mandatory nature, enforcement by authorities, status of implementation level, and coverage.

The analysis revealed that countries located in the West-Pacific area are moving strongly forward with respect to ambitious climate policies. Japan, South Korea, and Australia have significant policies in place, either with an Emissions Trading Scheme (South Korea, Australia) or ambitious energy efficiency benchmarks (Japan), covering the majority of national emission-intensive industries. All of these countries currently shape their policies possibly raising ambition. These measures could be considered qualitatively comparable to the EU ETS in terms of potential price signals and their mandatory nature.

Additionally, China and India give signals of tackling climate change with several policy packages that are mandatory, although the stringency of the energy efficiency targets is not very clear for both countries. Policies in both countries are diverse and developing fast in terms of coverage and ambition. An assessment of whether these are comparable to the EU ETS would require further detailed technical analysis.

Brazil, Indonesia and South Africa on the other hand show less strict policies: they use voluntary emission saving measures to combat climate change. Policy development is quite active in Indonesia but to a lesser extent in Brazil and South Africa. At the far end, Canada, the US, and the Russian Federation lag behind and did not announce a coherent and ambitious policy framework for their national industries or a plan towards it yet. The policies of these countries would not be comparable to the EU ETS.

Limited information on carbon efficiencies complicates cross-country comparisons

For the assessment of greenhouse gas efficiencies in the investigated countries a wide range of publicly available literature and data was assessed to obtain a shortlist for further investigation. The data in the shortlist was then amended by references obtained through an extensive questionnaire amongst Member States, NGOs and industrial sector associations. All information was assessed and cross-compared in terms of its scope, sector and country coverage, data collection methodology and approach to derive the data, homogeneity of data, primary vs. secondary sources, public vs. private data sources etc.

The assessment reveals that data availability of industrial GHG intensities that can be used for cross-country comparisons appears to be very limited. Without exception all industrial sectors face one or more serious issues in interpreting and comparing GHG intensities between EU and third countries across the world.

Of the scrutinized sectors, cement and aluminium show the best data availability, due to sectoral benchmarking initiatives on a global level. They allow a comparison of GHG intensities to some extent and between EU and at least some third countries.

The cement industry in Central America and Africa produces cement within +/-5% of the European emission intensity of cementitious products. South America and India perform on average even better than European installations, mainly due to their low clinker to cement ratio. Japan, Australia and New-Zealand show GHG intensities 6% higher than in Europe. Regarding clinker production, all third countries in this study, except for the former Soviet Union, show emissions per tonne of clinker within +/- 5% compared to the European average value of 860 kg CO_2 / t clinker.

Data for China are very limited in terms of data representativeness (only 5% of production covered). A further serious limitation is that indirect emissions from electricity consumption are not taken into account yet. These would add roughly 10% of emissions per tonne of cement. Further research is needed to get a more reliable, country-specific and complete picture of the GHG intensity of cement manufacturing.

The GHG intensity of aluminium in the European Union is comparable to that of the Russian Federation. However, it is significantly higher than in Norway and significantly lower than that of the USA and China. No GHG intensity data are available for other regions in the world, although energy intensities are. Due to large differences in the emission factor of electricity (the main energy input in primary aluminium smelting) across different regions in the world, energy intensity is not a sufficient indicator for cross-country comparisons of GHG intensities.

For steam cracking, methanol, chlorine and soda ash, energy efficiencies for several countries are available. One complication is that there is no average European value to compare results with. Furthermore, additional analysis would be required to convert energy efficiency values to GHG intensities, which for the complex chemical sector is not a straightforward exercise.

For iron and steel most of the available data is of limited or unknown quality, preventing a solid comparison. The identified sources claim that both the average GHG intensity as well as the energy efficiency of the EU is comparable to that of US, Japan and South Korea. As indicated in the assessment of the data sources, these results should be interpreted with care: although the observations seem to be in line with each other, only one reference (UNIDO, 2010)[2] has been identified as suitable for cross-country comparisons in this study. Further analysis would be recommended to validate these results.

Some sectors included in our analysis have no data available at all or have data of insufficient quality to allow cross-country comparisons. This holds for copper, nickel, zinc, pulp and paper, and refineries. For sectors not further mentioned in this study (e.g. lime, ferro-alloys, bricks, gypsum etc) no data have been found at all.

[2] UNIDO (2010): Global Industrial Energy Efficiency Benchmarking.

On a more general note, it can be concluded that most public data sources were found not to be a suitable basis for cross-country GHG efficiency comparisons due to serious flaws in combining data from different sources collected via different approaches. Exceptions consist of the aluminium and cement industry where company data is collected in a methodologically sound and transparent way for the purpose of benchmarking the sector. Benchmarking approaches like these are a suitable means to compare GHG intensities across different countries, and therefore would deserve more attention in other relevant sectors. Another useful approach would be to dive into the processes used in different regions and determine what factors influence the carbon intensity.

4.2 Methodological considerations for inclusion of third countries

In a next step, different methodologies to take commitments of third countries into account are elaborated for each carbon leakage indicator and assessed in terms of their suitability and data requirements. Given the challenge at present to identify third countries with comparable mitigation efforts and GHG efficiencies, the methodological discussion is framed around three groups of countries:

a) countries that are fully integrated into the EU ETS,

b) countries with comparable efforts with linked carbon markets, and

c) countries with comparable efforts but no linking.

Bubble approach vs. deduction approach

Countries of the first group are fully integrated in terms of the rules and regulations of both the EU ETS and economic activity (at current NO, LI, IS). It is therefore recommended to treat them the same way as the EU MS countries and fully include their data on all components of the two carbon leakage indicators (induced carbon costs and trade intensity), thus pursuing the so-called **bubble approach**. This requires additional data which is partly available at Eurostat and would need to be completed by national sources.

For countries that conduct comparable efforts, it is recommended to adjust the methodology for the induced carbon cost indicator only with respect to the carbon price. More specifically, in case of carbon market linking the resulting EU ETS carbon price would be taken for the calculation of the induced carbon cost indicator while in case carbon markets are not linked the EU ETS price would not be affected and the carbon price entering the induced carbon cost calculation would not be adjusted. Only in case induced carbon costs are explicitly known for countries with comparable efforts that are not linked to the EU ETS, the price differential may be considered to be taken as a proxy for additional induced carbon costs in the EU. With respect to the calculation of the trade intensity indicator, it is recommended to only include trade between the EU and those countries that do not commit to comparable efforts. In other words, trade flows with comparable effort countries need to be deducted from imports to and exports from the EU (**deduction approach**).

While the bubble approach is more data and resource intensive than the deduction approach, it allows accounting for a complete integration of those EU ETS countries that are not EU Member States. These countries follow the same rules and regulations not only for the EU ETS but also for most economic legislation within the European Economic Area and, thus, face the same carbon price and the same trade regulations both for EUAs and general commodities. A change in any of these regulations will affect all these countries in the same way. This implies that the ability to pass through additional costs, its effect on competitiveness and the consecutive risk of carbon leakage is the same for a given sector within all of these countries.

Should it not be possible to overcome resource and data constraints a simplified approach would imply to treat these integrated countries in the same way as any other country with comparable efforts.

5 Literature review on the issue of carbon leakage

The aim of the literature review was to provide further clarity on the issue of carbon leakage to inform all of the remaining tasks associated with the project. The risk of carbon leakage was discussed reviewing attempts in the literature to identify sectors that may be especially exposed to carbon leakage and quantify the respective (potential) carbon leakage effects. The literature review also attempted to compare, where appropriate, the estimation of carbon leakage rates in the literature by categorising studies that apply similar modelling approaches and assumptions and further outlining where gaps in the literature exist. The main findings from the literature review include the following.

The list of sectors 'deemed to be at risk of carbon leakage' in the quantitative assessment conducted by the European Commission is often considered too long within the literature.

Jürgens et al (2012)[3] believes it is unclear whether the objective of the carbon leakage provisions is to minimise Type I errors (i.e. rejecting the addition of a sector to the carbon leakage list, when it should be accepted) or Type II errors (i.e. approving the addition of a sector onto the carbon leakage list, when it should be rejected). Jürgens et al (2012) emphasises that only Type I errors result in carbon leakage whereas Type II errors result in the over-compensation to sectors that are not at risk of carbon leakage.

According to Droege and Cooper (2010)[4], the list of sectors at risk of carbon leakage may include too many Type II errors and suggest that an inadequate choice or indicators and/or too low thresholds being applied in the assessment are primarily responsible. For example, the majority of sectors deemed at risk of carbon leakage qualify on the basis of the trade intensity indicator alone (Carbon Trust, 2010)[5], which implies that the threshold for the indicator was possibly set too low.

3 Juergens, I.; Barreiro-Hurlé, J. and Vasa, A. (2012): Identifying carbon leakage sectors in the EU ETS and implications of results, Climate Policy, DOI:10.1080/14693062.2011.649590

4 Dröge, S. and Cooper, S. (2010): Tackling Leakage in a World of Unequal Carbon Prices. A study for the Greens/EFA Group. Climate Strategies. May 2010.

5 Carbon Trust (2010): Tackling carbon leakage: Sector-specific solutions for a world of unequal carbon prices.

There is agreement between econometric studies in the literature that certain sectors can pass through additional carbon costs, however the evidence is not conclusive and more research is necessary.

Oberndorfer et al. (2010)[6] shows that with the exception of ceramic goods, the remainder of the products assessed are able to pass through only parts of their costs into output prices. The range of cost pass-through varies considerably across sectors.

Alexeeva-Talebi (2010)[7] agrees that producers of cement, lime and plaster are capable of passing through the majority of additional costs and also identifies a wide range of cost pass through rates that exist across the different sectors (i.e. 0% to 75%).

Both studies calculate rather different cost pass through rates for some sectors, which reflects the use of different data sets, different lengths of their time series and/or different specification of their estimated equations. Further research would be needed to harmonize assumptions and improve the robustness of results.

Beyond the comparison of absolute targets for emission reductions to assess comparability, the transfer of abatement technologies is an important discussion point in the UNFCCC negotiations between developed and developing countries, which may impact upon the carbon leakage risk of European industry.

Kuik and Gerlagh (2007)[8] suggest that the risk of carbon leakage may be offset by another spill-over effect i.e. the transfer and diffusion of environmentally sound technology.

Carbon leakage rates calculated by ex-ante modelling range considerably in the literature from 2% to 73% for sectors covered by the EU ETS and primarily focus on the short run competitiveness and investment channels of leakage.

The lower rates of leakage within this range tend to assume a relatively low carbon price and preventative measures such as free allocation or border tax adjustments

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6 Oberndorfer, U. et al (2010): Understanding the Competitiveness Implications of Future Phases of EU ETS on the Industry Sectors. Centre for European Economic Re-search ZEW Discussion Paper No. 10-044, Mannheim

7 Alexeeva-Talebi, V. (2010): Cost Pass-Through in Strategic Oligopoly: Sectoral Evidence for the EU ETS. Discussion Paper No. 10-056. Centre for European Economic Research (ZEW), Mannheim, Germany

8 Kuik, O. and Gerlagh, R. (2007): Carbon leakage with international technology spillo-vers, Working Papers Fondazione Eni Enrico Mattei Nota Di Lavora 2007.33

(Kuik and Hofkes, 2010)[9] while the more extreme carbon leakage rates assume a relatively high carbon price and no preventative measures (Ponssard and Walker, 2008)[10].

However, the underlying assumptions of the modelling approach (i.e. energy and trade elasticities) are of even greater importance in determining the rate of carbon leakage.

The results of ex-ante modelling are not validated in the most recent empirical ex-post studies, which generally fail to identify large negative impacts on the competitiveness of firms participating in the EU ETS.

The econometric analysis failed to identify a statistically significant effect of CO_2 pricing on the net imports of primary aluminium and therefore Sartor (2012)[11] concluded that there is no evidence to suggest that the carbon price has caused a net increase in imports of primary aluminium during the first 6 and a half years of the EU ETS.

An analysis by Reinaud (2008)[12] failed to confirm the assumption that CO_2 prices impacted upon EU primary aluminium trade flows.

However the evidence base is not necessarily representative and may be subject to considerable bias and the limited empirical data sets may not account for factors such as long-term electricity contracts.

Given the complexity of the carbon leakage problem, and the necessity for modelling approaches to simplify the real world in order to comprehend it, the rates of carbon leakage calculated by studies in the literature are often not comparable with one another.

The higher rates of carbon leakage identified in the literature seem to be associated with rather simple assumptions (i.e. homogenous products) that may not accurately reflect the real world and therefore over-estimate the extent of the problem.

However, the lower rates of carbon leakage, especially for the EU ETS, often assume preventative measures such as free allocation that will not continue indefinitely into Phase III of the EU ETS and therefore may under-estimate the extent of carbon leakage.

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9 Kuik O. and Hofkes M. (2010): Border adjustment for European emission trading: Competitiveness and carbon leakage. Energy Policy, Elsevier, vol. 38(4), pages 1741-1748, Issue (Month): 4 (April)

10 Ponssard, J.P. and Walker, N. (2008): EU Emissions Trading and the cement sector: a spatial competition analysis, Climate Policy (2008) Volume: 8, Issue: 5, Publisher: Earthscan, Pages: 467-493

11 Sartor, O. (2012): Carbon leakage in the Primary Aluminium Sector: What evidence after 6 ½ years of the EU ETS? CDC Climate Research. Working Paper No 2012-12.

12 Reinaud, J. (2008): Issues behind competitiveness and carbon leakage. Focus on Heavy Industry. OECD/IEA Information Paper.

In order to reach a better consensus on this issue, it will be necessary for the models used and the assumptions taken to be documented in a more transparent manner and possibly for greater collaboration between academia and industry to agree upon certain parameters set in the modelling exercises.

6 Summary and conclusions

By the EU ETS directive the Commission is required to determine a list of sectors or sub-sectors deemed to be exposed to a significant risk of carbon leakage and to update this list every five years, based on data of the "three most recent years". The project assessed the methodology and data needs for the quantitative assessment and found that the update can largely rely on the methodologies and data sources used in the first carbon leakage assessment in 2009, for some aspects refinements are recommended. Based on the criteria in the directive and past qualitative assessments a framework for a harmonized qualitative assessment was elaborated. Furthermore for some countries comparable GHG mitigation efforts were found and two options to include third countries into the assessment developed. .Research activities in the area of carbon leakage were monitored in the literature review showing clearly that the determination of sectors at risk of carbon leakage is challenging and political compromises may have resulted in a list of sectors that is too long.

Findings for the quantitative carbon leakage assessment

The two quantitative indicators defined in the EU ETS directive which should be assessed to evaluate the risk of carbon leakage are trade intensity and additional cost induced by the implementation of the EU ETS (induced carbon cost – ICC). For the update of the quantitative assessment, it is recommended to keep Eurostat as data source where applicable. Eurostat provided data on trade and turnover (for trade intensity) as well as GVA (for induced carbon cost). Direct emissions should continue to be based on registry data (CITL/EUTL), the matching of installations to industrial is recommended to be updated and double checked with data from the allocation applications (NIMs). In need of European sources electricity consumption (needed to compute indirect emissions) could as before be collected from Member States with the help of Eurostat to address confidentiality concerns.

The emissions factor for electricity and the carbon price projection were based on the Impact Assessment; an update can thus not rely on the same data source. The emissions factor can be based on IEA data or needs to be computed based on Eurostat data taking into account the effects of CHP. If legally possible, which is not assessed in this report, an updated carbon price projection could take into account recent developments and provide estimates for the years of validity of the carbon leakage list (2015-2019). Short-term forecasts elaborated mid/end 2013 could be deemed more appropriate than long-term projections.

In the last assessment a uniform auctioning factor was used to estimate free allocation. This approach can be refined with data on free allocation in the third trading phase which has not been available when the first assessment was carried out. It is recommended to base sector-specific auctioning factors on NIMs data.

Framework for a harmonized qualitative assessment

There might be industrial sectors which do not meet the quantitative thresholds, but are nevertheless exposed to carbon leakage e.g. sectors being just below the thresholds.

Therefore the EU ETS directive enables the Commission supplement the carbon leakage list based on qualitative arguments. In the project a harmonised and structured framework was proposed to guide potential future qualitative assessments.

The framework was structured along the three criteria mentioned in the amended ETS Directive (paragraph 17 of article 10a) as being relevant in the qualitative assessment and the indicators used in the qualitative assessments carried out for the carbon leakage list 2013-2014.

In a first step it is proposed to assess to which extent a sector will be exposed to carbon cost. This is suggested to be assessed based on the abatement potential and the associated costs as well as the indirect carbon costs included in supplied materials and heat. If the sector is found to be exposed to carbon cost, the next step of the assessment is taken, if not, no further assessment is deemed necessary.

In a second step the extent to which a sector is able to pass these costs on to its customers is proposed to be assessed. If the bargaining power of the sector in the value chain is high and the homogeneity of produce low, it is expected that the sector will be in a better position to pass through the carbon cost. Also low transportability will favour local/regional markets. As indicators to assess the position of the sector in the international market import intensity and the robustness of the sectors net export position over time are proposed. If the sector is found not to be able to pass through the induced carbon cost, the next step in the assessment would be taken.

The third step of the assessment would consist in the analysis to which extent the sectors inability to pass on costs is likely to result in carbon leakage. As an indication of the sectors capacity to absorb carbon costs the profit margins can be evaluated, both in absolute terms and in relation to additional carbon costs. Furthermore the carbon intensity of likely substitutes assessed to judge whether the substitution would increase overall emissions which would counteract the purpose of the regulation.

International considerations and inclusion of third countries efforts into the calculation

The ETS Directive stipulates that the carbon leakage list shall be determined after taking into account to which extent third countries undertake comparable efforts to reduce GHG emissions and have comparable carbon efficiency to the EU. In the present study the commitments to reducing GHG emissions of 11 countries outside the EU27 are analysed and the GHG efficiencies in relevant industrial sectors compared. The countries were chosen based on their share of total industrial emissions in global emissions; they are China, USA, India, the Russian Federation, Japan, South Korea, Indonesia, South Africa, Canada, Australia, and Brazil. Furthermore methodologies are elaborated and assessed for taking into account the commitments of these third countries in the carbon leakage assessment.

A thorough qualitative assessment of commitments and policies carried out for the countries selected. The most important policies were identified and assessed in more detail regarding type of policy, level of stringency, mandatory nature, enforcement by authorities, status of implementation level, and coverage. Japan, South Korea and Australia were identified as countries which have measures in place which can be considered comparable to the EU ETS. They have mandatory policies in place covering the majority of national emission-intensive industries and might possible raise their ambition. Diverse policies to combat climate change are in place and developing fast in China and India. Whether their stringency is comparable would need further detailed analysis. Policies in the other countries assessed were found not to be comparable. They either rely on voluntary emission saving measures or had no coherent policy framework in place.

The assessment of a wide range of sources concerning GHG efficiencies yielded very few data that enables a comparison of industries GHG efficiencies in the EU and in third countries. The best data availability was found in sectors with benchmarking initiatives at global level; these are the cement and aluminium sector. In the cement sector emission intensity for most countries ranges +/-5 % around the European value. A serious flaw in the dataset is the poor coverage of Chinese cement manufacturing which accounts for a significant share in global production. Concerning GHG intensity in the Aluminium production Europe performed better than the USA and China but significantly worse than Norway. For other world regions energy efficiency are available, but as the emission factor for electricity varies widely, these cannot be taken for further comparison without conversion. Even more complex would be the conversion of energy efficiency to GHG efficiency values in the chemical sectors; if there were an average European value to compare results with. In the iron and steel sector data limitations were found to be severe. No cross-country comparison was possible for copper, nickel, zinc, pulp and paper, and refineries due to lack of data or data quality.

In a next step, different methodologies were assessed to reflect countries undertaking comparable efforts into the carbon leakage assessment metrics. Three type of countries were distinguished: countries being fully integrated into the EU ETS (namely Norway, Iceland and Liechtenstein), countries with comparable efforts and linked carbon markets and countries with comparable efforts but without linking.

For countries which are fully integrated into the EU ETS it is recommended to treat them as any EU Member State and include them into the carbon leakage when calculating the indicators (‘bubble approach’). If data gaps do not allow for a full inclusion, as fall-back approach they can be reflected in the same way as countries with linked carbon markets.

For countries with comparable efforts (no matter whether linked or not) it is suggested to deduct trade to these countries when computing the trade intensity (‘deduction approach’). The linking of carbon markets leads to adjustments in the carbon price. Therefore the expected price resulting from linking is considered appropriate when evaluating the induced carbon cost of the directive. Countries with comparable efforts but with either independent (not linked) carbon markets or other types of policies will not affect the EU carbon price and thus cannot be reflected in the same manner. Only in case induced carbon costs are explicitly known for countries with comparable efforts that are not linked to the EU ETS, the price differential may be considered to be taken as a proxy for additional induced carbon costs in the EU.

Findings from the literature review

The risk of carbon leakage may result as a by-product of unilateral environmental policies and may undermine the credibility of the policy depending upon the extent of the problem. The rate of carbon leakage that can be attributed to a unilateral policy such as the EU ETS is the key question for policy-makers in determining the effectiveness of unilateral environmental policies to reduce GHG emissions without harming the competitiveness of regulated industries. In order to determine the rate of carbon leakage due to the EU ETS, the literature has identified various ways by which the problem may occur (i.e. short term competitiveness, investment and fossil fuel channels) and established a range of important indicators (i.e. trade intensity, CO_2 cost and the ability to pass through additional costs) to assess the risk of carbon leakage for particular regions and sectors. This improved understanding of carbon leakage in the literature has been accompanied by the development of economic theories (i.e. Pollution Haven Hypothesis) that have impacted empirical analyses aiming to quantify the rate of carbon leakage of unilateral environmental policies.

It is evident from the literature review that determining the list of sectors that are at risk of carbon leakage is challenging and political compromises may have resulted in a list of sectors that is too long. The limited availability of empirical data means that there is a reliance on ex-ante modelling to inform policy makers on the impact of the EU ETS on carbon leakage. With regards to the potential scale of carbon leakage, rates range considerably in the literature from 2% to 73% for sectors covered by the EU ETS and primarily focus on the short run competitiveness and investment channels of leakage. The lower rates of leakage within this range tend to assume a relatively low carbon price and preventative measures such as free allocation or border tax adjustments while the more extreme carbon leakage rates assume a relatively high carbon price and no preventative measures. However, the underlying assumptions of the modelling approach (i.e. energy and trade elasticities) are of even greater importance in determining the risk of carbon leakage. Interestingly, the results of ex-ante modelling are not validated in the most recent empirical ex-post studies, which generally fail to identify large negative impacts on the competitiveness of firms participating in the EU ETS.

In order to reach a better consensus on this issue, it will be necessary for the models used and the assumptions taken to be documented in a more transparent manner and possibly for greater collaboration between academia and industry to agree upon certain parameters set in the modelling exercises. Furthermore, empirical ex-post approaches will need to be improved and utilise longer time series to provide more robust assessments of the risk of carbon leakage.

7 Annexes

Methodology & data for the quantitative carbon leakage assessment

Annex 1: Methodology for the quantitative carbon leakage assessment

Annex 2: Assessment of two methodologies to determine the auctioning factor

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Literature review on the issue of carbon leakage

Annex 6: Literature review

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sustainable energy for everyone

Support to the Commission for the determination of the list of sectors and subsectors deemed to be exposed to a significant risk of carbon leakage for the years 2015-2019 (EU Emission Trading System)

Methodology for the quantitative carbon leakage assessment

January 2013

Task 1 final report

Service Contract No 07.1201/2011/605733/SER/CLIMA.B.2

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The views expressed in this study represent only the views of the authors and not those of DG CLIMA or any other organization.

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List of abbreviations

CCGT	Combined cycle gas turbine
CDM	Clean Development Mechanism
CHP	Combined Heat and Power Plant
CITL	Community Transaction Log (EU ETS registry)
CN	Combined Nomenclature
CO_2 Eq	Carbon dioxide equivalents
CPA	Statistical classification of products by activity
ETS	Emission trading system
EU ETS	The European Union's emission trading system
GT	Gas turbine
GVA	Gross value added
N_2O	Nitrous oxide
NACE	Statistical Classification of Economic Activities in the European Community (Nomenclature statistique des activités économiques dans la Communauté européenne)
NIMs	National Implementation Measures
SIM	Sustainable Industry Monitor database

Executive summary

Emissions of large industrial installations in the EU are covered by the EU Emissions Trading Scheme. The EU ETS is a regional scheme and may thus lead to a risk of carbon leakage: the risk that companies move outside Europe due to increased costs, thus leaking emissions outside of the EU cap, possibly producing there at lower efficiencies. The Commission is required by the EU ETS directive to determine a list of sectors or sub-sectors deemed to be exposed to a significant risk of carbon leakage and to be updated every 5 years. The present list was adopted in 2009 and is valid for 2013-2014. This reports aims at providing the Commission with an overview how the quantitative carbon leakage assessment can be updated and which data sources are required.

For the trade intensity indicator it is recommended to keep the approach of the first carbon leakage assessment. Trade and production data is provided by Eurostat in the Comext data base. Where gaps in production data occur, Eurostat Structural Business Statistics turnover data can be used.

The Comext data can be used to carry out the trade intensity assessment at a very disaggregated level, moving beyond the 3-to 4-digit level required by the directive. This is not recommended as a general approach because it might produce misleading results for intermediate products which are not consistently valuated and reported. Furthermore the number of plants falling under the ETS directive may be very small and therefore not representative when moving to a very detailed level of assessment.

For the induced carbon cost indicator varies data sources have to be tapped to collect direct and indirect emissions, carbon costs and GVA data. For all industrial sectors covered by the ETS directive already in the base period; direct emissions (energy as well as process related) can be based on the values reported in the CITL. Direct emissions of activities entering the EU ETS from 2013 onwards can be based on the application for free allocation (National Implementation Measures – NIMs). The NIMs can also provide the statistical classification codes (NACE) for individual installations.

Indirect emissions are computed by multiplying the net electricity purchased from the grid for own use with a CO_2 emission factor for electricity. There is no European source for electricity purchased by industrial sectors for own consumption. In the last assessment Member States were asked to collaborate in the data gathering exercise and Eurostat assisted the Commission in calculating the value respecting confidentiality concerns; this approach is recommended.

There are several approaches to calculate the CO_2 emission factor for electricity: average emissions of total generation; of fossil electricity generation only; the marginal electricity generation and marginal built capacities. For the purpose of the Carbon Leakage assessment it is recommended to employ the average emissions of total generation; the other approaches cannot reflect the effects of increasing renewable energy generation on electricity prices and their CO_2-component. The emission factor can be based on IEA statistics or can be calculated based on Eurostat and EU GHG inventory data. The fuel input to CHP plants has to be attributed to electricity and heat in order to be able to calculate an electricity only emission factor.

Gross value added (GVA) data is reported by Eurostat in the Structural Business Statistics. Of all data sources presented, this is the data which is published with the longest time lag; only three years after the reporting year final values are provided. It may thus determine the base period which is defined in the EU ETS directive as the “three most recent years”.

The carbon price is the only component of the last carbon leakage assessment which is not based on historical data but on a projection. The CO_2-price assumed in the first carbon leakage list has – for a number of reasons which could not be foreseen at the moment the projection was elaborated – shown to be substantially higher than is realistically to be expected for 2013 and 2014. Therefore options to base the carbon price on historic data (EUA prices in the base period or current future prices) or on short term economic forecasts are explored. There may be certain legal constraints on the use of carbon price, which are not assessed in this report. As currently many fundamental decisions for the functioning of the carbon market are expected, if no legal constraints apply it should be considered to base the carbon price on forecasts elaborated towards end of 2013/beginning of 2014 and which cover explicitly the years of validity of the second carbon leakage list.

1 Introduction

The aim of the EU Emissions Trading Scheme (ETS) is to reduce the greenhouse gas emissions of the European Union in an effective and cost efficient way. The scheme has been revised and extended since its start in 2005. The EU ETS is worldwide unique in terms of activities and emissions covered, as it includes emissions from combustion installations and from industrial processes.

While the first and second trading period (2005 - 2012) were largely characterised by free allocation to industry sectors, the 2009 revised directive states that from 2013 onwards auctioning should be the basic principle for allocation. This requirement also introduces the principle of carbon leakage: the risk that companies move outside Europe due to increased costs, thus leaking emissions outside of the EU cap, possibly producing there at lower efficiencies. The Commission is required to determine a list of sectors or sub-sectors deemed to be exposed to a significant risk of carbon leakage. In 2009, the Commission has established the general methodology on the occasion of the first carbon leakage which applies for the years 2013 and 2014. To determine the list which will apply for the years 2015-2019, the Commission will need to review the list taking into account updated information.

The aim of the work carried out under Service Contract No 07.1201/2011/599024/SER/CLIMA.C2 is to provide support to the Commission in preparing the general revision of the list of sectors or sub-sectors that are deemed to be exposed to a significant risk of carbon leakage both in terms of qualitative and quantitative assessment. The objective of task 1 of this work programme is to establish a general methodology and data sources needed to calculate the two indicators for the quantitative assessment: Trade Intensity and additional cost induced by the implementation of the EU ETS. This report builds on the experiences made in the first assessment and concentrates on the improvement of those aspects which posed difficulties in the past. One component to assess the direct additional costs is the estimation of benchmark allocation carried out in task 2 (Assessment of two methodologies to determine the auctioning factor) to quantify the amount of allowances industrial sectors need to purchase on average if not deemed to be exposed; it is covered in a separate report.

The potential data sources required for the quantitative assessment are evaluated according to their quality. Quality criteria include:

- Availability, also for future updates of the carbon leakage list;
- Reliability, therefore verified or official data is given preference; and
- Consistency: as few sources as possible to avoid gaps/double counting.

The key factors that need to be considered in the calculation of the trade intensity and carbon cost indicators will be outlined in the following chapters in order to provide a set of recommendations on how best to perform these calculations in the update of the carbon leakage assessment. In Chapter 2 the data requirements of the trade intensity indicator (i.e. trade and production data) are discussed with a recommendation on the best data sources to use based on the quality criteria. In Chapter 3 the data requirements of the carbon cost indicator are outlined (i.e. direct and indirect emissions, gross value added (GVA), share of allowances to be purchased and CO_2 price) with a recommendation on the best data sources to use based on the quality criteria and options are also presented for the setting of assumptions (i.e. CO_2 price) that are necessary in the calculation. The main conclusions from Task 1 are subsequently summarised in Chapter 4.The references are to be found in Chapter 5.

2 Trade Intensity

Trade Intensity measures the importance of imports and exports in relation to the domestic market. The indicator of Trade Intensity is calculated using the following formula:

$$TradeIntensity = \frac{Imports + Exports}{Turnover + Imports}$$

Therefore information on the value of trade (imports and exports) and turnover is required. Turnover represents the domestic production within the EU. The currency does not necessarily have to be converted to Euro, as long as all figures are available in the same currency.

2.1 Trade and turnover data at 4-digit level

Data on imports and exports to third countries as well as turnover used to calculate trade intensity are published by Eurostat in the Comext database at http://epp.eurostat.ec.europa.eu/newxtweb/. This source was used in the carbon leakage assessment carried out in 2009 (EU 2010) and is recommended to be used in the update of the list.

Trade data is collected to products (rather than industrial sectors) and needs aggregation to be comparable to sectors in the NACE classification. In in the Comext database trade data is provided in different classifications (CN, HS, SITC and BEC) and per partner country. The Combined Nomenclature (CN) classification is the most detailed one; it includes ca. 10 000 eight-digit codes and can therefore be converted to many other classifications.

Production data is reported at the Comext website based on a list of products called PRODCOM list (about 4500 headings at 8-digit level relating to industrial products) with the first 4-digit referring to the equivalent NACE class and the next two digits referring to subcategories within the Statistical classification of products by activity (CPA).[1] All classifications have been updated to reflect the changes from NACE revision 1.1 to NACE revision 2. The corresponding classifications are CPA 2008 and CN 2008. Under the PRODCOM heading also trade data, already aggregated to the level needed, is published. As long as no disaggregation according to trade partner country is foreseen, the production and trade data reported here can be used without further conversion needs.

There are two sets of production data published on the Comext webpage. 'PRODCOM ANNUAL SOLD' refers to the products sold whereas 'PRODCOM ANNUAL TOTAL' to the product produced; the two differ mainly by the changes in stocks, intermediate

[1] Based on Eurostat Glossary: PRODCOM, accessed in April 2012, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:PRODCOM.

products produced and work in progress. ‘PRODCOM ANNUAL SOLD’ provides production value (as all sales are valuated but not necessary all internal intermediate products and reporting will most likely be less accurate for intermediate inputs) and relates better to the definition of turnover[2]. ‘PRODCOM ANNUAL TOTAL’ only provides production quantities but not their value.

An alternative source for turnover data is the Structural Business Statistic (SBS, http://epp.eurostat.ec.europa.eu/portal/page/portal/european_business/introduction). Turnover as well as production value is reported by NACE sector at 4-digit level in the annual detailed enterprise statistics for industry.[3] Obviously there is a link between the turnover and production value reported in SBS and measured in PRODCOM, but they differ because enterprises produce not only products of the sector in which they are registered and because producers also engage in other activities than the production that contribute to the turnover, such as installation, repair and maintenance or finishing etc. Therefore the PRODCOM data relates more closely to the trade data as both are product based (rather than based on the reporting entity), even though they are collected using different classifications. Another advantage of PRODCOM data is, that figures are published with a time lag of one year whereas SBS data is finalized with a time lag of 3 years (preliminary SBS data is available a year earlier[4]).

It is therefore recommended to keep the approach from the first carbon leakage analysis and base the trade intensity calculation on Comext data and use SBS data for gap filling, only.

2.2 Data at PRODCOM level

Based on the information available at PRODCOM level in Comext an assessment of trade intensity is possible at a significantly higher level of disaggregation (6- to 8-digit). Table 1 shows an example for disaggregation of three NACE rev.2 sectors based on PRODCOM ANNUAL SOLD data from 2010. It can be seen that trade intensity is both higher and lower at 8-digit level than at 4-digit level to an extent that some subsectors would not qualify for the thresholds defined in the directive while the overall sector would and vice-versa.

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[2] Definition according to the Eurostat metadata on the structural business statistics: “Turnover comprises the totals invoiced by the observation unit during the reference period, and this corresponds to market sales of goods or services supplied to third parties […].Production value measures the amount actually produced by the unit, based on sales, including changes in stocks and the resale of goods and services. The production value is defined as turnover, plus or minus the changes in stocks of finished products, work in progress and goods and services purchased for resale, minus the purchases of goods and services for resale, plus capitalised production, plus other operating income (excluding subsidies).”. See http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/EN/sbs_esms.htm, accessed in April 2012.

[3] Statistical identifier: sbs_na_ind_r2

[4] Statistical identifier: sbs_na_r2preli

Table 1 *Example for disaggregation of three NACE rev.2 sectors: 17.22 Manufacture of household and sanitary goods and of toilet requisites; 23.51 Manufacture of cement and 23.52 Manufacture of lime and plaster*

	Production	Import	Export	Trade Intensity
17.22 Manufacture of household & sanitary goods & of toilet requisites	18 106 568 219	799 113 090	2 432 493 120	**17.09%**
17221120 Toilet paper	5 439 058 041	62 358 690	255 418 090	5.78%
17221140 Handkerchiefs and cleansing or facial tissues of pape	985 864 532	42 292 570	67 936 550	**10.72%**
17221160 Hand towels of paper pulp, paper, cellulose wadding c	2 627 659 877	45 123 610	214 295 300	9.71%
17221180 Tablecloths and serviettes of paper pulp, paper, cellul	1 329 006 314	30 716 710	109 777 350	**10.33%**
17221210 Sanitary towels and tampons, napkins and napkin line	120 990 971	26 323 360	69 378 330	**64.96%**
17221220 Sanitary towels, tampons and similar articles of pape	869 397 211	92 404 910	379 886 650	**49.10%**
17221230 Napkins and napkin liners for babies and similar sanit	4 521 635 483	189 792 840	891 833 450	**22.96%**
17221240 Wadding; other articles of wadding	584 345 065	59 301 580	202 022 810	**40.60%**
17221250 Articles of apparel and clothing accessories of paper	32 000 000	78 828 230	14 752 120	**84.44%**
17221290 Household, sanitary or hospital articles of paper, etc,	884 030 810	52 558 360	126 898 350	**19.16%**
17221300 Trays, dishes, plates, cups and the like of paper or pa	712 579 915	119 412 230	100 294 120	**26.41%**
23.51 Manufacture of Cement	14 156 487 485	349 915 760	643 614 820	6.85%
23511100 Cement clinker	692 505 423	146 685 330	189 901 970	**40.11%**
23511210 Portland cement	11 504 170 321	171 384 420	382 213 250	4.74%
23511290 Other hydraulic cements	1 959 811 741	31 846 010	71 499 600	5.19%
23.52 Manufacture of lime and plaster	3 171 392 750	49 900 700	110 641 740	4.98%
23521033 Quicklime	1 594 549 801	25 457 740	32 210 990	3.56%
23521035 Slaked lime	444 000 000	2 476 820	18 583 330	4.72%
23521050 Hydraulic lime	129 591 454	194 330	2 706 000	2.23%
23522000 Plasters consisting of calcined gypsum or calcium su	802 040 986	17 368 330	48 348 400	8.02%
23523030 Calcined and sintered dolomite, crude, roughly trimme	201 030 509	3 450 220	8 129 720	5.66%
23523050 Agglomerated dolomite (including tarred dolomite)	180 000	953 260	663 300	**142.65%**

Source: Eurostat COMEXT PRODCOM ANNUAL SOLD data for 2010, aggregations & calculations by Öko-Institut

PRODCOM ANNUAL SOLD only includes partial information on intermediate products; they are reported only if sold to other firms and not when transferred within a single firm. This might lead to misleading results. An example is cement clinker, an intermediate product that is locally transformed into cement. As only a part of the cement clinker produced in the EU is reported as production; relatively small imports and exports lead to trade intensity over 30 %, whereas the final product cement faces low trade intensity. If the PRODCOM level is chosen as basis for the carbon leakage assessment, these relationships and especially the role of intermediate products in the results would need to be studied more in-depth to avoid misleading findings. A start could be to compare the production volumes in PRODCOM ANNUAL SOLD with the ones in PRODCOM ANNUAL TOTAL to identify product groups with major discrepancies.

Recalling that there are about 4 500 PRODCOM headings at 8-digit level, the number of sectors would be very high, having in mind that the number of installations covered under the emissions trading directive all over Europe is ‘only’ 11 000. This is also due to the fact that one industrial facility may produce products falling into a variety of PRODCOM heading. If emissions trading installations were attributed to headings according to the product category with the highest value (as is customary in statistics based on the reporting entity such as SBS which is the source for GVA data in the assessment); the number of emissions trading installations falling in one sector can be expected to be very low and affect the reliability of the data. Statistical outliers or reporting errors can dominate the result more easily when the number of reporting entities is low and the correct valuation of intermediate products becomes even more relevant.

Whereas for trade intensity a general disaggregation is feasible based on PRODCOM data for the majority of sectors[5], the challenges are even higher for carbon cost because of firms and installations manufacturing products classified in different PRODCOM codes. An attribution of emissions or electricity consumption to different products produced from an integrated production route is always subject to discussion as shows the example of attributing emissions from CHP power plants to electricity and heat. The same applies e.g. to chemical plants producing a variety of substances at the same time and in varying quantities depending on customers demand. The mismatch of data collected on a product basis and on a company basis will increase.

Therefore the recommendation is to stick to the 4-digit level as the principal level of disaggregation in the carbon leakage exercise and complement it with more detailed information where relevant. For sectors providing carbon cost on a subsector basis, the trade intensity can in most cases be easily calculated, too, and added to the assessment.

[5] There are sectors where service plays a major role (e.g. NACE rev.2 sector 33.2 “Installation of industrial machinery and equipment”) and no import/export data is available to calculate trade intensity.

3 Carbon Cost

The indicator of Carbon Cost is the sum of direct and indirect additional costs induced by the implementation of the emissions trading scheme, calculated as a proportion of the gross value added (GVA)[6]:

$$CarbonCost = \frac{DirectCosts + IndirectCosts}{GVA}$$

$$= \frac{(DirectEmissions * \%tobepurchased + ElectricityCons. * EmissionFactor) * CarbonPrice}{GVA}$$

or

$$= \frac{(DirectEmissions - FreeAllocation + ElectricityCons. * EmissionFactor) * CarbonPrice}{GVA}$$

Direct costs are the product of emissions covered by the ETS for which the installation receive no free allocation and the carbon price. This can either be expressed as the product of direct emissions and the share to be purchased (second line of the formulae) or as direct emissions minus free allocation (last line of the formulae). Indirect emissions result from the increase of electricity prices due to the ETS. This is assessed using the average emission factor of electricity production and an estimated carbon price. Data sources should thus include data on direct and indirect emissions, GVA and carbon price. The share of allowances to be purchased to cover direct emissions is assessed in task 2 of this project and therefore not covered in this report but in the report on task 2.

As electricity consumption was not available per NACE sector at 4-digit level for all countries carbon costs were calculated in the last assessment as described in the formula below. Basically only the GVA of those countries that also reported electricity consumption in a specific sector was taken to calculate the indirect carbon cost, calculated as a proportion of the gross value added (GVA):

$$CarbonCost = \frac{DirectCosts}{GVA} + \frac{\sum IndirectCosts_{country-con}}{\sum GVA_{country-con}}$$

3.1 Direct emissions

The availability of direct emissions data is a key challenge that needs to be overcome in order to calculate the value at stake indicator for the carbon leakage assessment. In

6 Gross value added is the value of output less the value of intermediate consumption; it is a measure of the contribution to GDP made by an individual producer, industry or sector (UN data glossary, http://data.un.org/Glossary.aspx?q=Value+added; accessed 22 June 2011).

the first carbon leakage assessment in 2009 a mixture of data from the Community Transaction Log (CITL), from Member States and from the EU inventory (for non CO_2 process emissions) was used to assess direct emissions. For some subsectors (e.g. hydrogen) it was necessary to tap additional data sources.

The experience from the data collection exercise for the first carbon leakage list showed that whenever possible the use of a single data source is preferable because of the difficulties to avoid double counting when several data sources are used (e.g. in the case of opt-ins if N_2O emissions are based on the inventories). Data collection by Member States proved to be very resource intensive (both for Member States and the Commission), many Member States had difficulties collecting the data and due to confidentiality issues it was not always possible to check the accuracy of the data.

The main data source for emissions is the CITL. Installations included in the CITL are asked to report their NACE code, as well. This information, however, is not part of the information checked by the verifier and may often be incomplete/inaccurate. The effort made by the Commission, DG ENTR, in 2009 to improve the matching of more than 11 000 installations to NACE codes was carried out under great time pressure. When switching from NACE rev.1 to NACE rev.2 the opportunity can be used to further improve the matching of installations. There are for example electricity generation units that report as industrial installations due to ownership rather than activity. And in the case of operators owning several installations those were often reported using the NACE code of the operator whereas the installations would belong to a different (sub)sector. DG ENTR has begun to update the matching of installations to NACE rev.2 codes in the SIM (Sustainable Industry Monitor) database. In the application for free allocation operators were required to report their NACE rev.1 code and could report additionally their NACE rev.2 code. This information included in the NIMs (National Implementation Measures) should be used to double check and correct the information included in the SIM so far.

A challenge is the accurate representation of new sectors that will only enter the EU ETS in 2013 as for these installations data on historic emissions is not included in the CITL and other data sources are not always available. The problem is that emissions of installations entering the EU ETS from 2013 onwards are not available in the CITL for the base period (e.g. 2009 to 2011). In theory this problem could be addressed by taking verified emissions from the baseline data collection according to §7(1) EU ETS directive. For part of the installations either verified emissions for the period 2005 to 2008 or 2009 to 2010 should be available. However, this would have a series of disadvantages:

- It is not clear, if verified emissions from the baseline are complete and can be mapped to NACE 4 sectors.
- Data from the baseline data collection according to §7(1) EU ETS directive is not available for the same period for all installations.
- Due to the high abatement potential of non-CO_2 gases the historic emissions do not realistically reflect the carbon costs in the period from 2015 to 2019.

Therefore, it is proposed to take the free allocation prior to the application of the cross sectoral correction factor (CLEF) in the national implementation measures (NIMs) as a proxy for the verified emissions for all installations that enter the EU ETS from 2013 onwards. They include e.g. emissions from non-CO_2 gases and CO_2 emissions from ammonia production.

From 2013 onwards all emissions will be recorded in the CITL and no additional data sources will be needed anymore. They will be published in April 2014 for the first time.

Summing up; the proposed approach is as follows:

- Use average verified emissions for the period 2008 to 2010 from installations already participating in the period from 2008 to 2012 to calculate direct emissions (energy & process related) for activities already covered under the scheme;
- Use free allocation in the year 2013 before the application of the CLEF (from the NIMs) to calculate direct emissions for activities entering the EU ETS from 2013 onwards;
- Base the matching of installations to NACE-code on the information submitted in the application for free allocation (NIMs).

3.2 Indirect emissions

Indirect emissions are computed by multiplying the electricity consumption with an emission factor for electricity. Data on electricity consumption by industrial sectors is not readily available at European level. In the first carbon leakage assessment electricity consumption data submitted by Member States & processed by EUROSTAT was used. For the first carbon leakage list an average emission factor of 465 g CO_2 / kWh (based on 2005 data) was used for all Member States and sectors.

3.2.1 Electricity consumption

As in the case with direct emissions there were difficulties of data availability and confidentiality. Many Member States had not information on electricity consumption by industry sectors at NACE 4-digit level. To cater for confidentiality concerns the data submitted by Member States was processed by EUROSTAT in the last assessment. After screening the below options it is clear that no real alternative exists for the next assessment:

- Using the electricity consumption from the last assessment is very likely not acceptable by stakeholders. Especially sectors not qualifying for the list would probably attack the approach and claim that the data set is outdated and therefore not reliable.
- From a consistency perspective it would be very elegant to ask ETS installations to report their electricity consumption and include it in the CITL. This would also avoid the problem of double counting emissions related to auto generated electricity. However, it is unlikely that there is enough time to change the

monitoring regulation. Therefore, this option is not elaborated further, but might be a way forward for future updates of the list.

Therefore, it is proposed to keep the existing methodology. The questionnaire would be shortened compared to the last assessment, as information on direct emissions would be taken directly from the CITL and include auto generation of electricity. The new questionnaire would only ask for information on net electricity purchased from the grid for own use (in GWh) by NACE-4 sector.

3.2.2 Emission factor for electricity

The definition of an appropriate emission factor for electricity in the EU-27 is a politically very sensitive topic and should therefore be carefully analysed. For the first carbon leakage list an average emission factor of 465 g CO_2 / kWh (based on 2005 data; Capros 2008) was used for all Member States and sectors. A uniform emission factor based on the average generation has advantages such as simplicity, transparency and equal treatment of sectors across the EU. Therefore it is proposed to keep the approach that has been used for the last assessment. However, in order to analyse the effects of alternative options, different options are discussed below.

The emission factor for electricity is needed to quantify the share of CO_2 costs in the electricity price. This can be determined ex-post or ex-ante depending on the question. There are different methodologies for calculating the average grid emission factor. For instance, the “Tool to calculate the emission factor for an electricity system (version 02.2.1)” prepared for evaluation of electricity generation projects under the Clean Development Mechanism (CDM) considers four options:

a) the simple operating margin (fossil average electricity mix without low-cost/must-run power plants),
b) the simple adjusted operating margin (fossil average electricity mix taking account the percentage of time when low-cost/must-run power plants are at the margin),
c) the dispatch data analysis operating margin (considering the marginal power plant during each hour of electricity demand) and
d) the average operating margin (average electricity mix including low-cost/must-run power plants).

The general approach is that the overall annual CO_2 emissions of the electricity system are divided by the overall net electricity generation. Their suitability is discussed in section 3.2.2.5. The options for calculating the emission factor for electricity assessed further within this paper include:

- Average electricity generation mix (section 3.2.2.1),
- Average fossil electricity generation mix (section 3.2.2.2),
- Marginal electricity generation in the current power system (section 3.2.2.3), and

- Marginal electricity generation considering capacity additions (section 3.2.2.4).

It is proposed to use a uniform emission factors for all sectors, regions or Member States. Region or Member State specific emission factors would contradict the principle of equal treatment of all Member States in community policies. Additionally it can be expected that electricity consumption will not be available for all Member States. Using different emission factors for Member States would mean that data availability would have a high influence on the CO_2 intensity of a given sector[7]. It is also proposed to take the same emission factor for all sectors. The main difference in the emission factor for electricity between sectors is if they have the possibility to use CHP or not. Sectors with CHP often use natural gas and have lower specific emissions. However, this effect (lower emissions from on-site CHP electricity generation) is already taken into account as this is reflected by the CITL emissions and only taking the net-electricity purchase and not the electricity consumption into account.

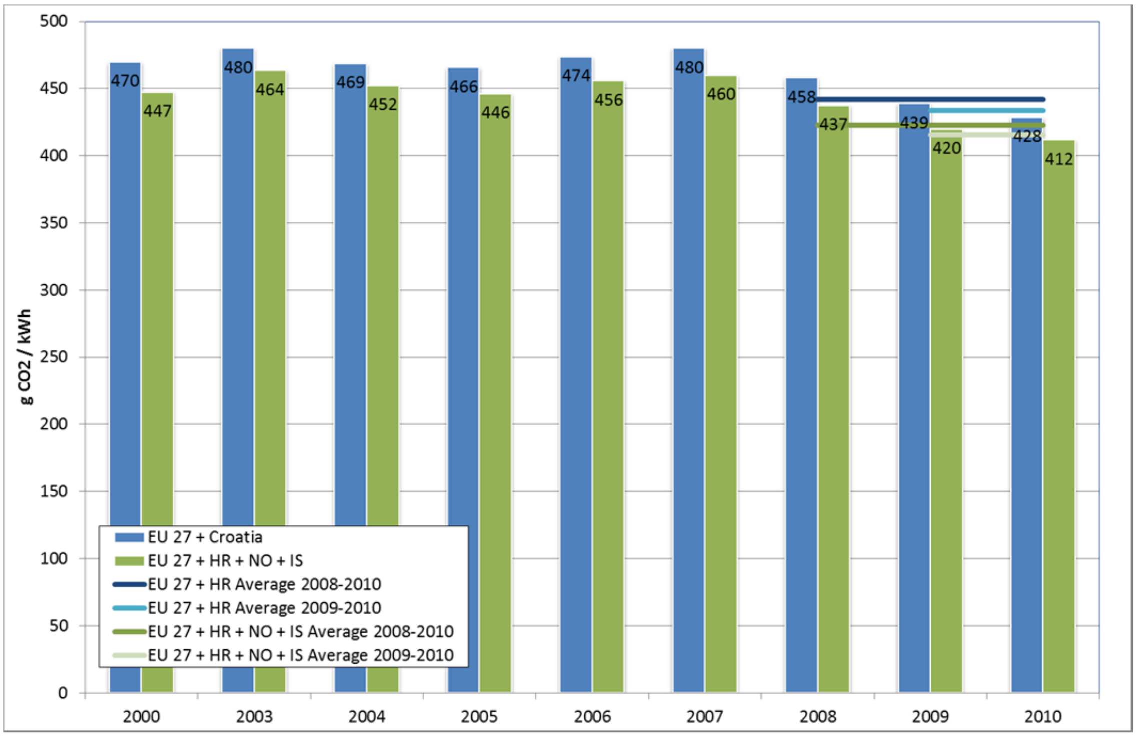
3.2.2.1 Average electricity generation mix

The emission factor based on the average electricity generation mix is the most straightforward method for estimating the emission factor for grid electricity. The general approach is that the overall annual CO_2-emissions of the electricity system are divided by the electricity generation. Due to the extension of renewable energies the average emission factor for the EU-27 is decreasing over time. In 2005 this factor was 465 g CO_2 / kWh (Capros 2008).

The average CO_2 emissions from electricity generation should include electricity generated both from electricity plants and CHP plants from main activity producers as well as auto-producers. IEA (2012) publishes this factor in its publication on CO_2 emissions from fuel combustion for the EU27 as well as Croatia, Norway and Island up to 2010 (see Figure 1). Using the electricity output provided in this publication, a weighted average was calculated for the EU27 plus Croatia as well as EU27 plus Norway, Iceland and Croatia. The CO_2 intensity varies from year to year according to the shares of generation by fuel in the mix. Hydropower generation might vary largely depending on weather conditions. It is therefore recommended to base the emission factor rather on a time period than on a single year; the base period should be identical to the other input parameters into the induced carbon cost calculation. Resulting CO_2 emissions were for the EU27 plus Croatia on average 442 g CO_2 / kWh in 2008-2010 and 434 g / kWh in 2009-2010. For the EU27 plus Norway, Iceland and Croatia were on average 423 g CO_2 / kWh in 2008-2010 and 416 g / kWh in 2009-2010.

[7] No data availability in a country with a high emission factor would lead to a lower CO_2 intensity than in reality and no data availability in a country with a low emission factor would lead to an increased CO_2 intensity.

Figure 1: Average CO_2 emissions per kWh from electricity generation



Source: Calculations by Öko-Institut based on IEA (2012)

An alternative would be to calculate the factor based on Eurostat and GHG inventory data. The emissions would be set in relation to total net electricity generation[8] both from electricity plants and CHP plants from main activity producers as well as auto-producers. Emissions can be calculated based on fuel input and emission factors for fossil fuels.

$$EF\ electricity = \frac{\sum_{i=fuel}(fuel\ input\ el.P_i + fuel\ input\ el.CHP_i) * EF\ fuel_i}{net\ electricity\ generation}$$

Emission factors for fossil fuels can be taken from the EU GHG inventory. Figures for electricity production are available at Eurostat (Annual data on supply, transformation and consumption of electricity[9]) as well as fossil fuel transformation input to electricity plants (Annual data on supply, transformation and consumption of solid fuels[10], oil[11], gas[12] as well as renewables and wastes[13]). The fossil fuel input to CHP plants is available at the same source but reports the input aggregated both for heat and power. To

8 The difference of net to gross electricity consumption is the electricity used in the power stations' auxiliary services.

9 Statistical identifier: nrg_105a.

10 Statistical identifier: nrg_101a.

11 Statistical identifier: nrg_102a.

12 Statistical identifier: nrg_103a.

13 Statistical identifier: nrg_1071a.

derive an emission factor for electricity only, the fuel input (and thus the emissions) has to be attributed to electricity and heat. The heat production of CHP plants (by fuels) is published by Eurostat as well[14].

The attribution formulae recommended for energy balances (2004/8/EC) calculates in a first step the primary energy savings assuming standard efficiencies for separate electricity and heat production. In then attributes the fuel inputs to electricity and heat produced in CHP plants (AG Energiebilanzen 2010).

$$fuel\ input\ el.CHP = fuel\ total\ CHP * (1 - share\ of\ PE\ savings) * \frac{eta\ el.CHP}{eta\ \ el.reference}$$

With:

$$share\ of\ PE\ savings = 1 - \frac{1}{\frac{eta\ therm.CHP}{eta\ therm.reference} + \frac{eta\ el.CHP}{eta\ el.reference}}$$

$$eta\ therm.CHP = \frac{heat\ generated * 100}{fuel\ total\ CHP}$$

$$eta\ el.CHP = \frac{electricity\ generated * 100}{fuel\ total\ CHP}$$

The reference conversion efficiencies are set exogenously, typically the reference conversion efficiency for heat is calculated with 80% and for electricity with 40% (e.g. German energy balance) or 35% (WRI GHG protocol).

3.2.2.2 Average fossil electricity generation mix

The average **fossil** fuel mix means that non-CO_2 emitting electricity generation options such as nuclear and renewable energy are not taken into account, when calculating the emission factor of electricity generation. It is argued that nuclear and renewable energy are not price setting in an electricity market. Therefore, they are not taken into account when the emission factor of electricity generation is calculated.

This approach is also included in the State aid Guidelines for indirect carbon costs compensation where maximum values are defined which may be used for the calculation of the aid amount (European Commission 2012a). The emission factors range from 0.56 g CO_2/kWh (Ireland) and 0.57 g CO_2/kWh for Spain and Portugal to 1.12 g CO_2/kWh for Bulgaria and Estonia. For Central-Western Europe (CWE, including DE, FR, BE, NL, LUX, AT) this leads to an emission factor of 0.76 g CO_2/kWh. For the UK a maximum emission factor of 0.58 g CO_2/kWh was established (European Commission 2012a).

However, it is necessary to raise the question if it is correct to calculate the CO_2 emission factor based on **all** fossil fuels used for electricity generation. In Europe there are

[14] Annual data on supply, transformation and consumption of heat. Statistical identifier: nrg_106a.

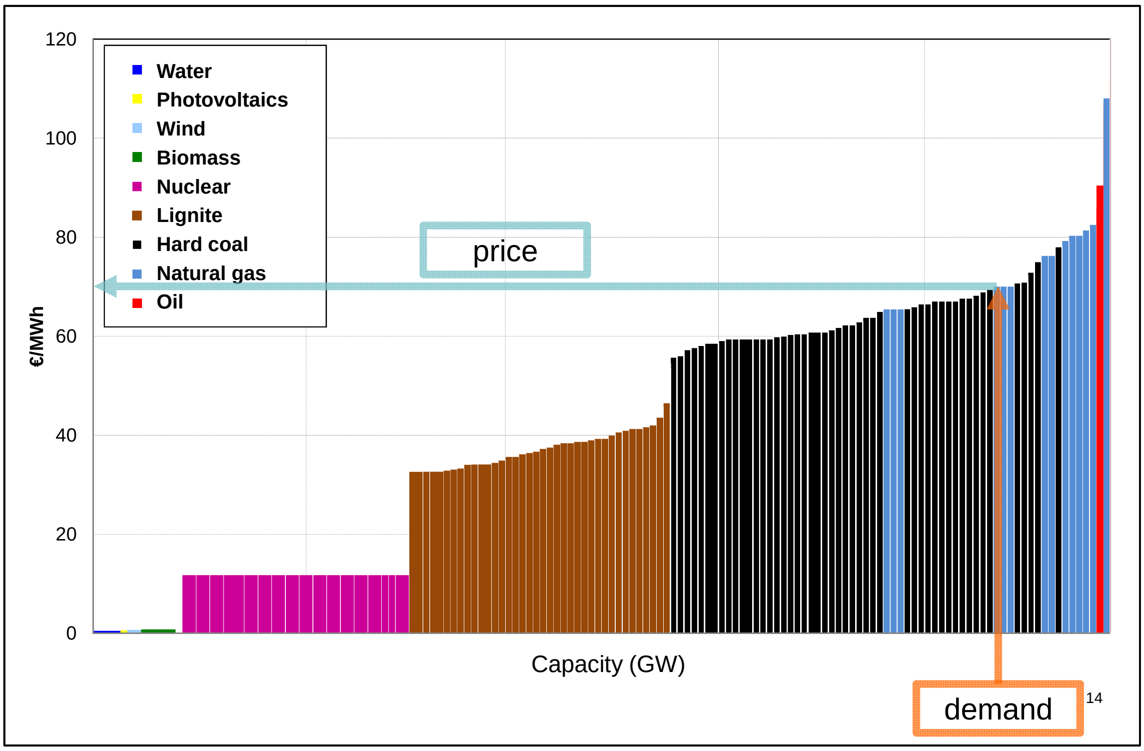
also fossil power plants that are not price setting and could therefore be excluded from the calculation according to the same reasons as nuclear and renewable energy is excluded. More precisely the question is if **fossil base load** power plants (i.e. lignite fired power plants) should be considered when the CO_2 emission factor is calculated.

3.2.2.3 Marginal electricity generation in the current power system

The average generation mix uses average CO_2 emission of the power sector with some power plants factored out similar to the option described above in section 3.2.2.2. However, actual CO_2 emissions depend on the type of power plant dispatched in each point in time.

Figure 2 shows so-called merit order for Germany. In this graph, power plants are sorted according to their short-term marginal generation costs in the year 2008 including fuel and CO_2 costs. This mean that power plants with low marginal generation costs (renewable, nuclear, lignite) are preferentially dispatched. Only with higher system load, hard coal-fired power plants are dispatched and eventually, natural gas-fired and fuel oil power plants are used.

Figure 2: Merit order of the German power sector in 2008



Source: Öko-Institut PowerFlex model

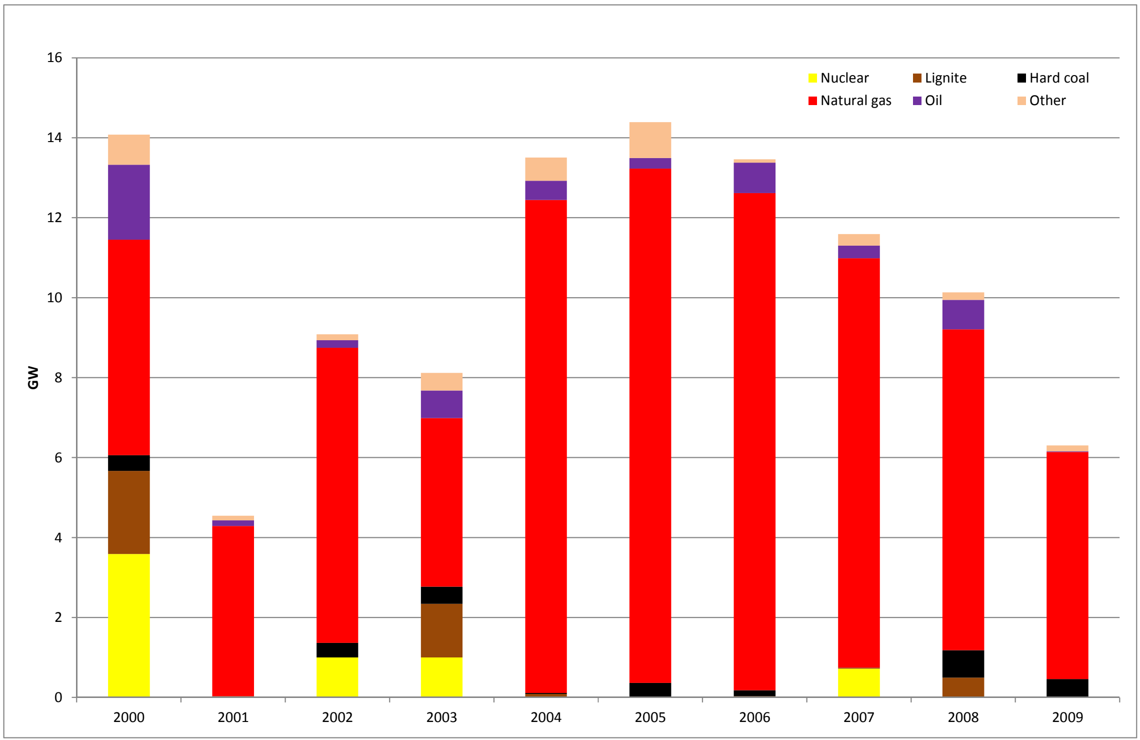
The system load depends on the day time and the week day. For instance, power plants dispatched during the night, are mostly baseload power generators such as nuclear or lignite, whereas in peak hours during day natural gas-fired power plants may be dispatched. In this regard, the related emission factor depends on the load pattern of the electricity system over time.

Within the scope of this project it was not possible to calculate the average marginal electricity generation emission factor for the EU-27, as this would require the use of an European electricity market model. However, it is very likely that results will be slightly lower as the average fossil electricity generation mix (as emission intensive lignite fired power plants are not as often the marginal power plants as coal and natural gas fired power plants).

3.2.2.4 Marginal electricity generation considering capacity additions

Both the average electricity generation mix and the marginal electricity generation as described above relate to the current electricity system. However, load demand by a certain activity does not only influence *operation of current power plants*, but also the *construction of new power plants*. The above-mentioned tool for the estimation of the grid emission factor for the CDM provides several options for calculating the so-called build margin emission factor. In general terms, the build margin is derived from the trend of the types of power plants currently under construction. Figure 3 shows the commissioning of new fossil-fired power plants in the EU-27 between 2000 and 2009.

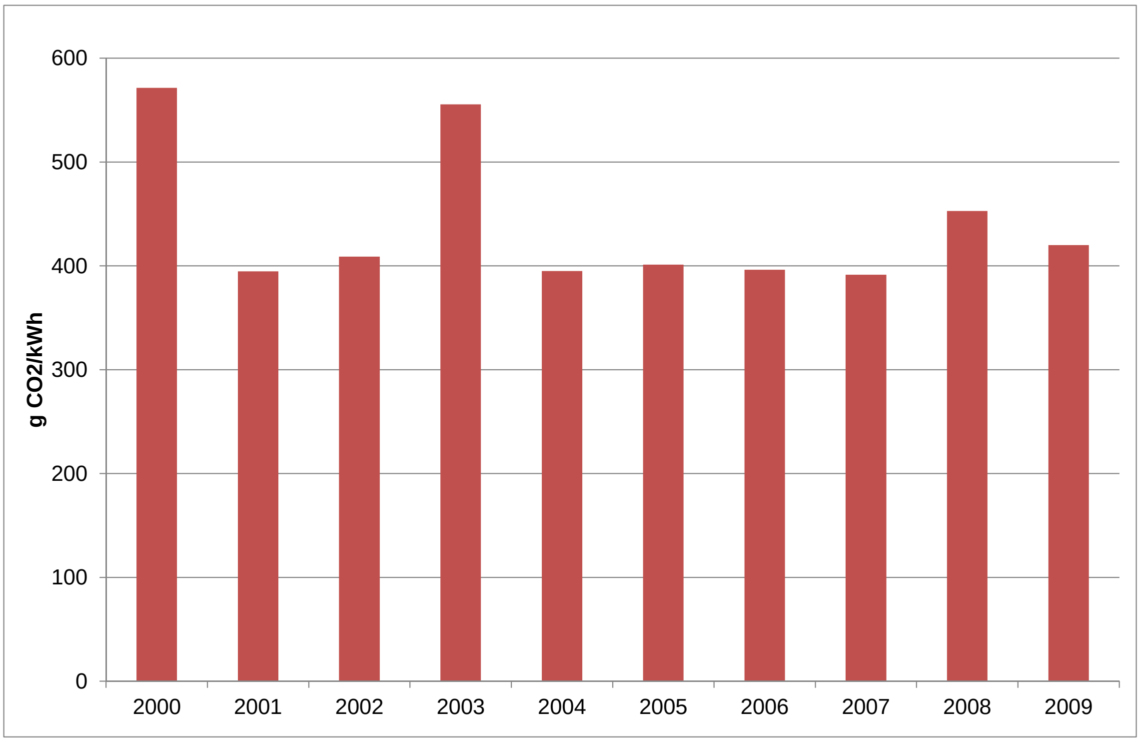
Figure 3: Commissioning of fossil capacities in the EU-27 in GW, 2000 to 2009.



Source: Platts, calculations by Öko-Institut.

It is evident that the majority of new capacity is based on natural gas. Assuming that power plants have the same operating hours per year and an efficiency of 51.7% for new gas-fired power plants[15] and 42.7% for new hard coal fired power plants and 40.3% for lignite fired power plants the average specific emissions of built margin power plants presented in Figure 4 are calculated (CEC 2011).[16]

Figure 4: Average specific emissions of built margin power plants in the EU-27 in g CO_2/kWh, 2000 to 2009.



Source: Capros 2008, DG Competition 2011, Platts, calculations by Öko-Institut.

It can be seen that the built margin specific CO_2 emissions are lower than 400 g CO_2/kWh in most years, which corresponds to a natural gas-fired power plant. Only in 2000, 2003 and 2008 sizeable amounts of coal-fired power plant were commissioned resulting in higher CO_2 emission factors (571, 556 and 453 g CO_2/kWh, respectively). However, all values lie far below the specific emissions of hard coal-fired power plants (793 g CO_2/kWh) and lignite-fired power plants (1,000 g CO_2/kWh).

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15 As a proxy for the mixture of new CCGT, GT and CHP plants.

16 Efficiencies are based on the harmonized efficiency reference values for the year 2001 in Annex 1 of Commission Implementing Decision (C 2011, 9523 final). The document includes higher efficiency values for later years. In order to do a conservative assessment the lower efficiency values resulting in a higher emission factor were chosen. This means the calculated specific emissions slightly overestimate the real specific emissions. The following fuel types and emission factors are used: lignite: 0.112 t CO_2/TJ, hard coal: 0.094 t CO_2/TJ and natural gas 0.056 t CO_2/TJ. Considering the electrical efficiency, this results in the following specific CO_2 emission per kWh electricity produced: lignite 1,000 g CO_2/kWh, hard coal: 793 g CO_2/kWh and natural gas: 390 g CO_2/kWh.

Data for the most recent 3 years would mean that the weighted average emission factor of new built capacity in the years 2009 to 2011 would be taken. Data for the year 2009 suggests a CO_2 emission factor of 420 g CO_2/kWh.

3.2.2.5 Comparison of the options

The electricity emission factor is needed to calculate (together with the carbon price) the induced carbon cost. It should therefore strive to reflect the carbon cost component passed through in electricity prices as far as possible.

There are several options to calculate a CO_2 emission factor for electricity in the EU. It can be based on average emissions of the overall electricity generation mix, of fossil power plants only, of the marginal electricity generation in the current power system or considering capacity additions. Member State specific CO2 emission factors would not be in line with the principle of equal treatment of all Member States in community policies and are not further studied in this paper.

The carbon cost included in the spot price for electricity reflects the carbon intensity of the last power plant deployed to satisfy electricity demand; the power plant at the margin. Depending on the hourly demand as well as conditions for renewable generation, fuel and CO_2-prices, the marginal power plant will differ and thus the carbon intensity; it would therefore require detailed modelling. As a proxy the average emission intensity of fossil electricity generation could be taken as a reference. This approach is customary in certain ex-post analysis e.g. under the CDM and in the discussion about indirect compensation.

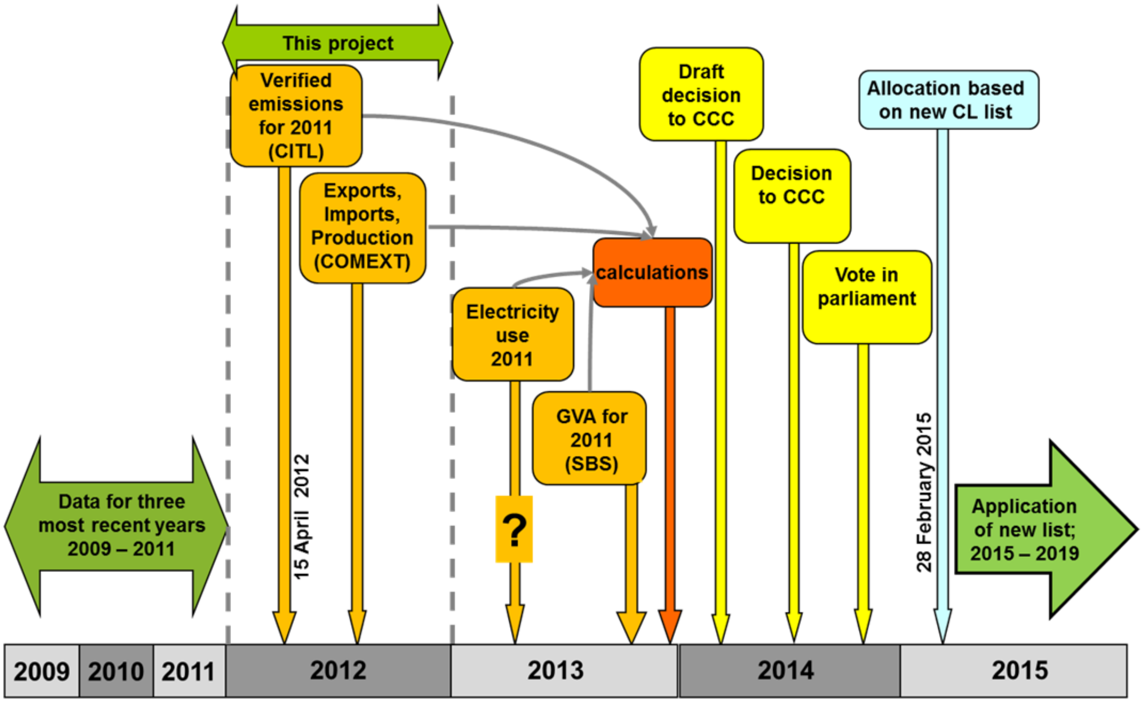
The approach has shortfalls, though. First, renewable energy generation is not reflected in this approach. It therefore neglects that the increase in renewable energy generation has led to lower prices at the exchanges. The short term marginal costs of renewables are near to zero and therefore they are placed at the very beginning of the merit order curve and pushing expensive generation capacities out of the market. Second, industries buy electricity contracts with longer time frames (up to three years ahead) in order not to depend on the volatile spot prices for electricity. Therefore the spot prices do not reflect the cost industries are facing. Third, it does not reflect appropriately the development of the power plant fleet by new built power plants which are replacing older generation capacities. The marginal built approach does reflect fossil capacity additions but not renewable capacities.

It is therefore recommended to keep the approach of using the average emissions per kWh electricity generated. Thus the increasing role of renewable energies is reflected and a uniform approach for all participating Member States is ensured. It is proposed to update the average emission factor for the new base period (2009 to 2011 or 2008 to 2010) based on IEA data. Alternatively it could be computed using Eurostat and GHG inventory data. For this assessment the difference to the emission factor in the first assessment is comparably small (442 or 434 g CO2/kWh depending on the base period compared to 465 g CO2/kWh in the last assessment), but the difference is expected to increase with further updates with growing renewable shares and replacement of old, less efficient fossil fuel generation capacities.

3.3 Gross value added (GVA)

The source of data on gross value added (GVA) used in the past was the Eurostat Structural Business Statistics, the only available source for GVA of industrial sectors at 4-digit level covering all 27 EU countries, Norway, Switzerland, Croatia and Turkey. For some countries and sectors the GVA is available to but not published by Eurostat due to confidentiality concerns (e.g. when the number of firms in the sector is very low or one firm dominating the sectors result). In the last assessment Eurostat calculated the indicator on behalf of the Commission and only provided the resulting value and thus respected the confidentiality. It is recommended to keep the approach.

Figure 5: Overview timeline for data availability and decision steps



Source: Figure by Öko-Institut

There is one challenge, though, concerning the timing. GVA data is published with a time lag of 2 years and substantially later than e.g. trade data or emissions data in the CITL (see Figure 5). Eurostat might assist with preliminary values. If this would not be the case, GVA data would have to be collected from national statistical offices directly at an earlier point of time or the date of publishing might define the "three most recent years" which are the base period according to the directive.

3.4 Carbon Price

In accordance with Article 10a (14) of the revised EU ETS Directive (2009/29/EC), the carbon price selected for the carbon leakage assessment was based upon a modelling exercise in the Impact Assessment accompanying the 'Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020' (CEC, 2008a-c). This modelling exercise produced several carbon price projections with various assumptions, such as the use of offsetting credits, achievement of the renewables target, etc. The projection that mirrored the decision the climate and energy package led to a carbon price of 30€/tCO_2 (Capros 2008). This was used for the first carbon leakage assessment. However, as a consequence of the economic crisis the EU ETS market is currently long and EUA prices are very low (5€ in January 2013) compared to earlier projections. Furthermore, the carry-over of more than 1 000 million surplus EUAs from the 2nd trading period and the continued use of CERs are likely to ensure that carbon prices remain lower than modelling projections.

Given the disparity between the carbon price used in the previous carbon leakage assessment and the current carbon price, it is necessary to consider updating the carbon price to reflect recent developments. There may be certain legal constraints on the use of carbon price, which are not assessed in this report. For the case that no such legal constraints apply, the following three options provide different approaches to carbon price setting based upon current market expectation, historical price trends or updated modelling projections of carbon prices.

3.4.1 Current market expectation for 2015

Due to the longer term impacts of the carry-over of surplus EUAs supressing carbon prices and the prospect of the Eurozone entering a second recession, it may be appropriate to consider setting the average carbon price for the carbon leakage assessment in accordance with the most recent monthly data for the purchase of EUA 2015 futures. The red line in Figure 6 illustrates the development of EUA 2015 future prices since the start of 2012 and the average future carbon price of 9 €/tCO_2 is represented by the black line. It is recommended that the time series of the data is extended (i.e. mid-2013) to provide a more robust average carbon price.

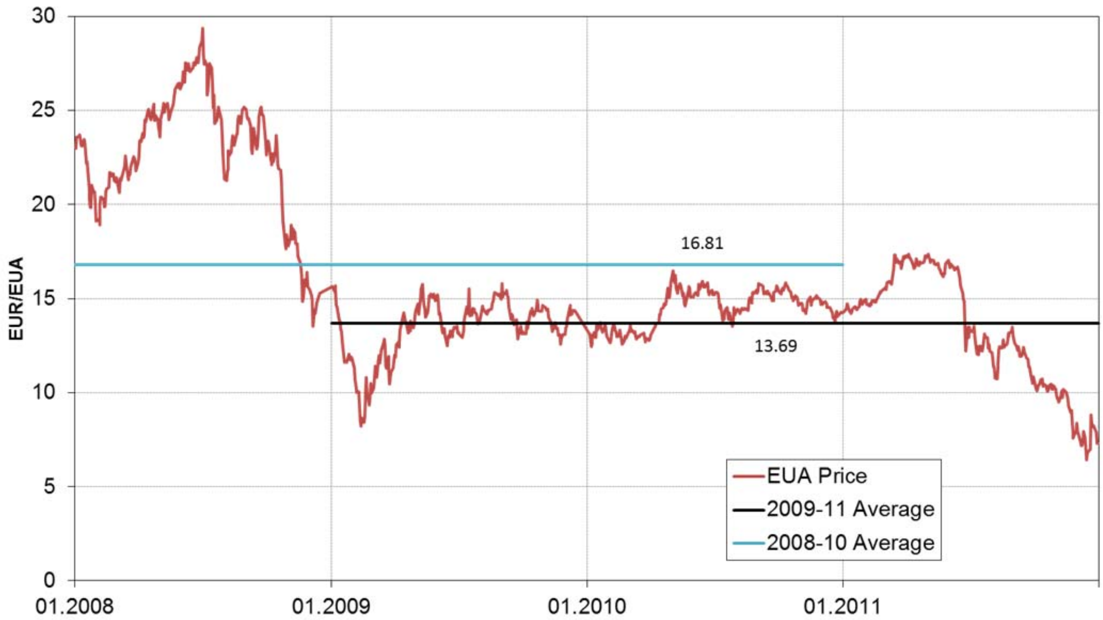
Figure 6: Development of EUA 2015 prices in 2012

Source: Point Carbon (2012) daily OTC closing prices for EUAs with delivery in 2015

3.4.2 Historic trend in the base period

The average carbon price for the carbon leakage assessment may be set in accordance with a longer time series for the three most recent years of available data as for the other components of the indicators. The development of EUA prices with delivery in December of the same year for 2008 to 2011 is shown in Figure 7 by the red line. Depending on the base period chosen, the carbon price would be 13.7 €/tCO_2 (for the time series 2009-2011; represented by the black line) and 16.8 €/tCO_2 if the base period 2008-2010 is chosen (represented by the blue line).

Figure 7: EUA prices for delivery in the same year (2008- 2011)



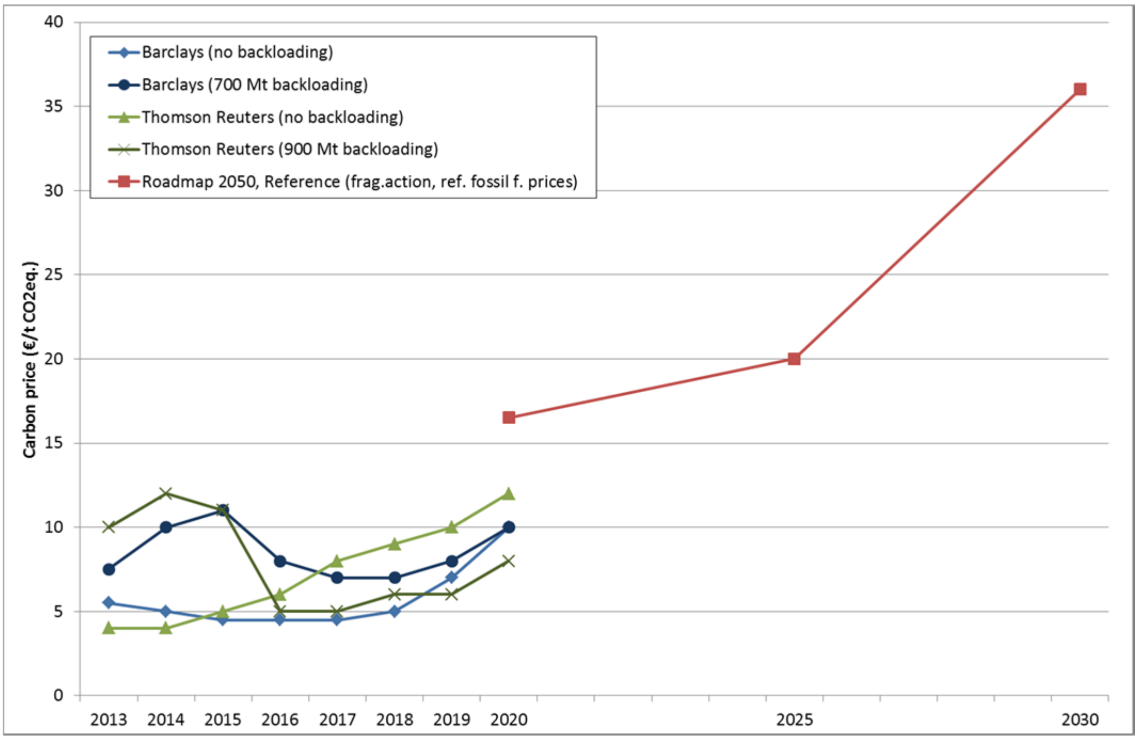
Source: Point Carbon (2012) daily OTC closing prices; presentation by Öko-Institut (2012)

3.4.3 Projections (2050 Roadmap) and short term forecasts

Similarly to the approach adopted in the previous carbon leakage assessment, the average carbon price may be set based upon modelling projections which take into account the economic developments since the implementation of the directive. If this option is preferred it is recommended that carbon price projections are taken from the Impact Assessment accompanying ‘a Roadmap for moving to a competitive low carbon economy in 2050’ (COM 2011). The modelling exercise in the Impact Assessment includes a reference scenario for the carbon price development of the EU ETS until the year 2050. Due to the carbon constraint set by the EU ETS, the PRIMES model can derive the carbon price associated with domestic emission reductions while also accounting for the use of flexibility mechanisms. The modelling exercise accounts for the recent economic crisis and this is reflected by the lower carbon price of 16.5 €/CO_2eq in 2020 compared to previous modelling by the Commission (Figure 8).

There are two shortcomings, though. Current projections rarely show modelling results for a year being part of the 2015 to 2019 period, the validity of the second carbon leakage list. Typically the first year with modelling results will be 2020. Secondly, the roadmap projections were elaborated before the Commission had presented its options to reform the carbon market. Only after verified emissions and surrendered units for 2011 were published, the full extent of the current imbalance of supply and demand became clear. Short term forecast by market analysts may fill this gap. Additionally, the business world might rather orientate itself at financial market forecasts then long-term studies

Figure 8: EU ETS carbon price development of the reference scenario in the Roadmap 2050



Sources: SEC (2011) 288, COM (2012) draft

In the Commission's draft staff working document accompanying the Commission Regulation to determine the volumes of GHG emission allowances to be auctioned in 2013-2020 (COM 2012b draft), several market forecasts are referred to. Two of them, the forecasts of Barclays and Thomson Reuters, include values for the whole period 2015-2019. Two scenarios are shown below; the reference case with no back-loading and the scenario mirroring closest the current draft proposal of the Commission on the timing of auctioning (see Figure 8).

3.4.4 Comparison of the options

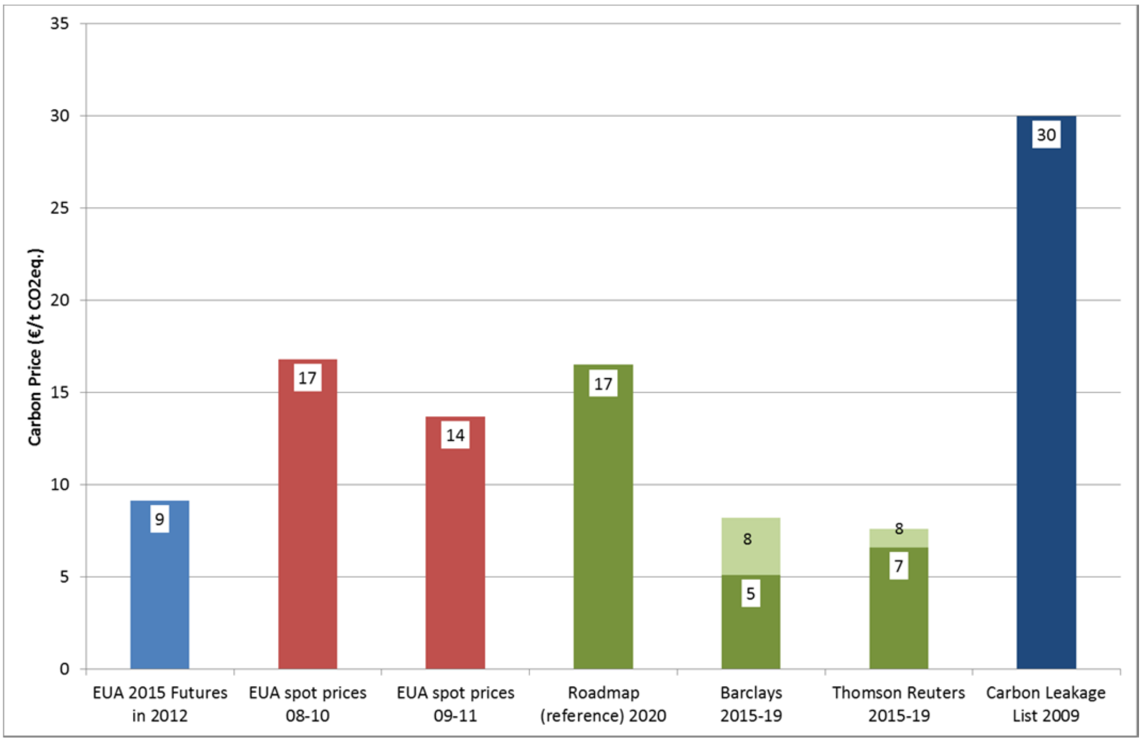
The carbon price in the 2009 carbon leakage list was based on the impacts assessments' projections (Capros 2008). Since 2008 emissions in the EU ETS have experienced a large drop mainly due to the economic crisis which was not anticipated in the economic growth assumptions of the impact assessment. The current imbalance of supply and demand in the EU carbon market have led to low prices at present and the expected price levels of 30 €/t CO_2 are not expected to be reached during the validity of the second carbon leakage list (2015-2019). Therefore an update seems appropriate to mirror the developments if legally possible, which is not assessed in this report.

One option to update the carbon price could be to follow the same approach and rely on recent modelling projections for the EU, e.g. the Roadmap 2050 communication, which reflects the economic developments since 2009. The Roadmap 2050 projects carbon prices of € 16.5 per t of CO_2 in 2020 (see Figure 9). Due to the uncertainty associated with modelling carbon price projections, alternative approaches based on historic trends may set a more accurate average carbon price for the next carbon leakage assessment.

The extended time series of the historic trend (2009-11 or 2008-2010) may provide a more robust average carbon price. An advantage of the approach is that the historic trend ensures that the average carbon price is set within the price fluctuations of the historic data. However, a disadvantage of the approach is the failure to account for future developments of the carbon price and therefore the average carbon price of 13.5 €/tCO_2 may actually be too high if economic conditions in Europe deteriorate further and policy interventions to increase EUA prices prove to be ineffective.

In the absence of a structural reform to address the growing surplus of emission allowances that is building up (i.e. increasing the target of the ETS, set aside of allowances) the prospect of carbon prices continuing to stagnate may serve as a justification for setting a low average carbon price in the carbon leakage assessment in line with the carbon price calculated under the current market expectation (2012) approach. The average carbon price of 9 €/tCO_2 reflects the expectation of the carbon market for EU-As in 2015 and may provide a better indication of how the carbon price will develop in the next few years than previous modelling exercises. Current price forecasts by market analysts expect similar prices of up to € 8 per t of CO_2. In contrast to the Roadmap 2050 projection published in 2011, these forecasts can take the current state of the carbon market in 2012 into account.

Figure 9: Comparison of different EUA price expectations for 2015-2019



Note: For Barclays and Thomson Reuters average values for the lower and higher estimates are shown as stapled bars.

Sources: SEC (2011) 288, COM (2012b) draft, Point Carbon (2012)

At present important decisions shaping the EU carbon market are envisaged. These include the timing of auctions as well as other possible measures to reform the carbon market. Additionally the inclusion of emissions from international aviation might be postponed for a year or replaced by an international agreement. Aviation is expected to be a net buyer and thus influence EUA prices, too. Many of these decisions are expected to be taken before end of 2013 and can be reflected in the updated carbon price for the second carbon leakage assessment. It is thus recommended to update the carbon price based on short term forecasts reflecting the recent developments.

4 Summary

Based on the assessment of data sources the authors of the paper recommend the following sources for the update of the carbon leakage list:

For the calculation of trade intensity the Comext database, PRODCOM ANNUAL SOLD can be relied on for information on trade as well as turnover/production.

For the calculation of carbon cost, quantification of direct and indirect emissions should draw on the CITL as main source and only be complemented for emissions from activities which were not covered by the scheme in the base period. Emission for those 'new' activities could be derived from free allocation decisions. GVA data is recommended to be taken from the Structural Business Statistics (SBS). For electricity purchased for own consumption no European data source could be identified, therefore it is recommended to replicate the data collection exercise with a simplified questionnaire to Member States.

For both the determination of the emission factor for electricity and the carbon price several options are analysed in this paper. It is recommended to base the emission factor for electricity on the average emissions in total electricity generation; this has been the approach in the first carbon leakage exercise, too. The emission factor for electricity should mirror the base period chosen for all indicators and thus be updated based on Eurostat and GHG inventory data.

The carbon price has been the only component in the last carbon leakage exercise that was not based on historic data but on projections which proved to be substantially higher than current prices on the market. Therefore an update is deemed appropriate to reflect the impact of the economic crisis and current developments in the carbon market. The price forecast should mirror the forthcoming political decisions shaping the EU carbon market.

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Support to the Commission for the determination of the list of sector and subsectors deemed to be exposed to a significant risk of carbon leakage for the years 2015-2019 (EU Emission Trading System)

Assessment of two methodologies to determine the auctioning factor

January 2013

Task 2 final report

Service Contract No 07.1201/2011/605733/SER/CLIMA.B.2

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The views expressed in this study represent only the views of the authors and not those of DG CLIMA or any other organization.

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List of abbreviations

AF	Auctioning Factor
BM	Benchmark
CHP	Combined Heat and Power
CITL	Community Independent Transaction Log
CL	Carbon Leakage
CLEF	Carbon Leakage Exposure Factor
CO2 Eq.	Carbon dioxide equivalents
CSCF	Cross-sectoral Correction Factor
HAL	Historic Activity Level
ICC	Induced Carbon Cost
EI	Emission Intensity
ETS	Emission trading system
EU ETS	The European Union’s emission trading system
LRF	Linear Reduction Factor
MS	Member State
NACE	Statistical classification system used by Eurostat
NIM	National Implementation Measures

Executive summary

The Auctioning Factor (AF) represents the share of direct emissions for which a sector needs to buy allowances on the market if it was not exposed to a significant risk of carbon leakage. The Auctioning Factor is used in the calculation of the induced carbon cost (ICC) ratio, where it is used as a percentage by which the direct emissions are multiplied. In the previous carbon leakage assessment for 2013-2014, a generic industry-wide value of 75% has been used.

This document describes two methodologies to determine sector-specific auctioning factors. The advantage of a sector-specific value is the higher accuracy and higher transparency of the auctioning factor. These advantages come at the cost of a higher effort to determine the value. Regardless of which method is chosen, the typical auctioning factor for sectors covered by product benchmarks would be in the range of 50% to 70%.

The two methods described in this report are called the "non-public NIM" method[1] and the "product benchmark" method. Each method is described in detail and is illustrated with examples and detailed calculations, a list with pros and cons and a list with pitfalls and possible solutions.

The non-public NIM method uses data from the non-public NIM files which Member States have submitted to the European Commission for the purpose of determining the amount of free allocation to ETS installations in the course of 2011-2012. In principle this files contain information on allocation, emissions, and relevant NACE codes per (sub)installation. Therefore, this method could theoretically yield a high level of accuracy, but depends to a large degree on the completeness and the correctness of entries like emissions, NACE code and heat flows which may not always have been well-verified. The method is designed to correct for emissions related to imported or exported heat. We expect that especially concerning the NACE code flaws will be found. Repairing each flaw on a case-by-case basis will be very labour intensive. We foresee this process can be managed by only paying additional attention to the largest sectors and installations.

The product benchmark method makes use of information on emissions and allocation that is available in the product benchmark curves. A complexity in this method is that product benchmarks need to be matched with NACE codes. In some NACE codes multiple product benchmarks are applicable, which complicates the calculations. In addition, a fall-back auctioning factor needs to be developed for those NACE sectors not covered by a product benchmark. This method will therefore probably be more time consuming than the NIM method, while it will yield results of equal or less robustness. Multiple issues have been identified in the product benchmark method, and more could

[1] 'Non-public NIM' refers to the National Implementation Measures (NIM) that list the free allocation to ETS installations in the third trading period. Although most Member States have published their national NIM, in general these public NIM files contain less information than the NIM files that have submitted to the Commission. The aggregation of these detailed NIM files is not available to the public, and we call this the 'non-public NIM'.

arise along the process of executing it (the devil is in the details), especially for complex sectors. Therefore, we would recommend pursuing the non-public NIM methodology.

1 Introduction of the Auctioning Factor

The Auctioning Factor (AF) represents the share of direct emissions for which a sector needs to buy allowances on the market *if it was not exposed to a significant risk of carbon leakage*. In other words: it is the difference between the amount of direct CO_2 emissions and the amount of final free allocation in case of "non-leakage" divided by the amount of direct emissions.

A sector that is not exposed to a significant risk of carbon leakage is in general still eligible for a certain amount of free allocation. This amount is amongst others determined by the Carbon Leakage Exposure Factor (CLEF). The CLEF for the years 2013 - 2020 in case of non-leakage is shown in Table 1 below. The average CLEF in the years 2015 - 2019, which is the period to which the upcoming CL revision applies, is 0.5143. Arguments to take an average CLEF in the determination of the risk of Carbon Leakage are:

1) Simplicity: with the average CLEF the total net carbon costs in the period 2015-2019 can be calculated. The result for 2015-2019 will be identical to the one where a calculation per year is done.

2) Cost-effectiveness: using an average CLEF means that the CL-list for 2015-2019 can be determined ex ante, instead of changes per year per sector. A year-specific CLEF would imply that an exposure status per annum is determined, e.g. a sector could be not-exposed in 2015 and could become exposed in 2016 to 2019 (when the CLEF becomes lower). This would imply annual adaptations to the whole CL-list and related implementation efforts by competent authorities. This is estimated to be a less cost effective solution compared to the situation with one list applicable for 2015-2019.

Carbon Leakage Exposure Factor	2013	2014	2015	2016	2017	2018	2019	2020
no CL	0.800	0.729	0.657	0.586	0.514	0.443	0.371	0.300

Table 1: Carbon Leakage Exposure Factors that are applied in case of no significant risk of carbon leakage

1.1 Sectoral vs. uniform Auctioning Factor

In this report we propose two methodologies to obtain a sectoral Auctioning Factor. What are the pros and cons of a sectoral AF compared to a uniform one?

- The biggest advantage is the **higher accuracy**. This is because the sectoral AF is based on the free allocation and emissions per sector. Sectors with a large share of non-eligible emissions (e.g. from self-generated electricity) or sectors with a relatively large difference between product benchmark and average emissions, are expected to have a relatively high demand of allowances at the auction. They will therefore have a higher auctioning factor than sectors with for example a relatively flat product benchmark curve. The auctioning factors for product benchmarked sectors are expected to be in between ~50% (for homogeneous sectors) and ~70% (for very heterogeneous sectors in terms of emission intensity).

- In addition, a sectoral factor is **more transparent** to stakeholders. Each sector could in principle do the calculations themselves leading to more stakeholder involvement and again higher accuracy of the data.
- A drawback of developing sectoral AFs is the **higher effort** it may take to develop them compared to a uniform factor, both for the Commission as well as to stakeholders. Given the fact that the upcoming leakage decision is about 10-100 millions of euros of compensation in the form of free allocation of allowances per sector, we recommend to invest in a more accurate sector-specific auctioning factor.

1.2 Calculation of the Auctioning Factor

For the purpose of calculating the AF, the CLEF is applied to the "basic amount of allocation" on sectoral level, i.e. the allocation to a sector without application of any carbon leakage factor[2]. The basic amount of allocation can be determined for each installation within a sector by multiplication of the historical activity level (HAL) of relevant sub-installations with the appropriate benchmarks (BM)[3]. Aggregation of the basic allocation over all sub-installations within a sector yields the basic allocation on sectoral level.

In summary, the average sectoral auctioning factor could be calculated as:

$$AF_{sector} = \frac{Direct\ emissions_{sector} - CLEF\ \times Basic\ allocation_{sector}}{Direct\ emissions_{sector}}$$

$$= 1 - 0.5143 \times \frac{Basic\ allocation_{sector}}{Direct\ emissions_{sector}}$$

Or:

$$AF = 1 - 0.5143 \times \frac{\sum_{subinstallation}^{sector} HAL \times BM}{Direct\ emissions}$$

Note that the amount of final allocation in case of "non-leakage" could be reduced by means of the linear reduction factor (LRF) or the cross-sectoral correction factor (CSCF)[4]. This would increase the amount of allowances an installation needs to buy on

2 The term "basic allocation" is also used in Guidance Document 2, Ch 4.1.

3 In principle this has been done on sub installation level. The relevant benchmark can be a product, heat, fuel or process emissions benchmark.

4 The LRF applies to all installations that are identified as "electricity generators"[4] and to all new entrants after 2013; the CSCF applies to all other installations. Electricity generators are defined in article 3(u) of Directive 2009/29/EC.

the market. Therefore, in principle these correction factors should be taken into account when determining the Auctioning Factor. This can be done by multiplication of the basic allocation with the respective correction factor. Note: this will not result in a circle argumentation: the AF calculation takes the impact of the correction factors into account only once.

A possible complexity is that part of a sector could be subjected to the linear reduction factor (the “electricity generators”), while the other part of the sector could be subjected to the cross-sectoral correction factor. Details specifying which part of the sector is subject to which correction factor are not publicly available. In the remainder of this document it is assumed that the linear reduction factor is applicable to a minority of the installations (in terms of emissions) and therefore could be neglected in a first order calculation, while the CSCF is assumed to be 1.0 (and therefore does not play a role in the calculations).

1.3 Use of the Auctioning Factor

The Auctioning Factor is used in the calculation of the induced carbon cost (ICC) where it is used as a percentage by which the direct emissions are multiplied. In the previous carbon leakage assessment for 2013-2014, a generic industry-wide value of 75% has been used. The induced carbon cost (ICC) is calculated as:

$$ICC = \frac{(Direct\ emissions\ \times Auctioning\ Factor\ + Indirect\ emissions) \times CO_2 price}{GVA}$$

If we apply the formula for AF into the above equation for the ICC we obtain:

$$ICC = \frac{(Direct\ emissions - 0.5143\ \times Basic\ allocation + Indirect\ emissions) \times CO_2 price}{GVA}$$

The scope of the parameters in the equations is the sectoral level, which for practical reasons could be defined by the NACE4 code structure of Eurostat in most cases.

According to the ETS Directive, data should “… be based … if available, trade, production and value added data form the three most recent years for each sector or subsector”. This does not automatically imply that the other parameters in the ICC equation, like the auctioning factor, should also be based on the three most recent years. Therefore, in this document we have used the most recent data available, which is not necessarily data from the three most recent years. For example, the product benchmark values are based on data from 2007 and 2008. More recent data is not available. The amount of free allocation is based on activity levels which could be from 2005 – 2008 or 2009 – 2010.

2 Scope of direct emissions

2.1 Self-generated electricity

A general point of attention is the scope of the direct emissions in the calculation of AF and ICC. How to deal for instance with direct emissions within a sector that are related to self-generated electricity or heat that is exported to other ETS installations?

In case a sector contains a plant that is self-generating electricity, on-site direct emissions will in general be higher compared to a plant where electricity is purchased, while the allocation to both plants will be similar. This leads to a higher auctioning factor for sectors with a lot of self-generated electricity. Will this lead to a larger ICC compared to a sector that purchases the same amount of electricity from the grid? The answer is no, provided that the indirect emissions are determined by using electricity purchased from the net and not electricity consumption (otherwise there will be double-counting).

Example:

		sector 1	sector 2	
Direct emissions		90	60	tCO2
	for self-generated electricity	30	0	tCO2
	for production	60	60	tCO2
Indirect emissions (from elec purchase)		0	30	tCO2
Allocation		60	60	tCO2
GVA		40	40	k€

Auctioning factor			
	1-0.5143 x Alloc / Direct emissions	65.7%	48.6%

Induced carbon cost ratio			
	if based on purchased electricity	4.4%	4.4%
	if based on consumed electricity	6.7%	4.4%

Table 2 *Emissions from self-generated electricity lead to a higher AF but should not lead to a higher ICC, if the ICC uses indirect emissions based on net purchased electricity from the grid.*

Conclusion: direct emissions for self-generated electricity can be included in the direct emissions component of the AF equation, provided that indirect emissions in the ICC calculation are based on electricity purchased from the grid.

2.2 Heat import / export

In case of **heat import from and/or export to other ETS installations**, a mismatch may occur between direct emissions and allocation depending on the methodology to determine the AF.

In case of the non-public NIM method: direct emissions are attributed to the exporting installation whereas the free allocation goes to the heat consuming installation. On a sectoral level this may cause a mismatch between emissions and allocation in case the installations involved belong to two different NACE codes. This may occur e.g. in case of CHP plants exporting heat to manufacturing plants, or for instance in the pulp and paper industry.

In case of this mismatch a correction needs to be applied, for instance as follows:

- For installations having cross-sectoral heat export: direct emissions related to the heat export need to be deducted from total direct emissions;
- For installations consuming cross-sectoral heat: direct emissions need to be increased with direct emissions that can be related to the consumed amount of heat.

Emissions related to imported or exported heat could be calculated by multiplying the amount of relevant heat (in TJ) by the heat benchmark (62.3 tCO_2/TJ).

In case of the product BM method: the product benchmarks did take into account emissions from heat consumption (even if the heat was imported). No mismatch occurs for the net importing sector. However, the product BM values did not take into account emissions related to heat export. In case of net heat export from one sector to another sector, this may cause an issue for the AF of the exporting sector.

In case of **heat export to non-ETS installations**, no mismatch between emissions and allocation occurs by definition, as the ETS installation receives the allocation anyhow, while also being required to hand over emission allowances for the associated emissions.

In case of **heat import from non-ETS installations,** no mismatch occurs between direct emissions and allocation: in the non-public NIM method the mismatch does not occur because no free allocation is provided for non-ETS heat consumption and the emissions take place elsewhere as well. In the product BM method, it is considered not an issue because both allocation and emissions in that method are based on the same benchmarking curves.

3 Non-public NIM method

3.1 Introduction

In the course of 2011-2012 each Member State (MS) submitted a (non-public) NIM file to the European Commission. A NIM file contains all installations of the respective MS that will participate in phase III of the EU-ETS and the preliminary free allocation for these installations including detailed information such as emissions, energy flows, historical activity levels, heat balance, electricity balance, etc. Installations only producing electricity are not eligible for free allocation (with a few exceptions) and for those installations historical data has not been collected.

The majority of Member States also published their NIM file on the internet; this public NIM file contains in general limited information, in most cases only the preliminary free allocation to installations is included.

3.2 Data sources

This method uses two data input sources:

- 27 NIM files (1 file per Member State);
- "Matching file" of DG ENTR in which CITL installations are matched with NACE codes[5].

3.3 Detailed description of method

1. Sort all installations within EU27 per NACE4 code (rev 2.0) using the 27 NIM files.
2. Improve the sorted list by comparing the result with the "matching file" of DG ENTR. In case the two sources have a discrepancy in terms of NACE4 code: case-by-case investigation which source contains the most representative NACE code and list results for updating the "matching file" of DG ENTR.
3. Collect direct emissions per installation per sector. As a quality check one could compare the emissions per installation with the emissions from CITL (available in "matching file" of DG ENTR). This check is not feasible for installations with a scope extension or installations that are new to the EU-ETS.
4. Collect cross-sectoral heat flows per installation (export or import). Heat exported to or imported from ETS installations has been filled in the NIM file, both the amount of heat per year as well as the name of the connected ETS installation(s). Using the list with ETS installations and NACE codes obtained in the previous step, one can check whether the identified heat flow is cross-sectoral or not.

[5] This file has also been used in the 2009 CL assessment of the Commission and has been continuously updated and improved over time. The current status and quality of the matching file of DG ENTR is not known to the consultants.

5. Correct direct emissions for the cross-sectoral heat flows:

   a. For installations having cross-sectoral heat export to other ETS installations: direct emissions related to the heat export need to be deducted from total direct emissions.

   b. For installations consuming cross-sectoral heat from ETS installations: total direct emissions need to be increased with direct emissions that can be related to the consumed heat.

   Emissions related to imported or exported heat could be calculated by multiplying the amount of relevant heat (in TJ) by the heat benchmark value (62.3 t CO_2/TJ).

   For a suggestion on a sensitivity check, see the last point below.

6. For each installation, take the median of the (corrected) direct emissions in the chosen baseline period.

7. Calculate the sum of the median values obtained in the previous step per NACE4 code.

8. Calculate the sum of the basic allocation per NACE4-code. In the NIM file the basic allocation can be found for each installation per sub installation. Unfortunately this is called “Prelim 2013 Alloc”, although the term preliminary is also used for the basic allocation times the CLEF! Therefore, care should be taken that the basic allocation is taken.

9. Calculate the Auctioning Factor per NACE4 code according to the first equation provided in the introduction. As a sensitivity check on point 5 one could check the effect per NACE code of omitting the cross-sectoral heat correction.

3.4 Example with detailed calculations

Example: manufacture of cement (NACE 2651 under rev 1.1, NACE 23.51 under rev 2.0)

Note: this example can only be based on NIM data that has been published by Member States. For data that is not in public NIM data, assumptions have been made.

1. Installations within EU27 are listed using 16 public NIM files, as have been publicly available on April 12, 2012. Sorting per NACE4 code cannot be done as the public NIM files do not contain this information.

2. Installations residing under NACE 26.51 are sorted using the “matching file” of DG ENTR. In total, 267 cement manufacturing installations are identified in EU27, of which the preliminary allocation for 2013 is known of 81 installations (30% of all cement installations representing 31% of emissions).

3. Direct emissions per installation have been collected using CITL data.

4. This step cannot be done with the public NIM files. However, cross-sectoral heat flow between cement and other sectors are expected not to be significant, and can therefore be neglected.
5. Not applicable.
6. The chosen baseline is not available. From CITL, the highest median of direct emissions in
   2005 - 2008 or 2009 - 2010 is taken. It is assumed that the highest emissions are correlated to the highest activity levels, and hence represent the chosen baseline period.
7. The sum of median values is 51.2 million tCO2.
8. The basic allocation is not available in the public NIM files. Assuming that for clinker production the preliminary allocation is equal tot the basic allocation (because fully exposed to a significant risk of carbon leakage), the sum of the basic allocation is 48.9 million EUAs.
9. The Auctioning Factor for NACE 26.51 is therefore calculated as 50.8%. This is the mean AF for the period 2015-2019.

Annum-specific auctioning factor

One could also calculate an AF per year. This would for the example described here give a substantial range to the AF (see Table 3), which could for example lead to sectors being not exposed to Carbon Leakage in 2015 – 2016 and becoming exposed in 2017-2019. This would imply that annual updates to lists are required, including accompanying implementation efforts by Competent Authorities.

Table 3: Annum-specific auctioning factors in 2015-2019 for the manufacture of cement.

2015	2016	2017	2018	2019
37.2%	44.0%	50.9%	57.7%	65.1%

3.5 Pro and con analysis

Table 4: Pro-con analysis of non-public NIM method

PRO	CON
High level of data availability (including for new sectors).	Commission needs to confirm legal basis to use data
Verified data, but limited to materiality impact on allocation.	NIMs could contain flaws, especially for those items that do not influence the allocation in a material way, e.g. CO_2 emissions, NACE codes. The Commission has done several checks on the data in the NIMs (not clear whether all data needs for this methodology have been checked).
Straightforward calculation.	In case of caveats (see previous point) a case-by-case check may be needed, which may be labour intensive.

A remark (neither pro nor con): UK and Germany have not used the standard NIMs data template. It is not fully clear to the team of consultants what level of detail has been submitted to the Commission.

3.6 Pitfalls and solutions

Table 5: Pitfalls and solutions for the non-public NIM method

Pitfalls	Solution
The NIM file may not contain a NACE4 code for a given installation.	If the installation has participated in phase 2, the corresponding NACE4 code can possibly be extracted from the DG ENTR file in which CITL installations are matched to NACE4 codes. If the installation is not present in CITL yet, or the DG ENTR file does not contain the NACE4 code, and the NACE code cannot be determined, one could take out the installation from the analysis. If the number of remaining installations within the NACE code is large enough, this will not have significant consequences on the AF, because both emissions and allocation of the installation will be removed from the analysis.
An installation could have reported an incorrect NACE4 code in the NIM file.	To which extent this caveat happens can be checked by comparison of the reported NACE4 code with the DG ENTR file in which CITL installations are matched to NACE4 codes.

Some installations produce products residing in different NACE4-codes. Allocating all emissions and allocation of that installation to a single NACE4-code may not be most accurate.	Because more detailed data is not available, this point cannot be addressed in this methodology. This point does not occur in the product BM method. It is expected that this situation occurs for a limited amount of sectors. Note that a similar issue occurs for GVA, which is determined by attributing the whole GVA of a legal entity to the primary NACE code of the legal entity; so the error may impact both sides of the ICC with a comparable effect and therefore is less serious.
Plants that entered the ETS in phase 2, but chose 2005-2008 as baseline period may not have provided their 2005 - 2007 emissions in the data collection template.	Use the highest number of either 2008 or median (2009, 2010). This gives a too low number for plants that have 2005 -2008 as baseline period, and have 2008 emissions lowest or second lowest in this period. If 2008 emissions are highest or second highest, it yields a too high number. Because multiple plants will be grouped per sector, this effect will be cancelled out partially.
For plants that were not involved in ETS phase 2, but participated in phase 1 (e.g. steam crackers, ammonia plants), emissions in 2008 - 2010 may not be available. This is an issue for those plants that have 2009 - 2010 as baseline period.	It can be assumed that due to the economic crisis from 2008 onwards, most plants will have used 2005 - 2008 as baseline period. In those cases 2008 data is missing. As solution one could take the average of the two highest values of 2005 - 2007, instead of the median of 2005 - 2008, which would yield essentially the same result (if 2008 had the highest emissions) or a somewhat larger value (in all other cases).
An installation which is new in ETS phase 3 may not have filled in its CO_2 emissions.	For plants that are joining in phase 3 for the first time, the emissions are not available in CITL. These plants could be neglected, or help from Member States could be asked. The auctioning factor for this limited amount of sectors could be based on either phase 1&2 plants in the same sector.
Some NACE4 sectors may not have any ETS installations, in which case no auctioning factor can be determined.	This situation will happen for many relatively small (in terms of direct emissions) NACE4 sectors. For these sectors a fall-back factor needs to be established. The fall-back auctioning factor could be the weighted average of the auctioning factors that have been calculated based on this methodology. Alternatively, one could derive a fall-back auctioning factor as described in the product BM based methodology.
Mismatch between historical emissions and actual emissions in case of significant capacity changes. In case of significant capacity increases the emissions are too low, in case of significant capacity decreases it is the other way around.	Based on our experience, we expect that there are more increases than decreases, so the increases and decreases do not cancel out each other. The number of significant capacity increases is overall not so large (based on experience in the Netherlands), but for some sectors it might be crucial to take them into account. Solution: neglect it for the time being; let this be solved by sectors themselves if they find this necessary.

3.7 Conclusion

This route could theoretically yield a high level of accuracy, but depends for a large degree on the completeness and the correctness of the NIM file, i.e. the completeness and correctness of entries like emissions, NACE code and heat flows which may not have been well-verified. The consultants expect that especially concerning the NACE code many flaws will be found. Repairing each flaw on a case-by-case basis will be very labour intensive. We foresee this process can be managed by only paying additional attention to the largest sectors and installations, and especially to those sectors for which when applying the full Induced Carbon Cost Ratio the result is close to the threshold.

4 Product benchmark approach

4.1 Introduction

In the introduction of this report it was showed that the auctioning factor can be calculated by means of the following equation:

$$AF = \frac{Direct\ emissions - CLEF\ \times HAL\ \times BM}{Direct\ emissions} = 1 - \ 0.5143 \times \frac{HAL \times BM}{Direct\ emissions}$$

For product benchmarks, the historic activity level HAL is equal to the amount of product produced, expressed in tonnes per year. Direct emissions per year divided by production per year is equal to the weighted average emission intensity, EI_{av}. In other words, for product benchmarks, the product-specific auctioning factor, AF_p, can be calculated using:

$$AF_p = 1 - 0.5143 \times \frac{product\ BM}{Direct\ emissions\ /\ tonne\ of\ product} = 1 - 0.5143\ \times \frac{product\ BM}{EI_{av}}$$

with EI_{av} being the weighted average emission intensity of a product. Interestingly, the product benchmarking curves can be used to provide both product benchmark values as well as the average emission intensity for a given product.

Note: the average emission intensity obtained from the benchmarking curves will be an installation average, not a volume-weighted average. In general, the more efficient installations (on the left hand side of the BM curve) will produce larger volumes. Hence, the weighted average will usually be somewhat lower than the installation average, but the extent by how much will depend on the characteristics of the sector.

4.2 Data sources

This method uses the following data input sources:

- Product benchmark values and average CO_2 emissions per ton product (available within DG CLIMA);
- “Matching file” of DG ENTR in which CITL installations are matched with NACE codes[6];
- Production quantities per Prodcom8-code: available through ComExt (Eurostat);
- NACE4-sector list (rev 1.1 and 2.0): available via Eurostat.

[6] This file has also been used in the 2009 CL assessment of the Commission and has been continuously updated and improved over time. The current status and quality of the matching file of DG ENTR is not known to the consultants.

4.3 Detailed description of method

1. Make a match/coupling between product benchmarks (and the corresponding auctioning factors) and NACE4 rev 2.0 sectors. This can be done on the basis of expert judgement[7]. Some product BMs are applicable in one NACE4-sector, others (e.g. mineral wool) might be applicable in multiple sectors. In the latter case, a distribution key needs to be determined, for example on the basis of production quantities. This will result in sectors fully or partially covered by one or more product BMs, or sectors not covered at all.
2. Calculate the auctioning factor for each product BM, using the equation provided in the introduction, i.e. $AF_p = 1 - 0.5143 \times \frac{product\ BM}{EI_{av}}$. Product benchmark values and average CO_2 emission intensities are available within DG CLIMA. This gives product specific auctioning factors, AF_p. Note, step 1 and 2 can be executed in parallel.
3. Determine the share of direct emissions per NACE4 sector that is covered by one or more product-specific auctioning factors AF_p (determined in step 1). The result is the share X_p of emissions covered by AF_p.
    - The share of emissions of a NACE4 code that is covered by a product benchmark (X_p) can be calculated as follows:
        - First, the total amount of emissions covered by each product specific auctioning factor AF_p is determined by multiplying the (weighted) average emission intensities (from the benchmarking curve) with sectoral production quantities (from Eurostat). Production quantities of the three most recent years (2009-2011) are available at Prodcom8-level and cover both ETS and non-ETS activities. This method assumes that there is at most 1 product BM applicable per Prodcom8-code, which goes well for most cases[8]. By linking product BMs to Prodcom8-codes (multiple Prodcom8-codes could be relevant), emissions per Prodcom8-code covered by product BMs can be calculated. In the end, this yields the total amount of emissions covered by an auctioning factor AF_p within a NACE4 sector.
            - Note: Production quantities in Eurostat are usually sold quantities, not real produced quantities, which may give unrealistic values for intermediate products. This issue could be solved by involving sector organizations for those cases that are identified on the basis of expert judgement.

7 Note: a preliminary match between product BMs and some NACE rev 1.1 sectors has already been carried out in the context of the SIM-project.

8 An example where it does not work is 26.14.12.10 “glass fibre mats” which is covered by two product BMs. Support from sector organizations could be requested for these limited cases.

- Second, from the matching file of DG ENTR direct emissions per NACE4 sector can be obtained, as covered by the EU-ETS. Under the assumption that there is no production of benchmarked products in the non-ETS part of the sector (if existing), it is now straightforward to calculate X_p (= the share of emissions covered per product BM per NACE4 sector).
- If a sector has production of benchmarked products in the non-ETS part of the sector (which could be assessed on the basis of expert judgement or by involving sector organizations), a mismatch occurs between the scope of Eurostat (full sector) and the scope of the "matching file" of DG ENTR (only EU-ETS part of sector).

  This could be solved by replacing production quantities from Eurostat with production quantities as reported by installations in the NIM data report. This, however, implies the usage of data from the non-public NIM files, which may not be available when the product BM methodology is pursued.

o It is recommended to check the end results on the basis of expert judgement. This requires detailed knowledge of the system boundaries of the product benchmarks. Expert judgement or input from sector organizations may indicate that the calculated result is not realistic, in which case more accurate data needs to be obtained in cooperation with sector organizations.

4. For the part of the sector not covered by product benchmarks, a fall-back approach is needed.

   A fall-back auctioning factor can be determined in various ways. We will now present two options which differ from the fall-back approach in the non-public NIM methodology.

   o Option 1:

   Presumably the simplest (and perhaps most transparent and politically acceptable approach as well) is to use the same methodology as has been used for the current Auctioning Factor of 75%. In this method, the average amount of direct emissions which are covered by free allocation is used. In the 2009 EC Carbon Leakage assessment it is assumed that this is 40%. Based on the product benchmarking curves (which cover roughly 75% of all free allocation), one could update this percentage, e.g. by taking the weighted-average of all (product BM / EI_{av}). This could for instance yield a value of 65%. The fall-back AF is then: 1 – 0.5143 x 65% = 67%.[9]

[9] Note, no corrections should be made for the overall cap reduction, provided that the CSCF = 1.0

- Option 2a:
  - Fuel consumption per industry category is taken from IEA energy statistics (NACE-sectors have to be matched with IEA industry categories)[10]. Fuel used for the purpose of electricity production (also available within IEA) should be subtracted, because this is not eligible for free allocation. When the result is multiplied with the fuel BM (56.1 tCO_2/TJ) it gives the basic free allocation (=$Allocation_{fuel}$) assuming the sector was covered by the fuel BM;
  - IEA has CO_2 emissions per industry category available[11] (=$Emissions_{fuel}$);
  - The fallback auctioning factor is then:

    $$= 1 – 0.5143 * Allocation_{fuel}/Emissions_{fuel;}$$

  - This option would yield a fall-back auctioning factor per industry category. By linking NACE codes to industry categories, one is able to obtain the fall-back AF per industry category. Alternatively, one could determine one generic fall-back auctioning factor which would apply to all NACE codes, by using the sum of $Allocation_{fuel}$ and $Emissions_{fuel}$ over all categories.
  - Note that this calculation neglects that part of the sector is covered by product BMs or heat BMs. As far as the part of the product BM is concerned, this is not considered as an issue, because the fall-back auctioning factor is only applied to the part of the NACE code that is not covered by product benchmarks. For the part of the heat benchmark, the additional detail for the heat benchmark could in principle be taken into account (see next option).
- Option 2b:

  Option 1 could be made more sophisticated by:

  - Taking into account the share of fuel used for direct heating, and for production of measurable heat. This requires estimates per sector[12] of the typical share of emissions covered by the heat BM and fuel BM, using typical heat production and typical conversion efficiencies.

[10] IEA industry categories are: Iron and steel, Chemical and petrochemical, Non-ferrous metals, Non-metallic minerals, Transportation equipment, Machinery, Mining and quarrying, Food and tobacco, Paper, pulp and print, Wood and wood products, Construction, Textile and leather, Non-specified industry.

[11] Data up to 2009 is available (not for free).

[12] The 2010 AEA report “EU Emissions Trading System: Benchmarking as a Allocation Methodology for Heat from 2013” could be used to determine typical conversion efficiencies.

- The results will allow determination of a fall back auctioning factor per sector based on both the fuel and heat benchmark.

It is expected that for a very limited amount of sectors, process emissions not covered by product benchmarks are significant[13]. Only for this limited amount of sectors (e.g. chemical industry codes), the share of process emissions, X_{pe}, should be estimated. It can be assumed that the process emissions have been allocated to the ETS installation by use of the process benchmark sub-installation (0.97 times historic emissions). For the other sectors, process emissions are assumed to be insignificant. For example, if within a NACE code 5% of the emissions stem from process emissions not covered by a product BM, then the share X_{pe} = 5%.

5. We recommend pursuing option 1 or 2a as this may be considered sufficiently detailed for a fall-back approach. The auctioning factor can now be calculated as:

productBM part:	$X_p * AF_p +$
fuelBM part:	$X_f * (1 – 0.5143 * Allocation_{fuel} / Emissions_{fuel})$
process emissions part:	$X_{pe} * (1 - 0.5143 * 0.97)$

with:

X_i : share of emissions in sector covered by product benchmark (p) or fall-back methodology (f) or process emissions benchmark (pe)

Example: within a NACE code two product benchmarks are applicable with auctioning factors of 65% and 60% respectively. The first product benchmark covers 25% of the direct emissions. The second covers 50% of the emissions. The remaining 25% of emissions is therefore covered by a fallback auctioning factor. Suppose the fallback AF is 55%. Then the auctioning factor for the whole NACE code is: 65% x 25% + 60% x 50% + 55% x 25% = 60%.

[13] Note that process emissions by product benchmarked industrial activities have already been taken into account in the product benchmark approach.

4.4 Example with detailed calculations

Example: manufacture of cement (NACE 26.51 under rev. 1.1, NACE 23.51 under rev. 2.0)

1. The product BMs relevant to NACE 26.51 are white and grey cement clinker.
2. For grey cement clinker production, the share of product BM to installation-average CO_2 emission intensity (=product BM / EIav) is found to be 89%. For white cement clinker this value would be 87% which is very comparable[14].
3. Activities covered under this NACE4 code include the manufacture of clinker, for which there are two product benchmarks. Then, clinker is converted into cement, by a process step that requires mainly electricity. With the assumption that this electricity is purchased and ignoring the remaining fuel use in the last process step, the full sector's direct emissions can be covered by two product benchmarks. The individual coverage of grey versus white cement clinker are not known. Therefore, we assume that the full sector is covered by the product BM of grey cement clinker (impact of assumption is less than 1% point) and Xp = 100%.
4. No fall-back benchmark is applicable to this sector.
5. The auctioning factor is then calculated as follows:

$$= X_p * (1 – 0.5143 * pBM / EI_{av})$$

$$= 100\ \% * (1 – 0.5143 * 0.89)$$

$$= \mathbf{54.2\%}$$

This value compares well to the auctioning factor obtained via the NIM method (50.8% on the basis of 30% representativity).

One could also take into account that the weighted average emission intensity is probably lower than the installation-average emission intensity (large plants are most often more efficient than small plants). A rule of thumb, based on our own expectation, would be to lower the installation-average by 5%. Taking that into account would result in a higher auctioning factor, in this case it would increase to **56.5%**. Since it is in the interest of sectors to have a higher auctioning factor, one could request the (verified) weighted average emission intensity from sector associations.

Example: Manufacture of bricks, tiles and construction products, in baked clay (NACE 26.40 under rev. 1.1, NACE 23.32 under rev. 2.0)

1. The product BMs relevant to NACE 26.40 are "Facing bricks", "Pavers", and "Roof Tiles".
2. The share of product BM to installation-average CO_2 emission intensity (=product BM/EI_{av}) for "Facing bricks", "Pavers", and "Roof Tiles" is found to be 64%, 85%,

[14] Numbers taken from confidential file Heiko Kunst (DG Clima). Not for further distribution.

and 66% respectively[15]. The product-specific auctioning factors are calculated using the equation in step 1 of the methodology and gives 67.1%, 56.3%, and 66.1%, respectively.

3. According to Guidance Document 9 the products "Facing bricks", "Pavers", and "Roof Tiles" are mostly found in Prodcom8 codes 26.40.11.10, 26.40.11.30, and 26.40.12.50, respectively. Production quantities of these Prodcom codes can be extracted from Eurostat.

Table 6: Production quantities within NACE 26.40 in 2009-2011

Production quantities (t) 2009-2011			
Prodcom	26401110	26401130	26401250
2009	57,000	2,100,934	3,081,269
2010	52,000	2,020,991	3,260,683
2011	63,245	1,605,188	3,350,195

Multiplying production quantities with the volume-weighted average emission intensity per product gives total emissions per product.

Unfortunately, the volume-weighted average emission intensity is unknown, but the installation-averages are known to DG Clima (but not based on the three most recent years), and are: 0.217, 0.226, and 0.218 tCO_2/t product, respectively[16].

Using these numbers gives the following estimation on the amount of emissions covered by the three product benchmarks:

Table 7: Estimated emissions related to NACE 26.40 in 2009-2011

Estimated emissions (tCO2) 2009-2011			
Prodcom	26401110	26401130	26401250
2009	12,380	474,564	672,277
2010	11,294	456,506	711,422
2011	13,736	362,584	730,952

How do these emissions relate to total EU ETS emissions in NACE 26.40? The total ETS emissions in NACE 26.40 can be extracted from the "matching file" of DG ENTR and which is shown in the table below.

Table 8: CITL emissions related to NACE 26.40

CITL emissions (tCO2)	
NACE	2640
2009	2,732,639
2010	2,622,888
2011	2,141,571

15 Numbers taken from confidential file Heiko Kunst (DG Clima). Not for further distribution.

16 Numbers taken from confidential file Heiko Kunst (DG Clima). Not for further distribution.

In the next step, the shares of emissions covered by “Facing bricks”, “Pavers”, and “Roof Tiles” can be calculated. Note that different years can be taken into account. In the period 2009-2011, the three product BMs cover on average 0.5%, 17.3% and 28.2% of NACE 26.40, in total 46.0%[17]. The first value of 0.5% seems on the low hand side. We would recommend in this case checking the coverage with the sector association(s), which is outside the scope of the current exercise.

The share not covered by any product BM is 54.0%, for which a fall-back approach is needed.

4. In this example, we assume a fall-back auctioning factor for NACE 2640 of 50% (the value will depend on the option the Commission prefers to determine the auctioning factor).
5. The auctioning factor of NACE 2640 can now be calculated as:

AF =

Facing bricks	67.1% x 0.5% +
Pavers	56.3% x 17.3% +
Roof tiles	66.1% x 28.2% +
Fall-back method	50% x 54.0%

= 55.7%

This outcome is subject to the remarks made under point 3 and 4, and gives the order of magnitude of the AF for this NACE code. A fall-back AF ratio of 40-60% would result in an AF in the range of 50-60%.

The AF for NACE 26.40 can also be calculated using the non-public NIM methodology. Using our dataset, based on a selection of public NIM files, we obtain an AF of **49.7%**, based on emissions and basic allocation data of 31% of the installations identified in NACE 26.40.

17 The year-on-year range of this coverage is between 42.4% and 45.9%.

4.5 Pro and con analysis

Table 9: Pro-con analysis related to the product BM method

PRO	CON
Doable for at least some (important) sectors.	Might be too complicated for a few complex NACE4-sectors, like paper and chemicals. It is unclear how to tackle these complex sectors.
	Matching product BMs with NACE sectors and Prodcom8-codes might be (too) complicated: • If a product BM is applicable to more than 1 NACE4-code (various chemical products, mineral wool) a split is needed; • If multiple product BMs are applicable to 1 Prodcom8-code, a split should be made on the basis of expert judgement or by involving sector organizations; • It may be difficult to link product BMs to Prodcom8 codes.
	Method can be time consuming due to its complexity and the identified issues.
	Very generic approach for sectors which are only limitedly/not covered by pBMs.

4.6 Pitfalls and solutions

Table 10: Pitfalls and solutions related to the product BM method

Pitfall	Solution
The average emission intensity obtained from the benchmarking curves will be an installation average, not weighted by product volumes.	A default correction of minus 5% (i.e. weighted av = 0,95 x av) could be applied, on the basis of preliminary 'expert judgement'. Therefore, an estimate, like 5%, can be mentioned as starting point. Sector organizations might have the data on the shelf and may give improved figures, if needed.
Production quantities in Eurostat are usually sold quantities, not real produced quantities, which may give unrealistic values for intermediate products.	This issue could be solved by involving sector organizations.
Due to statistical misreporting, the use of Eurostat data, especially on Prodcom8-level, may in some cases lead to inaccuracies.	This problem always occurs when Eurostat data is used. Leave it up to sectoral organizations to come with more accurate (and validated) data, if needed.

A mismatch may occur between the scope of Eurostat (full sector) and the scope of the “matching file” of DG ENTR (only EU-ETS part of sector).	This can be solved by replacing production quantities from Eurostat with production quantities as reported by installations in the NIM data report. This, however, implies the usage of data from the non-public NIM files, which may not be desirable / possible when the product BM methodology is pursued. An alternative would be to involve sector organizations.
For sectors with a significant amount of non-ETS emissions, the share of emissions covered by product BMs is overestimated, because the emissions covered by product BMs are not compared with the full emissions in a NACE4 sector (not available) but with the ETS emissions per NACE4 sector (available from “matching file”).	In the calculation of the AF, we assume that the AF calculated for the ETS part of a NACE4 sector is representative for the full NACE4 sector. This assumption is also used in the non-public NIM method. Care should be taken that consistent scopes are taken when calculating shares of emissions (see previous pitfall and solution).
The impact of correction factors is not taken into account.	In case the CSCF < 1.0, we recommend to take this factor into account as described in the Introduction. We recommend neglecting the linear reduction factor in the first draft calculations. For sectors that have an ICC <5% it should be checked whether the LRF, if taken into account, could lead to an ICC >5%.
In case of cross-sectoral heat import and/or export: No mismatch occurs for the net importing sector (in case covered by a product BM) because the product BMs have taken emissions related to heat consumption into account. However, emissions related to heat export are not included in the product BM values. In case of net heat export from one sector to another sector, this may cause an issue for the AF of the exporting sector.	Because of the complexities involved, we recommend not take this issue into account in the first draft calculations of the AF, using the product BM method. The issue could be discussed with the relevant sector associations, and could be taken into account (if sectors provide sufficient data) at a later stage.

4.7 Conclusion

Two NACE4 sectors have been successfully tested using this method, although additional checks, possibly involving the relevant sector association, would be recommended because of the pitfalls as described in above table. This makes this methodology more time consuming than the NIM method, while it will yield results of equal or less robustness. Multiple issues have been identified, and more could arise along the process of executing it (the devil is in the details), especially for complex sectors. Therefore, we would recommend pursuing the non-public NIMs methodology.

5 References

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Support to the Commission for the determination of the list of sectors and subsectors deemed to be exposed to a significant risk of carbon leakage for the years 2015-2019 (EU Emission Trading System)

Harmonized framework for qualitative assessment

January 2013

Task 3 final report

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The views expressed in this study represent only the views of the authors and not those of DG CLIMA or any other organization.

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List of abbreviations

AF	Auctioning Factor
BM	Benchmark
CHP	Combined Heat and Power
CITL	Community Independent Transaction Log
CL	Carbon Leakage
CLEF	Carbon Leakage Exposure Factor
CO_2 Eq.	Carbon dioxide equivalents
CSCF	Cross-sectoral Correction Factor
HAL	Historic Activity Level
ICC	Induced Carbon Cost
EI	Emission Intensity
ETS	Emission trading system
EU ETS	The European Union's emission trading system
LRF	Linear Reduction Factor
MS	Member State
NACE	Statistical classification system used by Eurostat
NIM	National Implementation Measures

Executive summary

There might be industrial sectors which do not meet the quantitative thresholds, but are nevertheless exposed to carbon leakage - e.g. sectors being just below the thresholds or sectors for which statistics are absent or of poor quality. Therefore the EU ETS directive enables the Commission supplement the carbon leakage list based on qualitative arguments. However, decisions based on qualitative arguments (hence: without strict thresholds) can always be questioned. To reduce the arbitrariness in the decisions the Commission requested the consortium to propose a harmonised and structured framework as the basis for potential future qualitative assessments.

In the amended ETS Directive (paragraph 17 of article 10a), three criteria are mentioned as being relevant in the qualitative assessment:

> *(a) the extent to which it is possible for individual installations in the sector or subsector concerned to reduce emission levels or electricity consumption, including, as appropriate, the increase in production costs that the related investment may entail, for instance on the basis of the most efficient techniques;*
> *(b) current and projected market characteristics, including when trade exposure or direct and indirect cost increase rates are close to one of the thresholds mentioned in paragraph 16;*
> *(c) profit margins as a potential indicator of long-run investment or relocation decisions.*

Over the past years, the Commission has supplemented the list with sectors deemed to be exposed to carbon leakage with six sectors, based on combinations of the abovementioned criteria.

The consortium has reviewed all criteria that have been used in the past. After consultation with the Commission, the long list of indicators has been assessed and reduced to a list with nine main indicators, which are viewed by the Commission as the most important indicators to be assessed within a qualitative assessment. The nine indicators have been structured in a three step approach, inspired by the three criteria mentioned in the ETS Directive.

Step 1: The extent to which a sector will be exposed to carbon cost
The first part of the qualitative assessment would provide a further interpretation of the quantitative carbon cost ratio. Its aim is to determine the amount of carbon costs the sector actually faces. In the quantitative assessment this has been assessed already on the basis of direct emissions and indirect emissions from electricity consumption. In this step, this assessment is extended and refined by taking into account:

- <u>Abatement potential and associated costs:</u> Quantification of “the extent to which it is possible for individual installations in the sector or subsector concerned to reduce emission levels or electricity consumption, including, as appropriate, the increase in production costs that the relevant investment may entail, for instance on the basis of most efficient techniques”.

- <u>(In)direct carbon costs from suppliers:</u> (In)direct costs from raw materials from supplier sectors (upstream), which are likely to be passed through to the sector being assessed. Also emission related costs from third party heat generation can be regarded in this respect. Indirect costs from electricity consumption are not intended here, as these are already included in the induced carbon cost ratio.

The first indicator may have a reducing effect on the carbon cost exposure. The second indicator may have an increasing effect on the carbon cost exposure.
Sectors that, after taking into account these indicators, still have a sufficiently high carbon cost exposure could proceed to the next step in the assessment, otherwise the carbon cost (relative to gross value added) are deemed as not significant enough for the sector to lead to a significant risk of carbon leakage.

Step 2: The extent to which a sector is able to pass these costs on to its customers

Whether or not a sector is able to pass these carbon costs on in market prices depends on various market characteristics which are assessed in this second step. The relevant market characteristics are:

- <u>Bargaining power of the sector in value chain</u>: an assessment of the bargaining power of a sector within its value chain by looking at the market concentration and industry structure. This directly influences the ability of a sector to pass through costs.
- <u>Import intensity</u>: a metric for the strength of exposure to international markets and world prices, which influences the ability to pass through costs. Import intensity is to be determined by looking at the ratio of imports relative to turnover, and the development of this ratio over time. The import intensity should also be seen in conjunction with the export specialisation position, preferably over time.
- <u>Export specialisation position:</u> a metric for robustness a sectors net export position over time, influencing the ability to pass through costs without risking to loose export markets. Export specialisation position is to be determined by looking at the development of the trade surplus (exports minus imports) of a sector over time and/or ratio of exports relative to turnover over time. The export specialisation position should also be seen in conjunction with the import intensity position over time.
- <u>Transportability</u>: Transport costs in relation to product value, as metric for the "local/regional" nature of a sector's market. Alternatively, since transport costs are closely related to the weight of products, transportability can be assessed by looking at the product's weight-to-value ratio as a proxy.
- <u>Homogeneity of produce:</u> A metric for degree of price competition, influencing the ability for producers to pass costs through. Homogeneous goods are physically identical, or at least seen as such by the buyer of the goods, and it is therefore difficult for a producer to distinguish themselves. Homogeneous products compete more on price and substitution of homogenous products from one producer by those of another producer is easier than in the case of highly differentiated products.

If the combined picture of these indicators provides an indication that carbon costs are hard to pass through and the sector thus needs to absorb most of it themselves, the sector could proceed to the next step of the assessment. Otherwise there is no need to go to the next step, even if carbon costs (step 1) are relatively high, since the sector can pass through a large part of the costs to its customers and is not – or to a limited extent only - affected by the costs itself.

Step 3: The extent to which the inability to pass on costs is likely to result in carbon leakage

Even if carbon costs faced by the sector are high (step 1) and the ability to pass these costs through is low (step 2), there would be no significant risk of carbon leakage if the sector can either absorb these costs e.g. because of sufficiently high profit margins, or if substitution of the product overall leads to a lower carbon footprint.

- Cost absorption potential: an indication of absorption capacity of additional carbon costs for a sector by looking at profit margins. This indicator could be determined by assessing two elements:
    1. Profit margins: High profit margins can indicate the ability for a sector to absorb the costs without problems. Low profit margins can indicate lack of such ability (and can also provide an indication for strong competition of the market with low cost pass-through ability).
    2. The share of additional carbon costs as % of profit margins. This provides a direct relation between profit margin and the additional carbon costs faced by a sector and indicates the extent of impact and hence the risk of lower future (inward) investments, of relocation or of shutting-down.
- Carbon intensity of likely substitutes: This indicator assesses the carbon intensity of tradable substitutes, both from within EU and from non-EU, having the same functionality, which is relevant *if* it has been established that there is indeed a significant substitution risk.

In summary:

The interrelation between the three assessment steps is depicted schematically in the picture below.

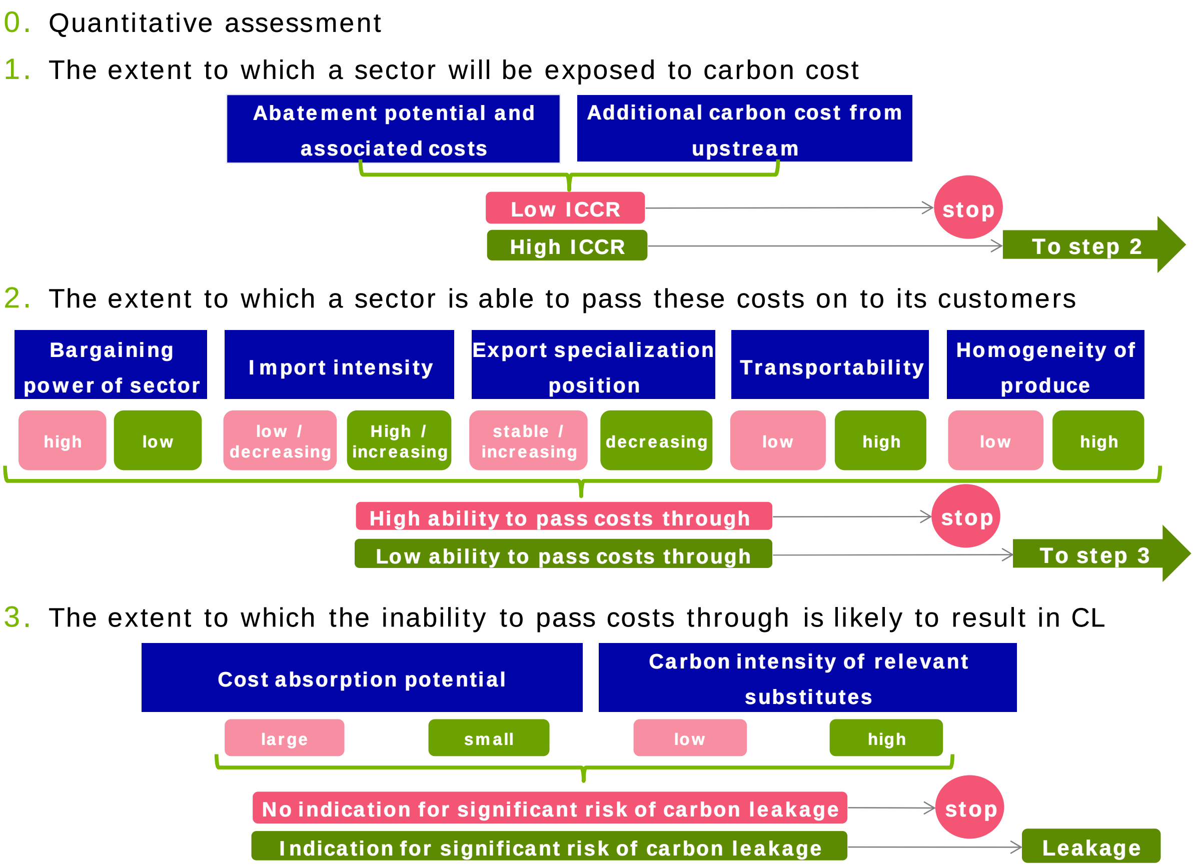


Figure 1: *Visual representation of staged qualitative assessment; green boxes are indications of a significant carbon leakage exposure, while red-coloured boxes are not.*

A sector could thus be in one the following stylised situations:

- Case A: Low carbon costs (step 1)
  - ⇨ If these costs are relatively low, there is no need to proceed to the next steps;
  - ⇨ There are **no indications** for a significant risk of exposure to carbon leakage.
- Case B: High carbon costs (step 1) + High ability to pass costs through (step 2)
  - ⇨ Even though carbon costs are high, the sector can pass them through;
  - ⇨ There are **no indications** for a significant risk of exposure to carbon leakage.
- Case C: High carbon costs (step 1) + Low ability to pass costs through (step 2) + Low extent to which this could lead to carbon leakage (step 3)
  - ⇨ Even though carbon costs are high and ability of the sector to pass costs through is low, the sector could potentially absorb the costs;
  - ⇨ There are **no indications** for a risk of exposure to carbon leakage.
- Case D: High carbon costs (step 1) + Low ability to pass costs through (step 2) + High extent to which this could lead to carbon leakage (step 3)

⇨ Carbon costs are high, the ability of the sector to pass costs through is low and the extent to which the sector can absorb this is low.

⇨ There are clear indications that this sector is exposed to a **significant risk of carbon leakage.**

A summarising overview of each of the indicators under step 1, 2 and 3 is provided in the tables below.

Table 1 Schematic overview of indicators determining Step 1: (in)direct costs of carbon faced by sector

Indicator	Indication of low impact on induced carbon cost	Indication of high impact on induced carbon cost
Abatement potential and associated costs	Low	High
Indirect carbon costs from suppliers	High	Low

Table 2 Schematic overview of indicators determining Step 2: ability of sector to pass costs through

Indicator	Indication for low ability to pass costs through	Indication for high ability to pass costs through
Bargaining power of sector in value chain	Low	High
Import intensity	High/increasing	Low/decreasing
Export specialisation position	Decreasing	Stable/increasing
Transportability	High	Low
Homogeneity of produce	High	Low

Table 3 Schematic overview of indicators determining Step 3: extent to which this could lead to carbon leakage

Indicator	Indication for high risk to carbon leakage	Indication for low risk to carbon leakage
Cost absorption potential	Small	Large
Carbon intensity of relevant substitutes	High	Low

1 Introduction

The European Commission is aware of the fact that a standard quantitative evaluation alone could lead to sectors being 'unintentionally' considered as not deemed to be exposed to carbon leakage. To avoid this, the Commission has the possibility to decide – based on qualitative arguments – that a sector is deemed to be exposed to carbon leakage. However, decisions based on qualitative arguments (hence: without strict thresholds) can always be questioned. To reduce the arbitrariness in the decisions the Commission requested a harmonised and structured framework as the basis for potential future qualitative assessments.

1.1 Indicators used in the past

In the amended ETS Directive (paragraph 17 of article 10a), three criteria are mentioned as being relevant in the qualitative assessment:

> *(a) the extent to which it is possible for individual installations in the sector or subsector concerned to reduce emission levels or electricity consumption, including, as appropriate, the increase in production costs that the related investment may entail, for instance on the basis of the most efficient techniques;*
> *(b) current and projected market characteristics, including when trade exposure or direct and indirect cost increase rates are close to one of the thresholds mentioned in paragraph 16;*
> *(c) profit margins as a potential indicator of long-run investment or relocation decisions.*

Over the past years, the Commission has supplemented the list with sectors deemed to be exposed to carbon leakage with six sectors[1] using combinations of the following criteria, obviously inspired by the abovementioned criteria:

1. Possibility to reduce emissions/electricity consumption:
   - Limited possibilities to reduce emissions without significant increase in costs.
2. Market characteristics:
   - Increasing international competitive pressure/imports from low cost manufacturing countries/international trade.
   - Price cannot easily be increased due to high price sensitivity, because the price is set on the world market; the market concentration of the client sector is much higher than the market concentration of the sector assessed; or the price elasticity is high for export.
   - Significant drop in production in the EU over the last years.

[1] 5 sectors in COMMISSION DECISION of 24 December 2009: 1730 Finishing of textiles, 2020 Manufacture of veneer sheets; manufacture of plywood, lamin board, particle board, fibre board and other panels and boards, 2416 Manufacture of plastics in primary forms, 2751 Casting of iron, 2753 Casting of light metals and 1 sector in COMMISSION DECISION of 11 November 2011: 2640 Manufacture of bricks, tiles and constructions products, in baked clay.

- High level of integration with other sectors deemed to be exposed to carbon leakage.
- Distortions of the market due to unfair commercial practices in third countries.
- The observed production growth of the sector was a period at the height of the European construction market.
- Regional markets trade with third countries, benefitting from short distances.
- Volatile demand.

3. Profit margins:
   - Negative or only very modest profit margins.
   - Additional costs of implementation of ETS would consume a significant share of profit margin (>30%).
   - Insufficient profit margin limits the capacity of installations to invest and reduce emissions, or in investments in the long run.
   - Large part of production in SMEs.

Additionally, the following arguments are mentioned:

- Significant reduction of energy use has already been achieved in (part of) the sector.
- Substitution threat by more CO_2-intense materials is significant – being especially a perverse effect if these other materials do not fall under ETS or are deemed exposed to carbon leakage.
- Other technologies (used outside EU) are several times more emissive.
- Loss of competitiveness would have domino effect downstream.

The consortium has reviewed all criteria that have been used in the past. After consultation with the Commission, this long list of indicators has been assessed and reduced to a list with nine indicators, which are viewed by both the Commission as the most important indicators to be assessed within a qualitative assessment. The nine indicators have been structured in a step-by-step approach, inspired by the three criteria mentioned in the ETS Directive.

1.2 Aim of this report

This report provides a structured framework to enable a harmonized qualitative assessment, consisting of:

- A step-by-step approach, including a consistent set of indicators for each step;
- A diagram reflecting the relatedness of the indicators and criteria;
- An elaborate description of each relevant indicator.

2 Step-by-step approach of qualitative assessment

This chapter aims to convey a step-by-step storyline of a qualitative assessment and interaction of the different indicators used.

2.1 Step 1: The extent to which a sector will be exposed to carbon cost

The first part of the assessment provides a further interpretation of the quantitative carbon cost ratio. Its aim is to determine the amount of carbon costs the sector actually faces. In the quantitative assessment this has been assessed already on the basis of direct emissions and indirect emissions from electricity consumption. In this step, this assessment is extended and refined by taking into account:

1) The extent to which a sector is able to cost-effectively reduce direct and indirect emissions;
2) The extent to which a sector faces additional carbon costs passed through to the sector by suppliers in the value chain (e.g. carbon costs in raw materials and outsourced heat).

The first indicator may have a reducing effect on the carbon cost exposure. The second indicator may have an increasing effect on the carbon cost exposure.

Only sectors that have a sufficient carbon cost exposure should proceed to the next step in the assessment, otherwise the carbon cost (relative to gross value added) are deemed as not significant enough for the sector to lead to a significant risk of carbon leakage.

2.2 Step 2: The extent to which a sector is able to pass these costs on to its customers

Whether or not a sector is able to pass these carbon costs on in market prices depends on various market characteristics which are assessed in this second step. The relevant market characteristics are:

- Bargaining power of sector in value chain;
- Import intensity (i.e. exposure to world market prices);
- Change in export specialisation position;
- Transportability;
- Homogeneity of produce.

If the combined picture of these indicators provides an indication that carbon costs are hard to pass through and the sector thus needs to absorb most of it themselves, the sector should proceed to the next step of the assessment. Otherwise there is no need to go to the next step, even if carbon costs (step 1) are relatively high, since the sector can pass through costs to its customers and is not – or to a limited extent only - affected by the costs itself.

2.3 Step 3: The extent to which the inability to pass on costs is likely to result in carbon leakage

Even if carbon costs faced by the sector are high (step 1) and the ability to pass these costs through is low (step 2), there would be no significant risk of carbon leakage if the sector can either absorb these costs easily e.g. because of sufficiently high profit margins, or if substitution of the product overall leads to a lower carbon footprint.

Overview of indicators

This interrelation between the three assessment steps is depicted schematically in the picture below.

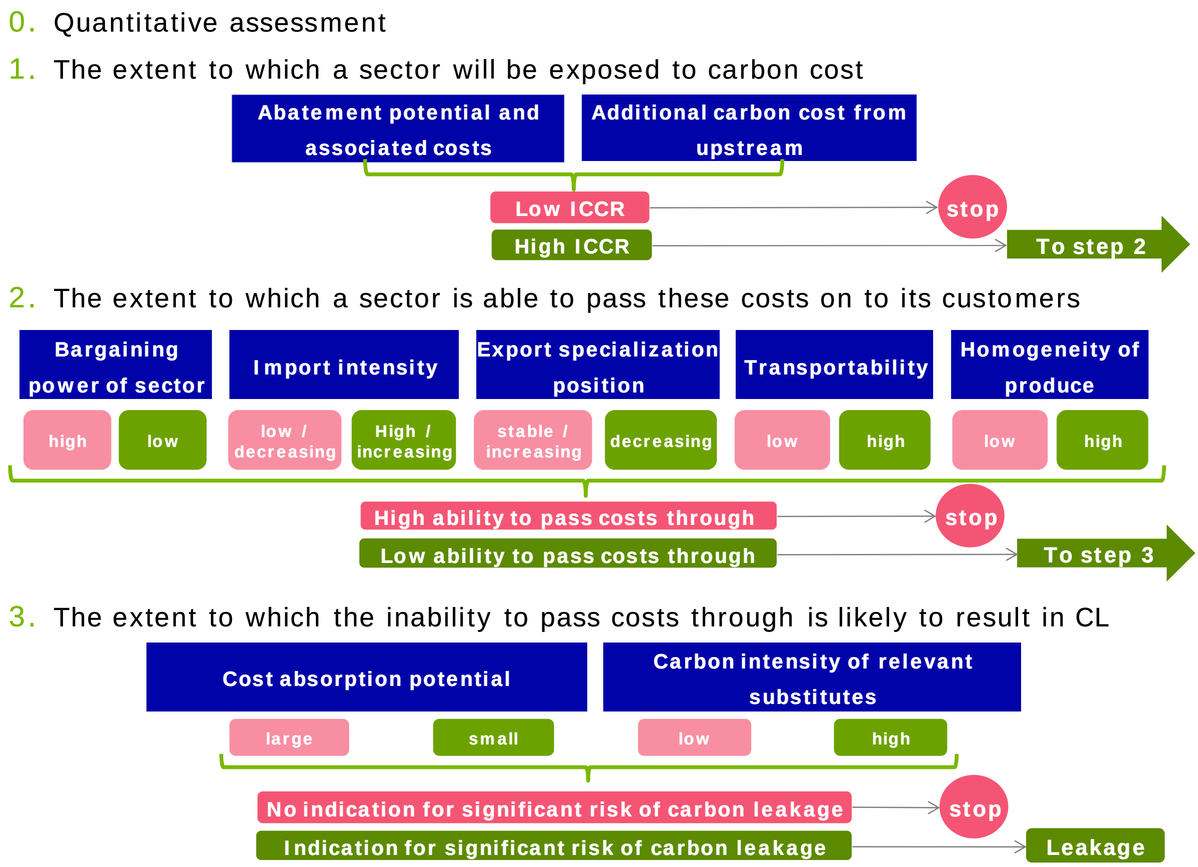


Figure 2: Visual representation of staged qualitative assessment

A sector could thus be in one the following stylised situations:

- Case A: Low carbon costs (step 1)
  - ⇨ If these costs are relatively low, there is no need to proceed to the next steps;
  - ⇨ There are **no indications** for a significant risk of exposure to carbon leakage.
- Case B: High carbon costs (step 1) + High ability to pass costs through (step 2)
  - ⇨ Even though carbon costs are high, the sector can pass them through;

  - ⇨ There are **no indications** for a significant risk of exposure to carbon leakage.
- Case C: High carbon costs (step 1) + Low ability to pass costs through (step 2) + Low extent to which this could lead to carbon leakage (step 3)
  - ⇨ Even though carbon costs are high and ability of the sector to pass costs through is low, the sector could potentially absorb the costs;
  - ⇨ There are **no indications** for a risk of exposure to carbon leakage.
- Case D: High carbon costs (step 1) + Low ability to pass costs through (step 2) + High extent to which this could lead to carbon leakage (step 3)
  - ⇨ Carbon costs are high, the ability of the sector to pass costs through is low and the extent to which the sector can absorb this is low;
  - ⇨ There are clear indications that this sector is exposed to a **significant risk of carbon leakage.**

The indicators that are to be considered under each step are described in detail in the next Chapter. A summarising overview of each of the indicators under step 1, 2 and 3 is provided in the tables below.

Table 4 Schematic overview of indicators determining Step 1: (in)direct costs of carbon faced by sector

Indicator	Indication of low impact on induced carbon cost	Indication of high impact on induced carbon cost
Abatement potential and associated costs	Low	High
Indirect carbon costs from suppliers	High	Low

Table 5 Schematic overview of indicators determining Step 2: ability of sector to pass costs through

Indicator	Indication for low ability to pass costs through	Indication for high ability to pass costs through
Bargaining power of sector in value chain	Low	High
Import intensity	High/increasing	Low/decreasing
Export specialisation position	Decreasing	Stable/increasing
Transportability	High	Low
Homogeneity of produce	High	Low

Table 6 Schematic overview of indicators determining Step 3: extent to which this could lead to carbon leakage

Indicator	Indication for high risk to carbon leakage	Indication for low risk to carbon leakage
Profit margins + additional carbon costs as share of profit margin	Small	Large
Carbon intensity of relevant substitutes	High	Low

3 Description of relevant indicators

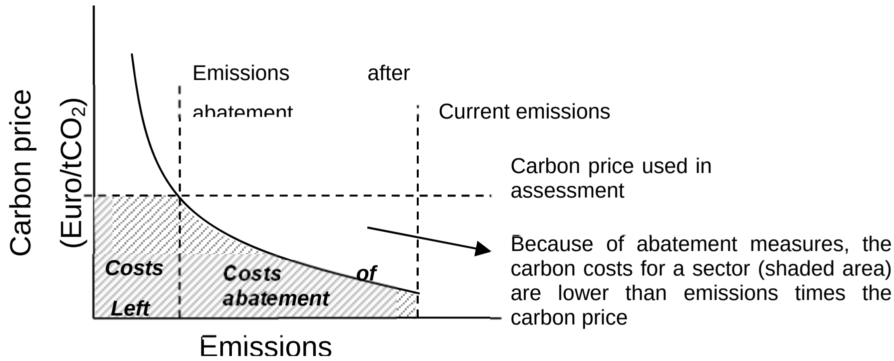
This chapter elaborates on the different indicators by zooming in separately on the description, relevance, relevant data sources, and evaluation of the indicator by the Commission.

3.1 Step 1: The extent to which a sector will be exposed to carbon cost

3.1.1 In Abatement potential and associated costs

Description:
This indicator quantifies "the extent to which it is possible for individual installations in the sector or subsector concerned to reduce emission levels or electricity consumption, including, as appropriate, the increase in production costs that the relevant investment may entail, for instance on the basis of most efficient techniques"[2].

Relevance:
Installations within a sector may have abatement options that have not (yet) been applied in order to reduce greenhouse gas emissions. If that is the case, then this should be considered in estimating the effective burden that carbon costs would bring to the sector.



Arguments as an indicator in favour of Carbon Leakage:
A sector without cost-effective abatement options will be unable to reduce their emission intensity, and will therefore be unable to alleviate the carbon costs imposed by ETS. Abatement costs are typically expressed in Euro/tCO_2 avoided.

Arguments as an indicator against Carbon Leakage:
A sector with cost effective abatement options can reduce its carbon cost more cost effectively then buying extra allowances. This effectively reduces the carbon costs.
The Commission could decide not to "reward" a sector for having a high - not implemented - cost effective abatement potential.

[2] Text taken from the amended ETS Directive 2003/87/EC, article 10.17a.

Data to be evaluated and relevant sources:

Determination of sectoral abatement measures and associated costs usually is a very time and cost intensive exercise. To reduce this burden, the following conservative default approaches could be used. Note that this 'one-size-fits-all' approach may not be realistic for certain sectors, but will lead to a significant reduction of efforts in case the default approach still leads to relatively high carbon costs.

It should be noted that in determining cost-effectiveness of abatement measures, the typical industry payback requirements and discount rates are relevant. We recommend that the EC prescribes these conditions clearly. Even though access to (third-party capital) may always be limited, this should not be a reason to grant exposure to carbon leakage.

1. **Primary default approach:**

   The direct and indirect carbon emissions could be reduced by a maximum of 12.5% in 2015 - 2019 compared to 2008-2010 levels at zero cost. Therefore, the induced carbon cost ratio as established by the Commission in the 2013 assessment is reduced accordingly by 12.5%.

   Explanation:

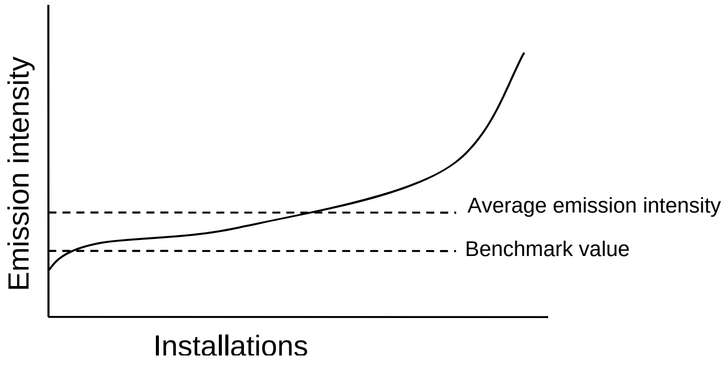
   The default approach uses a conservative (i.e. high-end) estimate of the economic reduction potential of the fuel and electricity intensity within industry, based on Fraunhofer et al. (2009)[3]. In that study, the energy intensity of industry reduces by approximately 11% (10 percentage points) between 2010 and 2020 under an economic scenario with high discount rates. On top of energy reduction measures, fuel switch measures would reduce a sector's emissions (no details available). Therefore, to be conservative, an emission reduction of 12.5% could be regarded as a conservative, high-end estimate of the economic abatement potential.

2. **Secondary default approach:**

   This approach makes use of the product benchmark curves that have been established for the purpose of the free allocation of allowances to estimate the economic reduction potential. Despite the limitations that this approach entails, it would offer a conservative, first order estimate of the economic abatement potential for a sector, without the burden that a MAC curve would bring about.

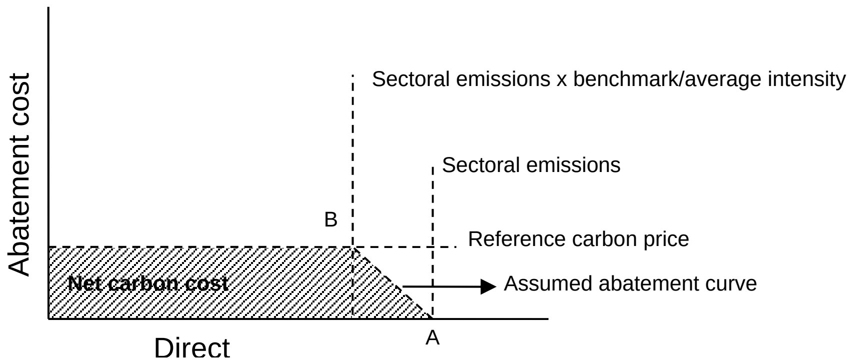
   Step 1: determine the benchmark level relative to the average emission level. The average emission intensity should preferably represent the weighted average emission intensity (weighted against emissions per installation).

[3] Fraunhofer ISI, ISIS, Wuppertal Institute, and TU Vienna, Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries, 2009, available at: http://ec.europa.eu/energy/efficiency/studies/doc/2009_03_15_esd_efficiency_potentials_final_report.pdf



Step 2: Determine direct carbon costs (shaded area) by assuming a linear abatement curve between point A (current sectoral emissions and zero abatement costs) and point B (reduced sectoral emissions at abatement costs equal to reference carbon price). This reference line is a conservative estimate because it can be assumed that overall it would cost more than the reference carbon price to bring down the emissions within the average installation to the benchmark level. Note, some measures (e.g. industrial insulation) may have negative abatement costs, which partly offsets the relatively expensive measures.

To determine that impact on the indirect carbon costs a similar reduction potential should be assumed.



A sector should use the product benchmark curves of those benchmarks that are applicable within their sector. If no product benchmarks are applicable a benchmark/average emission intensity ratio of 75% should be used[4].

This implies a reduction of the ICCR of 12.5% (half of 25%), which is therefore exactly equal to approach 1.

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[4] This is the aarithmetic average for all product benchmarks excluding the benchmarks for nitric acid, adipic acid and those not based on a curve.

Fallback option:
For sectors feeling that the default approaches do not take into account their abatement options and costs, it is possible to submit to the Commission a limited marginal abatement cost curve (MACC) based on the following harmonized approach:

- The top abatement measures (in terms of abatement potential) should be included;
- The sector should provide evidence that these measures cover at least 75% of the total sectoral abatement potential;
- All abatement measures cheaper than the reference carbon price should be included;
- If applicable, the sector should take into account all best available technologies as described in the BREF notes;
- A discount rate of 8%[5] and an economic depreciation period (based on economic lifetime of investment) should be used;
- Publicly available energy price scenario's should be used, as recent as possible;
- All other ingredients and assumptions (e.g. investment costs) need to be described transparently, allowing third-party validation of the MAC-curve.

The MACC should be accompanied by a sector-specific storyline in which the MAC curve is put into historical and future perspective, taking into account e.g. extrapolation of historical energy-intensity indices, autonomous improvements, etc.

<u>Evaluation of indicator by EC:</u>
This indicator could be evaluated as follows:

The Commission could assess the impact of this indicator by recalculating the induced carbon cost ratio: direct and indirect emissions will be reduced by a number that is determined according to the above methodology (e.g. 12.5% in case of the primary default approach). Net costs to apply these abatement measures will be added (e.g. zero costs in case of the primary default approach). This will result in a new ICCR which is "corrected" for economic abatement measures. This new ICCR could be evaluated in conjunction with (in)direct costs for suppliers.

3.1.2 **(In)direct carbon costs from suppliers**

<u>Description:</u>
(In)direct costs from raw materials from supplier sectors (upstream), which are likely to be passed through to the sector being assessed. Also emission related costs from third party heat generation can be regarded in this respect. Indirect costs from electricity consumption are not covered here, as these are already included in the induced carbon cost ratio.

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[5] Based on the weighted average cost of capital (WACC) in Europe taken from KPMG (2012) Cost of Capital Study 2011/2012. Available at: http://www.kpmg.com/ch/en/library/articles-publications/pages/cost-of-capital-study-2012.aspx

Relevance:
This indicator completes the indirect carbon cost, from "only" electricity to all supplying sectors. If costs are passed through by input suppliers, this can cause a knock-on effect on more downstream producers/sectors, in addition to "own" additional carbon costs faced.
This parameter could have some disadvantages as well:
1) Possibility to pass through cost is simplified, as they are only based on trade intensity, not on EU-internal market characteristics.
2) This could cause a loop, and would imply redoing the exercise every year. For example: A sector could become CL partly based on this parameter. When its supplying sector becomes carbon leakage, the earlier decision could have been different. In practice, this effect might be rare.

The possibility of supplier sectors with carbon leakage status making windfall profits, or passing through marginal costs is not taken into account here (as this would lead to double compensation).

Arguments as an indicator in favour of Carbon Leakage:
In analogy with the quantitative assessment, supplier sectors with a relatively low trade intensity and relatively high (in)direct carbon cost could have meaningful cost and could be in the position to pass these costs through.

Arguments as an indicator against Carbon Leakage:
It could be argued that the risk for carbon leakage would not be increased by:
- Supplier sectors with carbon leakage status (already taken into account).

Also, the assessment should consider if there has been any compensation provided for indirect costs via the State Aid guidelines for the sectors concerned.

Only the effect of additional carbon costs passed through by identified supplying sectors should be taken into account.

Data to be evaluated and relevant sources:
- Data on the relation between the sector and the specific upstream (sub)sectors, based on e.g. trade statistics, input-output tables, sector-specific data sources.
- Trade intensity – as defined in the revised ETS directive and assessed by the Commission - of identified upstream (sub)sector, on the basis of Eurostat.
- Induced carbon cost – as defined in the revised ETS directive and assessed by the Commission - of identified (sub)sector, based on either Eurostat or a verified bottom-up data collection by the sector.

Evaluation of indicator by EC:
This indicator should be evaluated in conjunction with the abatement potential and associated costs.

If evaluated quantitatively, this indicator would quantify the induced carbon costs that are passed through to the sector by upstream sectors. These are additional carbon costs that a sector would face on top of carbon costs associated with direct emissions or electricity consumption. It would be possible to add these carbon costs to the induced carbon cost ratio of the sector concerned.

3.1.3 **Evaluation of step 1 'the extent of carbon cost exposure'**

Evaluation: the extent to which a sector is exposed to additional carbon cost, could be evaluated by calculating the induced carbon cost of the sector and taking into account:

- Upstream carbon cost which are passed through by suppliers. These carbon cost could be added to the nominator of the induced carbon cost ratio.
- Cost-effective greenhouse gas abatement potential. This economic abatement should be taken into account as described previously, and has a decreasing effect on the nominator of the induced carbon cost ratio.

A specific threshold (number or range) can then be set in order to evaluate when this should be judged as high or low. For example, if this "extended" induced cost ratio has a value >3.5% a sector could be regarded as sufficiently exposed to additional carbon cost, and could proceed to step 2.

Motivation of proposed (example) threshold: The 3.5% threshold is motivated by the idea that sectors with a (default) ICCR of>4% are sufficiently exposed to proceed to step 2, i.e. 87.5% * 4.0 = 3.5. In other words: sectors having an ICCR >4% can pass this first step by simply applying the default methodology. Sectors having an ICCR <4% need to do a more detailed analysis (e.g. MAC curve and/or upstream sector analysis), and may fail to pass this step.

3.2 Step 2: The extent to which a sector is able to pass on these costs to its customers

3.2.1 **Bargaining power of sector within value chain**

<u>Description:</u>
This indicator provides an assessment of the bargaining power of a sector within its value chain by looking at the market concentration and industry structure. This directly influences the ability of a sector to pass through costs. It is most relevant to assess the sector's own characteristics, and place that in context of the characteristics of the next chain in the value chain, i.e. the buyer of the sector's products. Market concentration relates to the number of companies that account for the (majority of) total production in a market and the respective market shares. This can be analysed with the Herfindahl-Hirschman index.

<u>Relevance:</u>
This indicator provides insight into the ability of a sector to pass costs through to the buyer of its products (not necessarily end consumers), based on bargaining power. For example if the sector under consideration consists of a large number of smaller producers, which all sell to a few large retailers as next step of the value chain, then

these small producers will not have good bargaining power vis-à-vis the few large retailers. The buyers in this example possess the bargaining power and the sector under consideration is likely to have a low ability to pass costs through.

Arguments as an indicator in favour of Carbon Leakage:
In case the sector under consideration has a low market concentration rate and a weak position within the value chain, e.g. because there are many SME's in the sector producing for a few large buyers, then the ability of this sector to pass costs through to the next player in the value chain is likely to be low.

Arguments as an indicator against Carbon Leakage:
In case the sector under consideration has a high market concentration rate and a strong position within the value chain, e.g. because there are only a few dominant players in the sector and/or the producer has a unique product to offer that will not easily be sourced from elsewhere, then the ability of this sector to pass costs through to the next player in the value chain is likely to be high.

Data sources to be used:
Simple data on the number of firms in a sector can be obtained from Eurostat Structural Business Statistics (SBS). More detailed data for market concentration rates can be obtained from sector sources. Also, DG Competition sources might be useful in some cases.

Evaluation of indicator by EC:
It is suggested to evaluate this indicator as follows:

- Market concentration can be assessed by using the Herfindahl-Hirschman (HI) index. This indicator is calculated by taking the sum of the squares of the market shares of the firms in a market[6]. In case the four largest producers in the market possess a large majority of that market, market concentration (and the HI index) can be considered high. In case the four largest producers in the market possess less than half of the total market, then market concentration (and the HI index) can be considered low.
- In case there is no data available to assess the HI index, the mere quantity of companies in a sector can also already provide a proxy for likely market concentration.
- Qualitative analysis of the value chain characteristics can include assessment of the next chain in the value (buyers of the sector's products) and can be used to put the market concentration rates in perspective. This might involve opinions of independent experts.

In case market concentration is low and/or the position in the value chain of a sector weak, then the ability to pass costs through is likely to be limited.

6 For example, if there are four companies in a market that respectively possess 60%, 30%, 20% and 10% of the market, then the HI index = $(0.6)^2 + (0.3)^2 + (0.2)^2 + (0.1)^2 = 0.50$. This would be considered as a high market concentration ratio.

3.2.2 **Import intensity**

Description:
The indicator import intensity provides a metric for the strength of exposure to international markets and world prices, which influences the ability to pass through costs. Import intensity is to be determined by looking at the ratio of imports relative to turnover, and the development of this ratio over time. The import intensity should also be seen in conjunction with the export specialisation position, preferably over time. This is the next indicator described.

Relevance:
This indicator aims to assess the share of imports for a sector in the total EU market, relative to EU turnover, also over time. If a sector has relatively high imports, this is an indication for exposure to international markets and to world prices. If such exposure is high, the ability to pass costs through is likely to become lower (since the sector is dominated by world prices).

The quantitative trade intensity ratio already gives an indication of the extent to which a sector is internationally exposed. Nonetheless, the difference in import intensity between sectors is not fully captured by this ratio (and nor is the difference in export specialisation position between sectors – see next indicator). This is why looking at the import and export components separately in the qualitative analysis enables further insight regarding market characteristics of a sector.
For example, for a purely imaginary sector, the trade intensity ratio will be the same for a sector with 2000 turnover/0 imports/480 exports, as for a sector with 2000 turnover/500 imports/100 exports (in both cases 24%). Nonetheless, competitive pressure and exposure to world markets is likely to be higher in the latter sector – where imports from outside the EU are much higher – than in the former.

Looking at the development of import intensity over time is also relevant since this might reveal a pattern of increasing substitution of EU production by imports over time. For example, if a strong trade surplus of the sector has turned into a trade deficit in recent years, this might be an indication for exposure to risk of carbon leakage as a result of added carbon costs.

An example of where this argument has been applied in past qualitative assessments is manufacture of plastics in primary form. For this sector, it was showed that imports continue to increase, whereas exports go down. This has led to a downward pressure on prices in the sector, which limits the ability of producers to pass through costs in final prices.

Arguments as an indicator in favour of Carbon Leakage:
If a sector is a heavy importer, international competition on the EU market might be strong and exposure to world markets and prices high. Added carbon costs may not be easily passed through in domestic prices, since this might pose a risk of substitution of EU production by (cheaper) imports.
For example, in case the ratio of imports from 3rd countries over turnover of a sector is higher than the trade intensity ratio itself, this might be an indication that international

competition on the EU market is stronger than the trade intensity ratio alone might suggest.

Arguments as an indicator against Carbon Leakage:
If a sector doesn't trade much and hence import intensity (note: as well as export intensity) is low, international competition on the EU market and the international substitution risk might be limited. Cost pass through of added carbon costs in domestic prices might not be too problematic.
It should be noted that in this case the quantitative trade intensity ratio will also be low.

Data sources to be used:
Same data as in the quantitative assessment on import and export can be used to calculate separate (highly simplified) import intensity. Preferably data over time can be used to assess development of import ratios.

Evaluation of indicator by EC:
It is advised that the indicators “import intensity” and “export specialisation position” are assessed in conjunction. For import intensity the following evaluation is suggested:

- Import intensity of the sector is defined as total imports from 3rd countries into the EU for the sector under consideration divided by total EU turnover for the sector. If this ratio is higher than the quantitative trade intensity ratio itself and/or if it is near to or higher than 20-25 percent, import intensity can be considered as relatively high.
- Import intensity over time shows the development of import intensity preferably over the past 10 years, or in case of data limitations over the past 5 years. A clear increasing trend in import intensity over this time period indicates a growing import pressure and import substitution risk in that EU sector.

In case import intensity is considered high and/or a clear increasing trend in import intensity over time is exhibited, then this indicator reveals that this sector is possibly highly exposed to international markets and world prices. This can result in a high risk of substitution by imports from outside the EU in case prices of EU products increase and a limited ability for producers to pass costs through.

Additional note: in case severe barriers to trade are in place, e.g. high import tariffs, this might influence the trade data and hence this indicator considerably. Therefore, there might be exceptional cases where this could be considered in the qualitative assessment. This could be the case if severe import barriers are in place (and hence import intensity is low), but these barriers are about to be addressed, which will significantly increase import flows.
Under such special circumstances, an analysis of such barriers and the expected impact of resolving those barriers on import flows can be presented by the sector. Relevant data sources for such analysis may come from DG Trade, which e.g. performs Trade Sustainability Impact Assessments for each major upcoming trade agreement.

3.2.3 **Export specialisation position**

Description:
The indicator export specialisation position provides a metric for robustness of a sectors net export position over time, influencing the ability to pass through costs without risking to loose export markets. Export specialisation position is to be determined by looking at the development of the trade surplus (exports minus imports) of a sector over time and/or ratio of exports relative to turnover over time. The export specialisation position should also be seen in conjunction with the import intensity position over time.
Note: having a strong export position per se does not necessarily indicate an inability to pass through costs. The trend over time gives the main indication.

Relevance:
This indicator aims to assess the risk that a sector runs of losing export markets if it were to pass through added carbon costs. If a sector has a relatively strong export position, but is gradually losing this over time, then the ability to pass through costs without losing international competitiveness may be limited. This is the case since generally substitution risks on foreign markets are higher than on domestic markets and indeed more evidence is found in empirical research for loss of export markets as a result of price changes than for loss of domestic markets through substitution by imports.

As was explained also for the import intensity indicator, the quantitative trade intensity ratio does not fully capture the difference in (development of) export specialisation position between sectors. This is why it is useful to look at the import and export components separately in the qualitative analysis.

Looking at the development of this position over time might reveal a pattern of increased pressure on a strong export position of a sector and the risk of substitution of EU products by non-EU products on that relevant market. As was the case with import intensity, an example is a sector with a traditionally strong trade surplus that is decreasing steadily or turning into a trade deficit. This might be an indication for exposure to risk of carbon leakage as a result of added carbon costs.

This argument has for example been made in the qualitative assessment for the manufacture or veneer sheet, plywood, etc.

Arguments as an indicator in favour of Carbon Leakage:
If there are solid indications that an EU sector is losing its export specialisation position over time and is thus facing increased competition in non-EU markets, then this could imply lack of ability to pass through costs on these markets and hence a risk of losing export markets as a result of added carbon costs, possibly leading to carbon leakage.

Arguments as an indicator against Carbon Leakage:
It should be noted that a strong export position alone does not provide an argument in favour of carbon leakage. Only in case there are clear indications that the sector is

facing increased (price) competition on non-EU markets reflected in a declining export specialisation position, there may be a risk of carbon leakage.

Data sources to be used:
Same data as in the quantitative assessment on import and export can be used to calculate a simple net export figure (total exports minus total imports), and exports in relation to turnover. Data over time (preferably last 10 years) are required.

Evaluation of indicator by EC:
It is advised that the indicators "import intensity" over time and "export specialisation position" are assessed in conjunction. For the export specialisation position over time, the following evaluation is suggested:

- Export specialisation position can be assessed by looking both at the total EU exports to 3rd countries for the sector divided by EU turnover for the sector, and the trade surplus (total exports minus total imports), both over time. A sector with a ratio of export over turnover of around 20 percent or higher, and with a clear trade surplus (e.g. exports at least twice as high as imports), can be seen as having an export specialisation position.

In case this position shows a clear declining trend over the time period analysed, then the sector can be considered to be at risk of losing export markets in case it would pass through carbon costs. Ability to do so is hence judged to be limited.

Additional note: A more complicated, yet also more accurate assessment of export specialisation position can be provided by a Balassa index. A Balassa index for a sector gives the revealed comparative advantage, or a normalised export share. It is measured as [the share of exports in sector x / total EU exports], divided by [the share of exports in sector x / total exports for a group of relevant reference (non-ETS) countries]. If this index is >1, the EU's sector x has a revealed comparative advantage, i.e. strong export specialisation position compared to the benchmark countries (non-ETS). If this index clearly declines over time, there might be risk of losing export markets and a lower ability to pass through costs.
Doing such a more accurate assessment might be advised in cases where this indicator will have a decisive role in arguing a case in favour or against risk of exposure to carbon leakage.

3.2.4 **Transportability**

Description:
This indicator assesses transport costs in relation to product value, as metric for the "local/regional" nature of a sector's market. Alternatively, since transport costs are closely related to the weight of products, transportability can be assessed by looking at the product's weight-to-value ratio as a proxy.

Additional note: In general, the weight-to-value ratio provides a useful proxy regardless of mode of transport and type of product and is used in empirical research. In some cases however, the volume is decisive, or there are very specific circumstances regarding transport requirements and modes of transport. This should in those cases be taken into account.

Relevance:
International transport costs, in relation to value of the products of that sector, influence the ease with which production can be substituted by production of/in regions outside of the carbon pricing zone. If international transport costs are relatively high compared to the product value, then markets are likely to be more regional and/or local and the risk of carbon leakage is likely to be lower. This is because imports from other areas will have a larger impact on overall costs due to the high transport costs than the added carbon costs will have. In other words, a sector with high transport costs is likely to be more local/regional and more "shielded" from international competition. This argument might hold for entire production processes, or for parts of the production chain. In the latter case, the carbon leakage risk relates to the risk that a sector will outsource the energy-intensive part of the production chain to low carbon price regions outside the EU.

The change in transport costs over time can also be valuable to assess, since steep drops in transport costs in a specific sector over the past years can on the other hand imply a relatively quick increase in exposure to international competition and hence risk to substitution by import from lower-cost areas.

Arguments as an indicator in favour of Carbon Leakage:
If transportability (transport costs in relation to product value) is low, or has been declining sharply over recent years, this can be an indication that trade or outsourcing of parts of the production chain is or has become relatively cheap. This might imply that exposure to international markets and world prices are high. Depending on the nature of the product (homogeneity), this can be an indication that relocation of production in reaction to increased costs is relatively easy and hence there is risk to carbon leakage.

Arguments as an indicator against Carbon Leakage:
If transportability (transport costs in relation to product value) is high, trade in general and import specifically is expensive. This provides shielding against the relocation of (part of) EU production to non-EU areas.

Data sources to be used:

Data on transport costs needs to come from sector-specific sources that can be validated. In some cases, transport costs need to be seen in context of proximity to end user markets. The sector should provide convincing evidence of the location of its main customers, in a way that an average transport distance can be derived.

The proxy of weight-to-value ratios can be assessed based on trade statistics on quantities and values traded per sector, e.g. from the WITS database.

Evaluation of indicator by EC:

The following evaluation of transportability is suggested:

- Transportability can be assessed by looking either at share of transport costs in relation to product value, or in relation to total costs (e.g. transport costs >10% of total costs). The weight-to-value ratio of products can also be used as a proxy of transportability. As a rough indication, a weight-to-value ratio of e.g. higher than 10 (kg/EUR) can in any case be seen as high, whereas a ratio of e.g. lower than 1 can be seen as low.

If the transport costs of a sector are low or have been declining considerably, then the risk of relocation of production, outsourcing or import substitution can be considered high and the ability to pass through costs is low.

Additional note: in addition to transport costs, in some special cases the nature of the product might also be considered as a factor for transportability. This is relevant for products with characteristics like low durability. If the durability of a sector's product is very low and/or fragility very high, then markets may also be more local and the risk of carbon leakage exposure lower.

3.2.5 **Homogeneity of produce**

Description:

This indicator provides a metric for degree of price competition, influencing the ability for producers to pass costs through. Homogeneous goods are physically identical[7], or at least seen as such by the buyer of the goods, and it is therefore difficult for a producer to distinguish themselves. Homogeneous products compete more on price and substitution of homogenous products from one producer by those of another producer is easier than in the case of highly differentiated products.

Relevance:

The homogeneity of the produce of the sector impacts the likelihood of being able to pass costs through. If a product is that standardised that it can be produced anywhere and sold regardless of producer or origin (i.e. highly commoditized) then the supplier's ability to pass on costs will be limited.

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[7] Note that the mere fact that the product has a single product benchmark in ETS is not necessarily related to homogeneity. Quality differences in seemingly homogeneous products can cause significant differences in market value.

Arguments as an indicator in favour of Carbon Leakage:
A sector that produces very homogeneous products is likely to face relatively strong price competition, meaning that substitution of products is relatively easy and passing through costs for producers will be difficult.

Arguments as an indicator against Carbon Leakage:
A sector that produces highly differentiated products is more likely to compete (also) on non-price factors like quality, product-specific features and brand, meaning that it is likely to be somewhat easier to pass costs through.

Data sources to be used:
Price elasticities can provide useful insights for the strength of price competition, since they directly reflect the extent of response to price changes and hence a metric for price competition. Homogeneous products will show high price elasticities. However, elasticities are not widely available and identifying objective data that indicate homogeneity of the products in a sector may be challenging. Price data and market demand figures can be provided by the sector. Also, an element of expert opinion may be required to assess this. For example, it is quite straightforward that the product electricity is more homogeneous and price sensitive than the product branded perfume. Also, products that are e.g. traded on (international) commodity markets can also be seen as relatively homogeneous.

Evaluation of indicator by EC:
The following line of reasoning is suggested for evaluation of homogeneity of produce:

- Homogeneity of produce can be assessed by the height of price elasticities, through data and market demand figures, by expert opinions and by e.g. whether or not products are traded on (international) commodity markets.

In case the products of a sector are relatively homogeneous, it is likely that price competition is strong and producers will not be able to differentiate prices and pass through additional costs.

Because of the difficulties to objectively assessing this important indicator, it is therefore advised to use this indicator as complementary evidence for strong price competition, in conjunction with other indicators in step 2.

3.3 Step 3: The extent to which the inability to pass on costs could result in carbon leakage

3.3.1 **Cost absorption potential**

Description:
This indicator provides an indication of absorption capacity of additional carbon costs for a sector by looking at profit margins. This indicator could be determined by assessing two elements:

1. Profit margins: High profit margins can indicate the ability for a sector to absorb the costs without problems. Low profit margins can indicate lack of such ability (and can also provide an indication for strong competition of the market with low cost pass-through ability).
2. The share of additional carbon costs as % of profit margins. This provides a direct relation between profit margin and the additional carbon costs faced by a sector and indicates the extent of impact and hence the risk of lower future (inward) investments, of relocation or of shutting-down.

<u>Relevance:</u>
Profit margin levels of a sector on the one hand indicate the flexibility that a sector may have to decide itself on the level of cost pass through, given its desired pricing strategy. So if a sector has high profit margins, it may choose to absorb some of the additional costs, even though passing through would (partly) be possible. If profit margins are low, cost absorption might not be a sustainable choice for a sector. On the other hand, not all sectors have the ability to pass costs through and hence an active choice regarding whether or not to absorb costs (this has been established in the previous block of indicators, step 2). In these cases producers will have to absorb any additional costs.
This is why the general level of profit margins of the sector (preferably over time) already provides relevant information for the qualitative assessment (also note that low profit margins can in itself be an indication that a sector is operating in a very competitive market with low cost pass through rates).

Then specifically for sectors with low profit margins and/or strong indications from the previous block of indicators that they cannot pass through costs, it is relevant to assess the additional carbon costs as a percentage of profit margins. If this share is large, then the additional carbon costs would have to be borne by a sector through significant reduction of profit margins. If profit margins are reduced below sustainable levels and/or (long-run) investments can no longer be made (including in abatement measures), this may force a decision to relocate or shut down.

<u>Arguments as an indicator in favour of Carbon Leakage:</u>
For sectors with low profit margins and/or where carbon costs would make up a significant share of profits, additional carbon costs may reduce profits below sustainable levels, increasing the likeliness to stop production or relocate, especially when this sector cannot fully pass costs through (step 2).

Additional note: For sectors with high profit margins where carbon costs would take up a large share of profits, companies may be inspired to relocate to areas where they can still retain the higher profit margins. This situation is not highly common, but could occur exceptionally for some sectors.

<u>Arguments as an indicator against Carbon Leakage:</u>
Sectors with high profit margins and/or where carbon costs match only a limited share of profits can in most cases easily absorb the additional carbon costs without too much risk for carbon leakage, even if this is a sector that cannot fully pass costs through.

Data sources to be used:
Detailed information on profit margins can be retrieved from the sector, e.g. from legal entity statements or other financial company data, and validated independently. Also, at NACE 4 level, they can be derived from Eurostat SBS.

Evaluation of indicator by EC:
The following evaluation of this indicator is suggested:

- An assessment of whether profit margins of the sector are low, medium or high needs to be made. It is difficult to put exact numbers to what can be considered as a high and low profit margin, as this depends a lot on the sector and its market characteristics (e.g. whether it is a low profit-high turnover market or a high profit –low turnover market, on the capital intensity of the sector, etc.). For the purposed of this assessment, profit margins close to zero or lower than 2% can in any case be considered to be low, whereas profit margins higher than 10 % can be considered high.
- An assessment of the share of additional net carbon costs (as determined in step 1 of this assessment) over profits needs to be made by means of a threshold to be set. For example, carbon costs making up a share of more than roughly 1/3 of profits for a sector could be considered high.

In case profit margins of a sector are low and/or the share of additional carbon costs in profits is high then the extent to which carbon costs impact the sector and could lead to carbon leakage can be considered high.

3.3.2 **Carbon intensity of likely substitutes**

Description:
This indicator assesses the carbon intensity of tradable substitutes, both from within EU and from non-EU, having the same functionality, which is relevant *if* it has been established that there is indeed a significant substitution risk.

Relevance:
This indicator can provide insights into whether or not it is problematic from a carbon footprint/carbon leakage perspective that a particular sector's product is assessed to face a high risk to be substituted by materials/products with similar functionalities.

In case an EU-product (or material) is impacted by carbon costs and because of high price and/or substitution elasticity is likely to be substituted by a tradable non EU-product or EU (non-ETS) product with similar functionalities, then the carbon intensity of that substitute is relevant. In case the carbon intensity of that likely substitute is higher than that of the product being substituted as a result of carbon costs, then this might lead to an overall increase of the carbon footprint, which is undesirable. The opposite could also be the case, where the carbon intensity of substitutes is lower than that of the substituted product/material. In that case, the overall carbon footprint will decrease and there is no significant risk of carbon leakage through substitution, which fits the policy objectives of the ETS Directive.

Arguments as an indicator in favour of Carbon Leakage:

If a particular sector's product is assessed to face a high risk to be substituted by a product or material with similar functionalities and the carbon intensity of that most likely substitute(s) is higher than the carbon intensity of the sector's product being substituted, then the overall carbon footprint will increase as a result. This is an undesired carbon leakage effect, and hence an argument in favour of exposure to a significant risk of carbon leakage of a sector.

Arguments as an indicator against Carbon Leakage:

If a particular sector's product is assessed to face a high risk to be substituted by a product or material with similar functionalities, but the carbon intensity of that most likely substitute(s) is lower than the carbon intensity of the sector's product being substituted, then there is no risk of carbon leakage. In fact, the overall carbon footprint will decrease as a result, which is the desired effect, and hence this is an argument against exposure to a significant risk of carbon leakage risk for that sector.

Data sources to be used:

Detailed market data and substitution elasticity rates should preferably be used in order to determine substitution risk, but these are not readily available for most (sub)sectors. This information will therefore have to come from the sector itself, and would need to be validated on accuracy and reliability.

The carbon intensity of relevant substitutes should come from Life Cycle Analysis data which is to a large extent available in literature and/or in existing LCA databases. This should result in a carbon intensity range of the relevant substitute products, which should be compared consistently with the carbon intensity range of the (sub)sector concerned. If no existing data is available, or if this data is outdated or not representative, comparative LCA analysis could be carried out using one of the internationally accepted methodologies.

Evaluation of indicator by EC:

The following evaluation for the indicator “carbon intensity of likely substitutes” is suggested:

- The evaluation is relevant in case there is a risk that the product or material of a sector facing additional carbon costs will be substituted by another (cheaper) product or material, either from outside the EU or a material not affected by additional carbon costs. Substitution rate elasticities from validated sector data can for example be assessed.
- In that case the carbon intensity of likely substitutes can be assessed by looking at LCA performance comparisons, e.g. by using public studies.

In case there is a clear substitution risk and the carbon intensity of that substitute is higher than of the product being substituted, then the extent to which the inability to pass through costs could result in carbon leakage can be considered high.

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Support to the Commission for the determination of the list of sector and subsectors deemed to be exposed to a significant risk of carbon leakage for the years 2015-2019 (EU Emission Trading System)

Assessment of third country GHG commitments and industrial efficiencies

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Task 4 final report

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The views expressed in this study represent only the views of the authors and not those of DG CLIMA or any other organization.

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List of abbreviations

BAU	Business-as-usual
BPT	Best Practice Technology
BRIC	Brazil, Russia, India and China
CL	Carbon Leakage
CSI	Cement Sustainability Initiative
EDP	Effort Defining Policies
EEI	Energy Efficiency Index
EU	European Union
EU ETS	European Union Emissions Trading Scheme
GES	Generator Efficiency Standards
FSDS	Federal Sustainable Development Strategy
GDP	Gross Domestic Product
GHG	Greenhouse gas
HHV	Higher Heating Value
IAI	International Aluminium Institute
IEA	International Energy Agency
IETA	International Emissions Trading Association
IIP	Institute for Industrial Productivity
LHV	Lower Heating Value
NAMAs	Nationally Appropriate Mitigation Actions
OPEC	Organization of the Petroleum Exporting Countries
RGGI	Regional Greenhouse Gas Initiative
SEC	Specific Energy Consumption
TMS	Target Management System
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America

Executive summary

The carbon leakage provisions included in the Emissions Trading Directive (Directive 2009/29/EC) aim to protect European producers from a competitive disadvantage compared to producers in countries without carbon constraints. Article 10a (18(1)) of the Emissions Trading Directive states that the carbon leakage list shall be determined after taking into account *"a) the extent to which third countries representing a decisive share of global production firmly commit to reducing GHG emissions in the relevant sectors to an extent comparable to that of the EU and within the same timeframe, and b) the extent to which carbon efficiency in these countries is comparable to the EU".*

The aim of this analysis is therefore:

1. To analyse commitments of countries outside the EU27, so-called third countries, to reducing greenhouse gas emissions;
2. To analyse greenhouse gas efficiencies of relevant industrial sectors in third countries compared to the EU.

The third countries selected for this report are: China, USA, India, the Russian Federation, Japan, South Korea, Indonesia, South Africa, Canada, Australia, and Brazil. They have been selected on the basis of their large share of total industrial emissions relative to global emissions.

Comparison of third country commitments to reducing GHG emissions

The assessment of commitments and policies which are developed and implemented by third countries to limit industrial greenhouse gas emissions is based on a thorough qualitative review of industrial energy and climate policies. Climate commitments have been based on up to date information in the Climate Action Tracker. National industrial energy and climate policies have been collected using amongst others the Institute for Industrial Productivity (IIP) database on industrial efficiency policies and the IEA policy and measures database on Energy Efficiency. In addition, country-specific sources have been used to find details of national GHG policy measures.

For each of the eleven selected countries, we identified the most important policies, which are then assessed in more detail regarding type of policy, level of stringency, mandatory nature, enforcement by authorities, status of implementation level, and coverage.

Conclusion: West-Pacific countries are moving strongly forward

Based on the overview of climate policies reviewed in this study, a qualitative assessment has been made of the policies which are developed and implemented by third countries to limit industrial greenhouse gas emissions.

We find that countries located in the West-Pacific area are moving strongly forward with respect to ambitious climate policies. Japan, South Korea, and Australia have significant policies in place, either with an Emissions Trading Scheme (South Korea, Australia) or ambitious energy efficiency benchmarks (Japan), covering the majority of national emission-intensive industries. All of these countries currently shape their policies possibly raising ambition. These measures could be considered qualitatively comparable to the EU ETS in terms of potential price signals and their mandatory nature.

China and India give signals of tackling climate change with several policy packages that are mandatory, although the stringency of the energy efficiency targets is not very clear for both countries. Policies in both countries are diverse and developing fast in terms of coverage and ambition. An assessment of whether these are comparable to the EU ETS would require further detailed technical analysis.

Brazil, Indonesia and South Africa show less strict policies: they use voluntary emission saving measures to fight climate change. Policy development is quite active in Indonesia but to a lesser extent in Brazil and South Africa. Canada, the US, and the Russian Federation lag behind and did not announce a coherent and ambitious policy framework for their national industries or a plan towards it yet. The policies of these countries would not be comparable to the EU ETS.

Comparison of GHG efficiencies between EU and third countries

For the assessment of greenhouse gas efficiencies in the investigated countries a wide range of publicly available literature and data was assessed to obtain a short list for further investigation. The data in the shortlist was then amended by references obtained through an extensive questionnaire amongst Member States, NGOs and industrial sector associations. All information was assessed and cross-compared in terms of its scope, sector and country coverage, data collection methodology and approach to derive the data, homogeneity of data, primary vs. secondary sources, public vs. private data sources etc.

Conclusion: Limited availability on carbon efficiencies complicates cross-country comparisons

The assessment reveals that data availability of industrial GHG intensities that can be used for cross-country comparisons appears to be very limited. Without exception all industrial sectors face one or more serious issues in interpreting and comparing GHG intensities between EU and third countries across the world.

Sectors with the best data availability are cement and aluminium, due to sectoral benchmarking initiatives on a global level, and allow comparison of GHG intensities to some extent and between EU and at least some third countries.

The cement industry in Central America and Africa produces cement within +/-5% of the European emission intensity of cementitious products. South America and India perform on average even better than European installations, mainly due to their low clinker to cement ratio. Japan, Australia and New-Zealand show GHG intensities 6% higher than in Europe. Regarding clinker production, all third countries in this study, except for the former Soviet Union, show emissions per tonne of clinker within +/- 5% compared to the European average value of 860 kgCO_2 / t clinker.

Data for China are not useful due to poor data representativeness (only 5% of production covered). A serious limitation is that indirect emissions from electricity consumption are not taken into account. These would add roughly 10% of emissions per tonne of cement. Further research is needed to get a more reliable, country-specific and complete picture of the GHG intensity of cement manufacturing.

The GHG intensity of aluminium in Europe is comparable to that of the Russian Federation, significantly higher than Norway, and significantly lower than that of the USA and China. No GHG intensity data are available for other regions in the world, although energy intensities are. Due to large differences in the emission factor of electricity (the main energy input in primary aluminium smelting) across different regions in the world, energy intensity is not a sufficient indicator for cross-country comparisons of GHG intensities.

For steam cracking, methanol, chlorine and soda ash energy efficiencies for several countries are available. One complication is that there is no average European value to compare results with. Furthermore, additional study would be required to convert energy efficiency values to GHG intensities, which is for the complex chemical sector not a straightforward exercise.

For iron and steel most of the available data is of limited or unknown quality, preventing a solid comparison. The identified sources claim that both the average GHG intensity as well as the energy efficiency of the EU is comparable to that of US, Japan and South Korea. As indicated in the assessment of the data sources, these results should be interpreted with care: although the observations seem to be in line with each other, only one reference (UNIDO, 2010) has been identified as suitable for cross-country comparisons in this study. Further analysis would be recommended to validate these results.

Some sectors included in our analysis have no data available at all or have data of insufficient quality to allow cross-country comparisons. This holds for copper, nickel, zinc, pulp and paper, and refineries. For sectors not further mentioned in this study (e.g. lime, ferro-alloys, bricks, gypsum etc) no data have been found at all.

On a more general note, we conclude that most public data sources are not a good basis for cross-country GHG efficiency comparisons due to serious flaws in combing data from different sources collected via different approaches. Exceptions consist of the aluminium and cement industry where company data is collected in a methodologically sound and transparent way for the purpose of benchmarking the sector. Benchmarking approaches like this are a suitable means to compare GHG intensities across different countries, and therefore deserve more attention in other relevant sectors. Another useful approach would be to dive into the processes used in different regions and determine what factors influence the carbon intensity.

1 Introduction

The aim of this part of the assessment is to analyse the commitments of countries outside the EU27, so-called third countries, in sectors covered by the EU-ETS, as well as GHG efficiencies in different regions and countries across the world. This is motivated by Article 10a (18(1)) of the Emissions Trading Directive which states that the carbon leakage list shall be determined after taking into account:

> *a) the extent to which third countries representing a decisive share of global production firmly commit to reducing GHG emissions in the relevant sectors to an extent comparable to that of the EU and within the same timeframe, and*
>
> *b) the extent to which carbon efficiency in these countries is comparable to the EU.*

As the carbon leakage status is at this moment only relevant for EU-ETS installations, the analysis of third country commitments and GHG efficiencies needs to be focussed on the industry sectors (or subsectors) that are found to be in the EU-ETS.

2 Selection of third countries

The scope of work has been limited initially to the 10 most important countries. The selection of the top 10 of most significant third country countries has been made taking the abovementioned article 10a(18(1)) of the ETS Directive into account, which states that the third countries concerned should represent a decisive share of global production in sectors or subsectors deemed to be at risk of carbon leakage.

2.1 “a decisive share … in sectors”

Three approaches are – in principle – possible to select on “a decisive share of global production in [exposed] sectors or subsectors”:

1. Make a country selection for all CL-exposed NACE4 codes individually, and describe all included countries; data availability would make this exercise very time consuming.
2. Make a country selection for the most important aggregation of CL-exposed sectors. Linking NACE4 codes to these sectors would not in all cases be straightforward and this approach was not possible within the budget of this task – and therefore not pursued.
3. Make a country selection for the industry as a whole, and describe the included countries.

In line with the proposal, we follow approach 3). This approach is straightforward, and in practice more or less the same countries will appear in most of the specific sectors anyhow. In addition, the majority of the industry is exposed to Carbon Leakage which makes a differentiation between leakage and non-leakage industries at this moment not relevant (even if possible).

2.2 “a decisive share of global production”

To determine the selection of 10 countries representing a decisive share of production in industry, we identified (again) three possible approaches:

1. Selection based on total industrial production; industrial production for different (sub-) sectors can be found in the UN production statistics or production from various (sub-)sector associations. Production data from different (sub-) sectors can, however, not be simply aggregated due to the different nature of the products e.g. a tonne steel cannot be simply added to a tonne ammonia to represent the total tonnes of production of two sectors.
2. Selection based on total industrial energy consumption; The energy consumption of the industry can be found in IEA statistics published each year. A third country top 10 can then be constructed by ranking the energy consumption of each country.

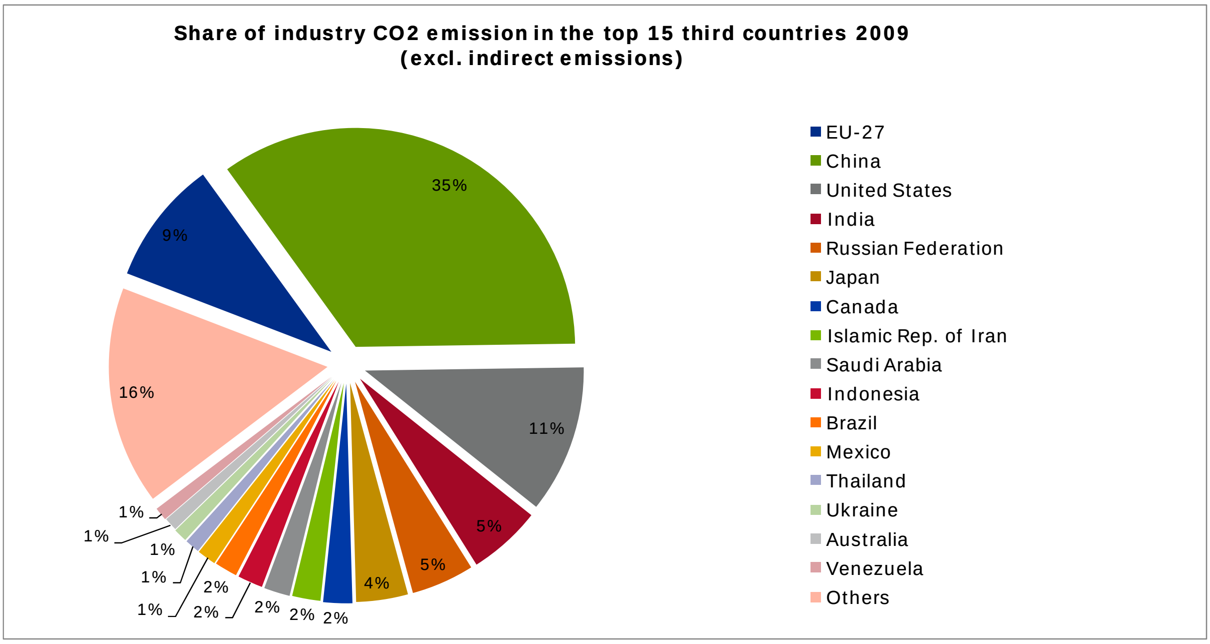
3. Selection based on total industrial CO_2-emissions; The IEA statistics also contain the CO_2-emissions of the industry per country, both including and excluding indirect emissions.

The third possibility is further away from the definition in article 10a(18) as an additional emission factor is included by obtaining the CO_2-emissions from the energy consumption. However, the final goal of the ETS Directive is CO_2-emissions reduction, so it would be more in the 'spirit' of the ETS Directive to determine the top 10 of most significant countries from their share in the global industry CO_2-emissions. Therefore, the third approach is followed.

2.3 Selection of the most significant countries

From an analysis of the IEA 2011 report 'CO_2 emissions from fuel combustion Highlights' (IEA, 2011), a list of countries and their corresponding CO_2 emissions for 2009 in the industry was obtained. The industry CO_2 emissions were obtained by summing the CO_2 emissions from 'Manufacturing industries and construction' and 'Other energy industry own use' (categories as defined in the IEA statistics). An overview of industrial CO_2 emissions shares excluding indirect emissions of the top 15 countries is given in Figure 1, and including indirect emissions in Figure 2.

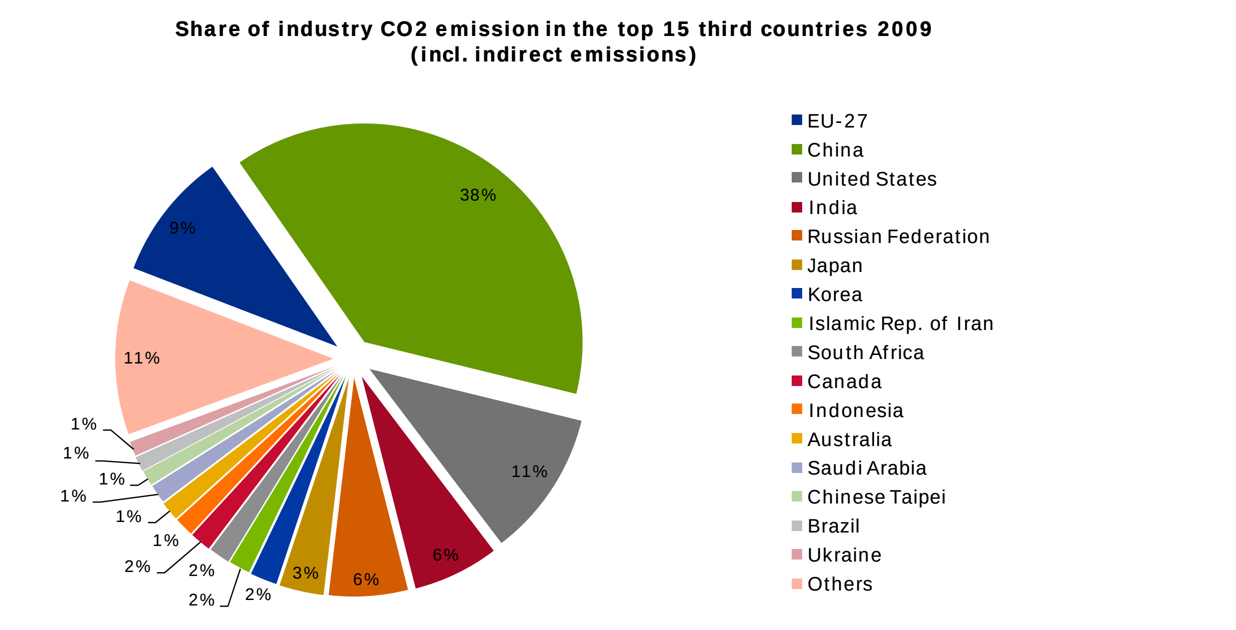
Figure 1 Industrial CO2-emissions share of the EU-27 and the top 15 third countries ranked according to total direct CO2-emissions



Source: data from IEA, 2011

-

Figure 2 *Industrial CO2-emissions share of the EU-27 and the top 15 third countries ranked according to total direct and indirect CO2-emissions*



Source: Data from IEA, 2011

The top 5 countries do not change for indirect emissions included or excluded. However, in the ranking of number 6 - 10 some changes occur: Saudi Arabia and Brazil have been replaced by Korea and South Africa when the indirect emissions are included. Since the industry in the EU ETS has to account for the cost of indirect emissions as well, we will base our selection of the top 10 most significant countries on the direct and indirect emissions (Figure 2).

2.4 The 11 selected third countries

Following discussions with the Commission, we made one exception and one addition to the top 10 as listed in Figure 2.

The exception is the Islamic Republic of Iran. The CO_2 emissions of Iran are largely driven by the oil production, given the fact that it is OPEC's second largest oil producer, and the industry is mainly focused on refineries and the chemical and petrochemical industry. Due to the exclusion of the Islamic Republic of Iran, the next country in the row, Australia, will be added to the top 10.

As a second point of attention Brazil needs special consideration. Brazil is not included in the top 10 countries, while the economy of Brazil is one of the largest in Latin America and a BRIC-country. Additionally, Brazil is included in the top 10 countries CO_2 analysis excluding indirect emissions of all major industry sectors (Iron and Steel, Chemical and Petrochemical, Non-Ferrous Metals, Non-Metallic Minerals and Pulp, Paper and Printing) (IEA, 2011). The reason for Brazil falling out of the top 10 countries when indirect emissions are included is that Brazil has a substantial amount of energy supply in hydro and biomass. Nonetheless, with the current and expected growth of

Brazil, the commitments of Brazil will have a significant influence on future CO_2 emissions and will therefore be included in the country selection given in Table 1.

As a result, we will consider 11 third countries, presented in the table below.

Table 1. Industrial CO_2 emissions from third country selection.

Industrial CO_2 emissions including indirect emissions in 2009		
Region	**Million tonnes of CO_2**	**Share in global industrial CO_2 emissions**
World	12471.1	100%
EU-27	1183.3	9%
Selected top 11	9215.1	74%
China	4800.2	38%
United States	1353.5	11%
India	793.5	6%
Russian Federation	726.8	6%
Japan	409.7	3%
Korea	249.7	2%
South Africa	196.4	2%
Canada	195.9	2%
Indonesia	176.3	1%
Australia	175.3	1%
Brazil	137.8	1%

3 Comparison of third country commitments to reducing GHG emissions

3.1 Focus on qualitative assessment of industrial energy / GHG policies

For comparison capabilities with the EU commitments, the focus of the analysis initially was on quantified pledges or commitments.

As described in the proposal, the UNEP Emissions Gap report was proposed to be used as the main source of information to be able to take the degree of implementation into the respective national legislation of the pledges under the Copenhagen Accord into account. The UNEP report, which refers to the Copenhagen Accord, gives and analyses the pledges on a national level of the EU-27 and the most important third countries. However, the Copenhagen Accord and therefore the UNEP report as well did not contain any industry-specific pledges or targets. Only emissions from land use, land-use change and forestry have been separately analysed.

The Climate Action Tracker was also mentioned in the proposal as a source for the most up to date information. On a national level the Climate Action Tracker does indeed contain the most up to date information on international pledges, but no industry-specific targets have been given. Only a projection of a total industry emissions reduction of 11-16% below 1990 levels by 2020 for the developed countries combined is given.

Additionally, third country pledges for the industry have been investigated in various IEA reports and the Ecofys country factsheets 2011:

- *IEA country reports to Energy Efficiency Working Party 2009*; many energy saving plans described for various countries, but none reflecting on the industry. Plans are mainly for the building and transport sector. No goals are given.
- *IEA Implementing Energy Efficiency Policies 2009;* an overview of successful policies implemented in various countries. Challenges and areas for improvement are given according to the IEA recommendations.
- *IEA Energy Technology Prospectives 2010;* prospectives and scenarios to achieve desired scenarios in the report are given, but no commitments of third countries.
- *Ecofys Country factsheets 2011*; an up to date overview of national and international pledges and targets for almost all countries. A short description of several national commitments and plans for the industry sector has been given for each country, but no quantified targets were given.

Since there appear to be no industry-specific quantified targets in international pledges, we shifted our focus – as agreed with the Commission – to a more qualitative assessment of industrial energy / GHG policies.

3.2 Methodology and sources

Since there appears to be no industry-specific quantified targets in international pledges, the scope of the analysis is broadened to include national pledges and qualitatively described targets and commitments in other reports than given in the proposal.

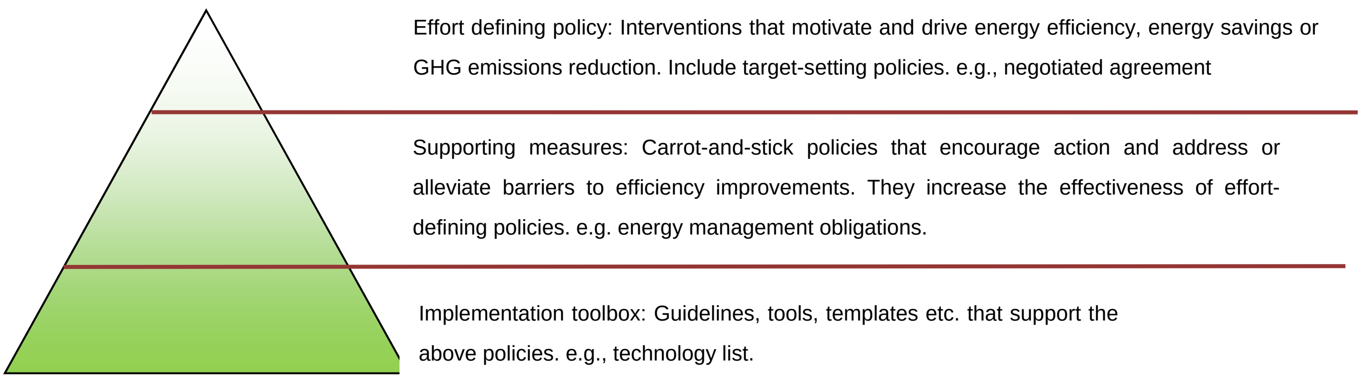
We have identified the following sources that may contain industrial targets:

- Institute for Industrial Productivity (IIP) database; compact but detailed overview of national industrial targets and commitments, but only for China, India, Japan and the US.
- International Emissions Trading Association (IETA); some of the identified top 10 countries have implemented emissions trading schemes, which covers (a part of) the industry and may contain an emissions cap.
- UNFCCC national communications and the corresponding in-depth review report; these reports mainly contain a description of the targets that have been reached and less detail on future targets or plans. The most recent national communications are not up to date for all countries, with some dating back to 2000. Some national communications are sorted on projects and plans rather than sectors. To be able to assess the targets for the industry for those reports, the whole section on future plans has to be accessed.
- Enerdata reports, e.g. Enerdata and the Economist Intelligence Unit, “Trends in global energy efficiency 2011. An analysis of industry and utilities”, 2011.

In addition, country-specific sources will be used to find details of national GHG policy measures.

For each of the eleven selected countries, we first identify the most important policies, which are then accessed in more detail regarding type of policy, level of stringency, mandatory nature, enforcement by authorities, status of implementation level, and coverage. In this analysis the most important policies are those policies that can be classified as Effort Defining Policies (EDP), as described by IIP:

Figure 3 Policy instruments as classified in three different policy levels by IIP



Source: http://iepd.iipnetwork.org

For Effort Defining Policies the following characteristics are collected, if available: timeframe of the policy[1], the share of industrial energy use covered by the policy[2], the amount of enterprises affected by the policy, governmental approval of policy (i.e. legal status), and potential overlap with other policies. Finally, a judgement is made whether the EDP should be accessed in more detail or not.

3.3 Summary of commitments and industrial GHG policies per country

In its 12th Five Year Plan **China** has set the target to reduce its nation-wide carbon intensity (carbon emissions per unit of GDP) in 2020 by 40-45% below 2005 levels. Under the new targets, energy intensity (energy consumption per unit of GDP) will be reduced by 16% and carbon intensity (carbon emissions per unit of GDP) will be reduced by 17% below 2010 levels by the end of 2015.

China enforces a wide range of climate policy instruments, which partly overlap with each other, and mainly focus on mandatory energy standards. For industry the target is to cut industrial energy intensity (per unit of GDP) by 21% in 2015 compared to 2010 and to realize an absolute energy conservation of 670 Mtce. This target is distributed to different energy intensive sectors yielding specific reduction targets for different sectors in the range of 17 – 20% CO_2 emissions reduction per unit of GDP (in 2015 compared to 2010). Targets are mandatory and progress is monitored by government agencies. In addition, China runs the Top 10,000 Program in which 15,000 enterprises - that cover two thirds of China's total energy consumption - need to meet annual energy saving targets. Moreover, industrial energy performance standards set minimum allowable energy efficiency values for existing plants and newly constructed plants, taking into account different types of raw materials, fuels, and capacities. The stringency of these energy standards have not been assessed within the scope of this study. Finally, China is phasing out small plants and outdated technology over time. The emissions trading pilot schemes in China are not assessed as they are currently at a regional level and scope and the caps are still being finalised, but these are expected to target sectors comparable to the EU Emissions Trading Scheme.

The **USA** announced a target to reduce national emissions by -17% relative to 2005 emissions in 2020 (equivalent to -3% relative to 1990) but the federal government did not adopt stringent climate policies for industry. The most ambitious and stringent climate policies covering industry are two regional cap-and-trade schemes (RGGI and California), but they are not adopted at federal level and are therefore not considered in this country-specific assessment. The four national programs that are developed in the USA are mostly about encouraging voluntary energy efficiency improvements without so much focus on enforcement. The Prevention of Significant Deterioration (PSD) sets

1 The revised ETS directive states that only commitments "within the same timeframe" should be taken into account.

2 EDPs with a scope of only part of a country (like in regional ETS systems) are only taken into account when at least 10% of the countries' industrial energy use is covered by it.

emission standards for industry, but on a case-by-case basis, and without clarity on the stringency of the standards.

India committed itself internationally to cut their national emission intensity (per GDP) by 20 to 25% in 2020 relative to 2005. To achieve this India launched amongst others a white certificate scheme, called Perform-Act-Trade. The scheme imposes mandatory specific energy targets on participants from the energy and industry sector. Installations that overperform on their energy savings receive white certificates, which can then be sold to other installations that are not compliant. The first phase of commitment and trading is three years (2011-2014). The methodology for target setting in the 7 industrial sectors (Aluminium, fertilizers, iron and steel, cement, pulp and paper, chlor-alkali, textile, chemicals) as well as the monitoring and verification protocols are still under preparation.

The **Russian Federation** committed to a reduction of national emissions of -15 to -25% relative to 1990 emissions by 2020. Russia also set a target of 40% reduction in GDP energy intensity by 2020 compared to 2007. In Russia one effort defining policy has been identified: the State Energy Efficiency Program. The State Program aims for a GDP energy intensity reduction of 13.5% by 2020 compared to 2007 (the other 26.5% reduction will be achieved without government support). The program contains energy conservation measures in various spheres of Russia's economy, including industry, as well as incentives.

On the international stage, **Japan** proposed to decrease emissions to -25% below 1990 emissions levels by 2020, on the condition of an effective international framework in which all major economies participate. Japan has introduced mandatory energy efficiency targets in the form of benchmarks, covering about 70% of final energy use in Japan. The names of underperforming companies are published on a list and fines are imposed. Japan has also introduced 1% annual energy efficiency improvement obligation for all businesses. For designated sectors that align quite well with EU-ETS sectors (Steel, Electricity, Cement, Paper & Pulp, Oil Refinery, Chemical) targets have been set at the energy efficiency level of the best performing companies (top 10% - 20%) within that industrial (sub)sector. These targets must be met in 2015 and 2020.

South Korea has agreed to reduce its national emissions 30% below reference emissions in 2020, which is 4% below the 2005 value. South Korea has developed and implemented several polices to stimulate a low-carbon society. Most notably is the development of an Emissions Trading Scheme which will start in January 2015. The ETS will be following the current Target Management System, that already covers around 70% of national GHG emissions and acts as a precursor the Korean ETS. The TMS is a system in which the government imposes the target for GHG emissions as well as the energy use to designated entities and by which the government checks on and manages the achievements of those entities. Details of the future ETS scheme (e.g. allocation methodology, determination of carbon leakage exposure, etc.) will be announced mid-2013.

The TMS and ETS will overlap with other policy measures, like the National Basic Energy Plan. This plan sets an energy intensity (per GDP) target and aims for a reduction of 46% between 2007 and 2030. The industry should contribute to about 44% of the emission reductions. In addition, South Korea promotes five-year voluntary agreements with industrial groups: businesses that enter into voluntary agreements or invest in energy-saving technologies are entitled to financial and technical support and tax credits covering up to 20 per cent of the investment cost.

South Africa has set an industry target of 15% reduction of final energy demand in 2020 compared to a baseline scenario. To reach this target the Minister for Energy and Minerals, together with the industry participants (36 major industrial energy users and 8 industrial associations), voluntarily committed themselves to implement the government target for energy savings. The list of commitments that was negotiated between both industry and government is known as the Energy Efficiency Accord, which was established in May 2005. Unfortunately, one area where the Accord has not been effective is the lack of common reporting requirements as well as agreed and enforced measurement and verification methodology. Companies differed in their perception of energy savings due to lack of agreement on baseline determination and Business-As-Usual projections of energy demand.

Canada made the commitment of reducing national emissions by -17% relative to 2005 by 2020 (+3% relative to 1990), thereby aligning their GHG emissions target with the USA. By 2020 Canada aims to produce 90% of electricity by non-emitting sources, up from 77% in 2008. As a starting point to achieve this, the Federal Sustainable Development Strategy (FSDS) has been designed, in which the strategy to address climate change is outlined. Canada is still in the process of developing and implementing more detailed climate change strategies. In September 2012 the government announced final regulations for reducing GHG emissions from coal-fired electricity generation by setting stringent performance standards. Other industrial policy instruments have not been defined yet by Canada. State level policies such as a carbon tax in British Columbia were not assessed in this report.

Indonesia proposed to cut national emissions by 26% by 2020 from business-as-usual (BAU) levels. Indonesia clarified that, in addition to its unilateral 26% target, it proposes a 41% reduction below BAU target based on supported Nationally Appropriate Mitigation Actions (NAMAs). These targets are supported by the National Master Plan for Energy Conservation, which has been in place since 2005 and was the framework for several subsequent energy laws. Specifically for industry, Indonesia developed the "Grand Strategy of Energy Conservation and CO2 Emission Reduction in Industrial Sector 2010 – 2020". The program consists of voluntary energy saving measures which are being implemented by industry. The government assists in implementing energy savings amongst others by providing energy audit training programs. Note that in Indonesia the industry accounts for only 3% of total national GHG emissions, while it is responsible for 47% of the national energy consumption.

Australia has committed to reduce its national greenhouse gas emissions by 5% compared to 2000 levels by 2020. In June 2011, the Australian government introduced the Clean Energy Legislative Package, which includes various support measures to stimulate clean energy and provide support to safeguard competitiveness, economic growth and household purchasing power. The Carbon Pricing Mechanism is an effort-defining policy under this policy. The scheme will start by introducing a fixed unit price on carbon, which will be followed by a cap-and-trade scheme after 2015. Linkage with the EU ETS is anticipated for the two trading phases: One-way link for 2015-18 with full linking by July 2018.

In addition, Australia is running Generator Efficiency Standards (GES), a voluntary programme whereby a fossil-fuel electricity generator enters into a legally binding agreement with the Australian national government to strive towards best practice levels in fossil-fired electricity generation in terms of energy efficiency and to reduce GHG emissions. This covers all businesses that use fossil fuels to generate electricity (not just power plants). In return for participation, the government offers recognition and support in the form of technical support and covering auditing costs.

Brazil announced to reduce its national emissions by 36.1%- 38.9% in 2020 compared to projected BAU emissions. The target is conditional to international financing. In 2009, Brazil adopted the National Policy on Climate Change, in which voluntary energy saving measures and CO_2 reduction targets at national level were announced. Under this policy framework sectoral climate change mitigation plans will be established for several relevant sectors, e.g. manufacturing industry and durable consumer goods industry, basic and fine chemicals industry, paper and cellulose industry, and mining.

3.4 Overview of GHG policies per country

An overview of different climate policies per country is provided below.

3.4.1 China

Table 2 Overview of Chinese policies

China Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Energy Intensity Target of the 11th Five Year Plan	Effort Defining Policy	2006-2010	-	-	-	The 11th Five Year Plan energy intensity targets were met. For 2011-2015 new intensity targets were introduced in the 12th Five Year Plan.	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Energy and Carbon Intensity Targets of the 12th Five Year Plan	Effort Defining Policy	2011-2015	-	Spread across power, industry, buildings, and transport sectors	Energy intensity targets set by the State Council.	No	Yes	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Top-1000 Energy-Consuming Enterprises Program	Effort Defining Policy	2006-2010	-	-	-	Is replaced by the Top-10,000 Energy-Consuming Enterprises Program.	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Top-10,000 Energy-Consuming Enterprises Program	Effort Defining Policy	2011-2015	85% of the total estimated industrial energy use	15,000 industrial enterprises	Energy Conservation Law. Targets set by the National Development and Reform	In line with the Energy and Carbon Intensity Targets of the 12th Five Year Plan.	Yes	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.

China Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
					Commission.			
Industrial Energy Performance Standards	Effort Defining Policy	2008-?	-	Enterprises that produce energy-intensive materials.	Energy Conservation Law	In line with the Energy and Carbon Intensity Targets of the 12th Five Year Plan.	Yes	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Small Plant Closures and Phasing Out of Outdated Capacity	Effort Defining Policy	2007-2015	-	18 industrial subsectors	Part of China's State Council's Comprehensive Working Plan of Energy Conservation and Emission Reduction	In line with the Energy and Carbon Intensity Targets of the 12th Five Year Plan.	Yes	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Energy Efficiency Appraisals for New Large Industrial Projects	Effort Defining Policy	2010-2015	-	New construction or fixed-asset investment projects	NDRC regulations of Energy-Efficiency Assessment and Review on Fixed-Asset Investment Projects	In line with the Energy and Carbon Intensity Targets of the 12th Five Year Plan.	Yes	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Mandatory Energy Managers and Energy Audits	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Ten Key Projects	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th

China Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
								2012.
Financial Rewards for Energy-Saving Technical Retrofits	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Differential Electricity Pricing for Industry	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Carbon Emissions Trading Pilots	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Energy Performance Contracting and Energy Service Companies (ESCOs)	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Low Carbon Development Zones	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Demand Side Management	Supporting	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.

China Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Implementation Measures	Measures							org/country/china), accessed on April 10th 2012.
EE Financing Regulations and Instruments	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Information System, Trainings, Standard for Energy Management & Auditing	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Training programs	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Technology Catalogs that are promoted by the Chinese government	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Guidelines for Validation, List of Qualified ESCOs, Energy Performance Contracting Standard	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.

China Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Lists of registered ESCOs in China	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Study tours and workshops on low carbon development zones for local governments	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Punishment measures in loans or re-financing process	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Guidelines for energy-efficiency reviews	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.

Table 3 China: Energy and Carbon Intensity Targets of the 12th Five Year Plan

CHINA: Energy and Carbon Intensity Targets of the 12th Five Year Plan			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The Energy and Carbon Intensity Targets of the 12th Five Year Plan support the 2020 target to reduce carbon intensity by 40-45% below 2005 levels. Under the new targets, energy intensity (energy consumption per unit of GDP) will be reduced by 16% and carbon intensity (carbon emissions per unit of GDP) will be reduced by 17% below 2010 levels by the end of 2015. The 16% reduction in this Five Year Plan will bring the total reduction for the total ten year period (2006-2015) to 32% below 2005 levels. The targets and expected achievements are broken down by sector and province.		IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	Mandatory targets set by the State Council	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Progress is monitored by Government Agencies. Enforcement by National Development and Reform Commission and Local, Provincial, Central governments.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented	3	The State Council has released a comprehensive work plan on energy efficiency and emissions reduction for the 12th Five Year Plan, which details 50 specific measures that are to be carried out in support of the energy intensity target	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Coverage	Spread across power, industry, buildings, and transport sectors	The Ministry of Industry and Information Technology (MIIT) released the 12th FYP on industrial energy conservation	IIP policy database (http://iepd.iipnetwork.org/country/china),

CHINA: Energy and Carbon Intensity Targets of the 12th Five Year Plan			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
		on February 27, 2012, which serves as the guidance document for national industrial energy conservation during the 12th FYP.	accessed on April 10th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Cut the industrial energy consumption per unit of value-added output by 21% from 2011 to 2015 and realize energy conservation of 670 Mtce (assuming GDP growth of 8.5% per year).	Reference level is 2010. More specific targets are given for energy intensive industries, such as: -Iron and Steel 18% (18% CO_2/GDP) -Chemical and Petrochemical 20% (17% CO_2/GDP) -Nonferrous metals 18% (18% CO_2/GDP) -Textile 20% (20% CO_2/GDP) -Building Materials 18-20% (18% CO_2/GDP)	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012. China MIIT Information Services (http://www.miit.gov.cn/n11293472/n11293832/n11293907/n11368223/) accessed on April 19th 2012.
Overlap with other selected policies	Yes	Top-10,000 Energy-Consuming Enterprises Program, Industrial Energy Performance Standards, Small Plant Closures and Phasing Out of Outdated Capacity, Energy Efficiency Appraisals for New Large Industrial Projects.	

Table 4 China: Top-10,000 Energy-Consuming Enterprises Program

CHINA: Top-10,000 Energy-Consuming Enterprises Program			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The Top 10,000 Program aims to cover two thirds of China's total energy consumption, or 15,000 industrial enterprises that use more than 10,000 tonnes of coal equivalent (tce) per year, and around 160 large transportation enterprises (such as large shipping companies), and public buildings that use more than 5,000 tce per year. The total number of enterprises covered by this program reaches to around 17,000.		IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Type of Effort Defining Policies:	3	Mandatory targets set by the State Council. If enterprises do not meet the annual energy-saving target, mandatory	IIP policy database (http://iepd.iipnetwork.org/country/china),

CHINA: Top-10,000 Energy-Consuming Enterprises Program			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)		energy audits will be conducted and adjustment/retrofits are required to be taken within a limited period of time.	accessed on April 10th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Progress is monitored by the National Development and Reform Commission. Enforcement by Local, Provincial, Central governments.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented	3		IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Coverage	15,000 industrial enterprises	Enterprises that use more than 10,000 tonnes of coal equivalent (tce) per year	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Absolute energy-saving target of 250 Mtce by 2015 (assuming GDP growth of 8.5% per year).	Reference level is 2010. The share of the energy-saving target of the Top 10,000 Program is 37% of the total energy-saving target.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Overlap with other selected policies	Yes	Energy and Carbon Intensity Targets of the 12th Five Year Plan, Industrial Energy Performance Standards.	

Table 5 China: Industrial Energy Performance Standards

CHINA: Industrial Energy Performance Standards			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	Industrial energy performance standards set minimum allowable energy efficiency values for existing plants and newly constructed plants, taking into account different types of raw materials, fuels, and capacities. Aside from the mandatory minimum energy efficiency standards a set of voluntary, more advanced, "reach standards" have been established.		IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	1	22 minimum energy efficiency standards in kgce/t, kWh/t or gce/kWh.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	2	The enforcement method remains unclear in case the plants do not meet their targets.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented	3	China began to conduct monitoring and examination on the implementation of the 22 standards in 2010.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Coverage	Enterprises that produce energy-intensive materials.	Materials covered include: cement, crude steel, caustic soda, copper, ferroalloy, coke, calcium carbide, ceramics, zinc, lead, yellow phosphorus, synthetic ammonia, flat glass, magnesium, copper-alloy, nickel, electrolyzed	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.

CHINA: Industrial Energy Performance Standards			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
		aluminum, tin, antimony, carbon materials, and wrought aluminum alloy and electricity from coal-fired power stations	
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Different mandatory minimum energy efficiency standards for each Product/Process/Size Unit.	List can be found at the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), and the Standardization Administration of China (SAC).	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Overlap with other selected policies	Yes	Energy and Carbon Intensity Targets of the 12th Five Year Plan, Top-10,000 Energy-Consuming Enterprises Program.	

Table 6 China: Small Plant Closures and Phasing Out of Outdated Capacity

CHINA: Small Plant Closures and Phasing Out of Outdated Capacity			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	Part of China's State Council's Comprehensive Working Plan of Energy Conservation and Emission Reduction to accelerate the closing of small plants and phasing out outdated capacity in high energy-consumption industries.		IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	Phase-out targets have been allocated to local enterprises by local governments and the Ministry of Finance (MOF) provides certain fiscal incentives to local governments to support the phasing-out.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines)	1	Progress monitored by Government Agencies. Enforcement by Local, Provincial, Central governments by closing plants down.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.

CHINA: Small Plant Closures and Phasing Out of Outdated Capacity			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
2 = No focus on enforcement by authorities			
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented	3	In 2007, China's State Council announced a Comprehensive Working Plan of Energy Conservation and Emission Reduction to accelerate the closing of small plants.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Coverage	18 industrials subsectors, involving 2255 enterprises.	Electric power, iron-making, steel-making, electrolytic aluminium, ferroalloy, calcium carbide, coking, cement, coal, plate glass, pulp and paper, ethanol, monosodium glutamate, and citric acid. Added since 2010: copper smelting, zinc smelting, lead smelting, leather manufacturing, textile printing & dyeing, and chemical fiber industry.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	A list of small plants is published each year with time frames for closure according to predefined closure thresholds.		IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Overlap with other selected policies	Yes	Energy and Carbon Intensity Targets of the 12th Five Year Plan, Industrial Energy Performance Standards.	

Table 7 *China: Energy Efficiency Appraisals for New Large Industrial Projects*

CHINA: Energy Efficiency Appraisals for New Large Industrial Projects			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	This policy applies to the domestic fixed-asset investment projects that are under the administration of the Development and Reform Commissions (DRC) of central and local governments. International projects are not under the interim regulation. Fixed-asset investment projects not only need to meet the requirements of land assessments and environmental assessments, but also need to pass the energy-efficiency assessments, in order to be accepted for further review and approval.		IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	Designed by the National Development and Reform Commission (NDRC), this policy includes two parts: 1. an ***energy-efficiency assessment***, which assesses the project's energy efficiency based on energy-efficiency regulations and standards and requires the project investor to write Energy-Efficiency Assessment Reports and Reporting Forms; and 2. an ***energy-efficiency review***, which reviews the submitted Energy-Efficiency Assessment Reports and Forms, and subsequently provides feedback and comments.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Progress monitored and enforcement by National and Local Development and Reform Commissions. If fraud is found in an energy-efficiency assessment report, the approval shall be revoked with a requirement to submit a modified report. If fraud is found in government authorities or personnel in charge of the review, they shall be punished with disciplinary sanctions or criminal charges.	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Status of development: 1 = Concept of policy approved by government	3	In September 2010, China announced the *Interim Regulation of Energy-Efficiency Assessment and Review on Fixed-Asset Investment Projects.* This policy took effect	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.

CHINA: Energy Efficiency Appraisals for New Large Industrial Projects			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented		on November 1, 2011.	
Coverage	Projects that: • consume no less than 3,000 tonnes of coal equivalent (tce) (electricity converted at heating value), • consume more than 5 GW of electricity, • consume more than 1,000 tonnes of oil, or consume more than 1 million cubic meters of natural gas.		IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	A list of small plants is published each year with time frames for closure according to predefined closure thresholds.	List of closure thresholds can be found at *Price, L. (2010). Information for Development of a Country Factsheet on Industrial Energy Efficiency Policies and Programs in China. Berkeley, CA: Lawrence Berkeley National Laboratory.*	IIP policy database (http://iepd.iipnetwork.org/country/china), accessed on April 10th 2012.
Overlap with other selected policies	Yes	Energy and Carbon Intensity Targets of the 12th Five Year Plan, Top-10,000 Energy-Consuming Enterprises Program.	

3.4.2 Europe

Table 8 EU-27: EU ETS

EU-27: EU ETS			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The EU Emissions Trading System (EU ETS) is a cornerstone of the European Union's policy to combat climate change and its key tool for reducing industrial greenhouse gas emissions cost-effectively. Being the first and biggest international scheme for the trading of greenhouse gas emission allowances, the EU ETS covers some 11,000 power stations and industrial plants in 30 countries.		European Commission (http://ec.europa.eu/clima/policies/ets/index_en.htm), accessed on April 10th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	2	Emissions trading scheme, based on the cap-and-trade principle. At the end of each year each company must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed.	European Commission (http://ec.europa.eu/clima/policies/ets/index_en.htm), accessed on April 10th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Industrial installations and aircraft operators covered by the EU Emissions Trading System (EU ETS) are required to have an approved monitoring plan, according to which they monitor and report their emissions during the year. In the case of industrial installations, the monitoring plan forms part of the approved permit that is also required.	European Commission (http://ec.europa.eu/clima/policies/ets/index_en.htm), accessed on April 10th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented	3	Legal framework: revised EU ETS Directive 2009 Phase-II (2008-2012) currently in progress. The time frame for Phase-III is 2013-2020.	

EU-27: EU ETS			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Coverage	About 12,000 power stations and industrial plants in 30 countries. January 2012: aviation included	Installations with a net heat excess of 20 MW in the energy and industrial sectors which are collectively responsible for close to half of the EU's emissions of CO_2 and 40% of its total greenhouse gas emissions.	
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Total GHG emissions 21% lower than 2005 level.		
Overlap with other selected policies	No		

3.4.3 USA

Table 9 Overview of US American policies

US Federal Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Greenhouse Gas Permitting	Effort Defining Policy	2011-2016	-	Larger industrial and commercial sources that release air pollutants.	under the Clean Air Act	No	Yes	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
New Source Performance Standards	Effort Defining Policy	2015-?	40% of the nation's GHG emissions	Fossil-fuel power plants, electric generating units (EGUs) and refineries	under the Clean Air Act	No	Yes	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Save Energy Now LEADER	Effort Defining Policy	1976-2011	-	-	-	Replaced by Better Buildings, Better Plants in 2011.	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Better Buildings, Better Plants	Effort Defining Policy	2011-?	-	Industrial plants	Supported by the Department of Energy in several forms of recognition for different actions taken by participants as well as new implementation	No	Yes	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.

US Federal Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
					tools.			
Climate Leaders	Effort Defining Policy	2002-2010	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Climate Vision	Effort Defining Policy	2003-2012	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Superior Energy Performance	Effort Defining Policy	2012-?	-	-	-	Supports Better Buildings, Better Plants	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Energy Star Program for Industry	Effort Defining Policy	1992-?	-	16 major industries	US Environmental Protection Agency provides recognition through ENERGY STAR to help energy programs to motivate teams, develop momentum, and build support	No	Yes	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.

US Federal Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Voluntary pledge, baseline, energy management plan, energy manager	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Five-step implementation program	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Business Energy Investment Tax Credit	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Modified Accelerated Cost-Recovery System	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Innovative Technology Loan Guarantee Program	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Greenhouse Gas Reporting Program	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-

US Federal Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
								federal) accessed on April 10th 2012.
Economy - Energy - Environment	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
White Papers on GHG Control Measures, Control Technology Clearinghouse, Applicability Tool, Code of Federal Regulations	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Support & co-funding of energy assessments (following ANSI certification), Software tools (Quick PEP), Energy management training	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Tools & guidance for GHG inventories & management, Inventory Management Plans (IMP), technical	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.

US Federal Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
assistance, Webinars								
Training Centers, Software Tools, GHG Reporting Guidelines	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
ISO 50001 standard, Energy Quick Start website, Best Practice Scorecard tool	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Guidelines for Energy Management, Industry-Specific Energy Management Tools & Resources, ENERGY STAR Industrial Benchmarking Tools, Target Finder, ETP template, Monitoring Protocols	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Form 3468	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.

US Federal Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Normal federal tax depreciation rulebooks and tools	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.
Applicability Tool, training, electronic GHG reporting tool (eGGRT)	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 10th 2012.

Table 10 USA: Greenhouse Gas Permitting

US FEDERAL: Greenhouse Gas Permitting			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	From 2011, under the Prevention of Significant Deterioration (PSD) program of the Clean Air Act, large industrial installations will be required to obtain permits for GHG emissions as well as for other air pollutants, and requires the implementation of Best Available Control Technologies (BACT).		IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	1	Installations covered by the permitting requirements must install "Best Available Control Technology" (BACT) for every pollutant subject to regulation under the CAA. The BACT requirements were defined by Environmental Protection Agency (EPA) on November 10, 2010 and provide guidance on technologies to be employed. The BACT specify a maximum amount of GHG emissions allowed to be emitted by the specific technology operated under the CAA.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Monitoring and enforcement by the EPA, verification by third party professional engineers. *Sanctions:* When EPA finds that a violation has occurred, the agency (at state level) can issue an order requiring the violator to comply, issue an administrative penalty order (using EPA's administrative authority to force payment of a penalty), or bring a civil judicial action (sue the violator in court).	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started.	3	- In phase 1 (Jan 2011-June 30, 2011) only newly constructed sources or significantly modified ones are subject to PSD permitting. - In phase 2 (July 1, 2011-June 30, 2013) modifications at existing facilities are subject to PSD permitting if the resulting GHG emissions increase at least 75,000 metric tons per year. Also facilities emitting at least	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.

US FEDERAL: Greenhouse Gas Permitting			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
3= Policy fully implemented		100,000 metric tons per year are subject to PSD permitting in phase 2. - A foreseen phase 3 (until April 2016) would reduce the threshold to a level not lower than 50,000 tons per year. Final details on this phase are to be decided in a later stage.	
Coverage	Larger industrial and commercial sources that release air pollutants.	Thresholds for coverage are 100,000 and 250,000 metric tons of GHG emissions per year, depending on the type of source.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Best Available Control Technologies (BACT),	Relative target, no absolute targets. BACT include relative emission targets and guidance to what type of technology or control level should be implemented. BACT specifications are being defined and in principle may include maximum emission levels. No information is obtained on whether this will be the case.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Overlap with other selected policies	Yes (Complementary)	New Source Performance Standards	

Table 11 USA: New Source Performance Standards

US FEDERAL: New Source Performance Standards			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	In December, 2010, the Environmental Protection Agency entered into two proposed settlement agreements to issue rules that will address greenhouse gas emissions from fossil fuel-fired power plants and refineries known as New Source Performance Standards (NSPS). These two industrial sectors make up nearly 40 percent of the nation’s greenhouse gas emissions.		IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Type of Effort Defining Policies:	1	The policy will encourage producers to invest in simple energy efficiency measures and best practices, for	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th

US FEDERAL: New Source Performance Standards			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)		reducing GHG emissions.	2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Monitoring, verification and enforcement by the Environmental Protection Agency. Sanctions are not yet known.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3= Policy fully implemented	1	The EPA is currently considering public submissions and is scheduled to propose regulations to address all these issues by December 10, 2011 and finalise regulations by November 10, 2012. Implementation was initially planned for 2013, but is being delayed till 2015.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Coverage	Fossil-fuel power plants, electric generating units (EGUs) and refineries covering 40% of the US's GHG emissions.	-	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Investment in simple energy efficiency measures and best practices.	Quantitative targets not yet known.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Overlap with other selected policies	Yes (Complementary)	Greenhouse Gas Permitting	

Table 12 USA: Better Buildings, Better Plants

US FEDERAL: Better Buildings, Better Plants			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The industrial component of the Better Buildings, Better Plants program provides different opportunities for national recognition based on level of commitment. The objectives are to achieve quantified energy savings over a ten-year period, transparently pursue innovative approaches to energy efficiency, and make a significant, near-term investment in an energy saving project or set of projects.		IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	The Better Buildings, Better Plants is a voluntary agreement between the Department of Energy (DOE) and Buildings and industrial plants. Different opportunities for national recognition based on level of commitment: - Better Buildings, Better Plants **Program Partners** pledge energy savings goals consistent with national targets and agree to report progress annually to DOE. Program requirements largely match those of the Save Energy Now LEADER initiative - Better Buildings, Better Plants **Challenge Partners** agree to transparently pursue innovative approaches to energy efficiency, and make a significant, near-term investment in an energy saving project or set of projects.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	2	Monitoring done by the target group. Verification by the Department of Energy.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started.	3	In 2011 the Save Energy Now Program transitions to Better Buildings, Better Plants Program.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.

US FEDERAL: Better Buildings, Better Plants			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
3= Policy fully implemented			
Coverage	Buildings and industrial facilities by voluntary participation.	-	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	- Set public energy goal for next 2-5 years OR - retain 25% energy intensity reduction in 10 years (goal already established under Save Energy Now)	Public energy goal requires the following actions to be taken: - Showcase project within 9 months. Can include: whole building improvements; projects over $1 million; or projects to reduce energy intensity by 10% or more within a single facility. - Organization-wide energy management plan within 9 months.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Overlap with other selected policies	Yes (Complementary)	Energy Star Program for Industry	

Table 13 USA: Energy Star Program for Industry

US FEDERAL: Energy Star Program for Industry			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. The official aim is to help targeted industries to save money and protect the environment through energy efficient products and practices.		IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	ENERGY STAR is a voluntary agreement between major industries and the US EPA. Through ENERGY STAR, US EPA helps industrial companies develop robust energy programs that create the necessary infrastructure for cost-effective GHG management. US EPA's ENERGY STAR program provides guidance, tools, and recognition to help companies improve their energy performance.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	2	By becoming an ENERGY STAR partner companies commit to a) measure, track, and benchmark energy performance, b) develop and implement a plan to improve energy performance, adopting the ENERGY STAR strategy, c) educate their staff and the public about the partnership and achievements with ENERGY STAR.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3= Policy fully implemented	3	In 2008, a total of 45 plants were awarded ENERGY STAR. Since then the number has grown rapidly, including the ones that take on an actual reduction commitment. EPA's website lists a total of 160 ENERGY STAR participants (January 2011) of which 26 sites achieved the ENERGY STAR Challenge for Industry goal.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Coverage	16 major industries	Steel Industry, Pharmaceutical Industry, Petrochemical Industry, Cement Manufacturing, Corn Refining, Food Industry, Glass Manufacturing, Motor Vehicle Manufacturing, Petroleum Industry, Pulp & Paper, Water/Wastewater. Parties can join at	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.

US FEDERAL: Energy Star Program for Industry			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
		plant level or company level.	
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Recognition for ENERGY STAR Leaders requires portfolio-wide energy efficiency improvements of 10%, 20%, 30% (or more) reductions in normalised energy use.	While the goal setting for ENERGY STAR is at the choice of the partner company, two other labels in the ENERGY STAR program have to meet government defined requirements in order to obtain recognition. One recognition specifically for industry is the Industry Challenge which recognises industrial sites that improve their energy efficiency by 10% within 5 years.	IIP policy database (http://iepd.iipnetwork.org/country/united-states-federal) accessed on April 11th 2012.
Overlap with other selected policies	Yes (Complementary)	Better Buildings, Better Plants	

3.4.4 India

Table 14 Overview of Indian policies

India Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Mandatory Energy Efficiency Standards (Pilot Phase)	Effort Defining Policy	2007-2011	-	Aluminium; fertilizers; iron and steel; cement; pulp and paper; chlor-alkali; textiles; chemicals.	Yes	Replaced by Perform Achieve Trade Scheme (PAT)	Yes	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Perform, Achieve, Trade Scheme (PET)	Effort Defining Policy	2011-	About 700 plants in 7 industrial sectors	cement, iron & steel, fertilisers, aluminium, chlor-alkali, paper, and textiles as well as the power sector and railways are also covered.	Yes	-	Yes	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Mandatory Energy Managers and Energy Audits	Supporting Measure	2010-?	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Financing Schemes of Indian Renewable Energy Development Agency Ltd. (IREDA)	Supporting Measure	1987-?	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.

India Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Venture Capital Fund for Energy Efficiency	Supporting Measure	2010-?	-	-	-	-	No	IIP policy database IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Partial Risk Guarantee Fund for Energy Efficiency	Supporting Measure	2010-?	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
National Energy Conservation Awards	Supporting Measure	1991-?	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.

Table 15 India: Mandatory Energy Efficiency Standards (Pilot Phase)

INDIA: Mandatory Energy Efficiency Standards (Pilot Phase)			
Indicator:	Assessment:	Explanation:	Source:
Brief description	The Energy Conservation Act (ECA) of 2001, which was amended in 2010, provides for the establishment of the Bureau of Energy Efficiency (BEE). BEE is in charge of developing mandatory energy efficiency standards and to monitor compliance. During the pilot phase, energy efficiency standards have been adopted for two sectors with Designated Consumers (cement and pulp & paper), but on a voluntary basis only.		IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.

INDIA: Mandatory Energy Efficiency Standards (Pilot Phase)			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	This was intended as a preparatory phase towards the introduction of mandatory energy efficiency standards in other industrial sectors.	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	2	BEE overviews the monitoring and verification only.	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented	3	-	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Coverage	Aluminium, fertilizers, iron and steel, cement, pulp and paper, chlor-alkali, textile, chemicals.	-	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Increase average energy efficiency level within the sector to the level of the best performing within the sector	-	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Overlap with other selected policies	Yes	Replaced by: Mandatory Energy Managers and Energy Audits Supported by: PAT Scheme	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.

Table 16 India: Perform, Achieve, Trade Scheme (PAT)

INDIA: Perform, Achieve, Trade Scheme (PAT)			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The PAT scheme is a trading scheme aimed to improve energy efficiency in industries across India. The Energy Conservation Act (ECA) makes it a mandate for PAT to create a domestic market for white certificates so as to meet total energy saving targets under the system in a cost-efficient manner. The first phase of commitment and trading is three years (2011-2014). The methodology for target setting in the 7 industrial sectors as well as the monitoring and verification protocols are still under preparation.		IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	2	The scheme imposes mandatory specific energy targets on participants. It allows using purchased excess energy savings in the form of white certificates for compliance.	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Government agency: Bureau of Energy Efficiency	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started.	3	-	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.

INDIA: Perform, Achieve, Trade Scheme (PAT)			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
3 = Policy fully implemented			
Coverage	Almost 100% industrial energy use	Industrial energy use from 700 plants covering 7 sectors including: cement, iron & steel, fertilisers, aluminium, chlor-alkali, paper, and textiles.	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	To enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities.	In the first PAT cycle (2011-2014), the quantitative objective of the PAT scheme is to save 10 million mtoe of energy, and 27 MtCO2	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.
Overlap with other selected policies	Yes	Supported by: Mandatory Energy Managers and Energy Audits, IREDA and Partial Risk Guarantee Fund for Energy Efficiency	IIP policy database (http://iepd.iipnetwork.org/country/india), accessed on October 18th 2012.

3.4.5 Russia

Table 17 Overview of Russian policies

Russian Federation Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Federal Targeted Program for an Energy Efficient Economy	Effort Defining Policy	2002-2010	-	-	-	-	No	Enerdata and the Economist Intelligence Unit, "Trends in global energy efficiency 2011. An analysis of industry and utilities", 2011.
State Energy Efficiency Program until 2020	Effort Defining Policy	2011-2020	-	All large energy users throughout the Russian Federation	Federal law No. 261-F3 "On Energy Conservation and Increase of Energy Efficiency"	No	Yes	Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf) accessed on April 11th 2012. Russian Ministry of Energy presentation (http://www.usea.org/Russia-Smart-Grid/Tuesday/REA%2010-11%20Slepkov%20Presentation.ppt%20(Eng.).ppt) accessed on April 11th 2012.

Table 18 Russian Federation: State Energy Efficiency Program until 2020

RUSSIAN FEDERATION: State Energy Efficiency Program until 2020			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The State Energy Efficiency Program until 2020 was adopted on July 15, 2009, following the President's Decree No.889 in June 2008, "On measures to raise energy efficiency and foster environmental stability in Russia's economy". The program sets a target of 40% reduction in GDP energy intensity by 2020 compared to 2007. The program contains energy conservation measures in various spheres of Russia's economy, including industry, as well as incentives.		Energy Forecasting Agency presentation (http://www.tumenprogramme.org/data/upload/download/1-1.Korovko_APBE_EFA_RussianlegislforEnergyEfficiency_XJWk0L.pdf) accessed on April 11th 2012. Russian Energy Agency presentation (http://www.tumenprogramme.org/data/upload/download/RussianEnergyAgency_Nk5Nf8.pdf) accessed on April 11th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets) 4 = GDP energy intensity target	4	Energy intensity target (per GDP)	Russian Energy Agency presentation (http://www.tumenprogramme.org/data/upload/download/RussianEnergyAgency_Nk5Nf8.pdf) accessed on April 11th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1 (Under assumption that in the program implementation will not be voluntary given the political climate)	Ministry of Industries and Trade is responsible for Program implementation coordination in part of conducting activities on energy efficiency improvement in industries.	Russian Ministry of Energy presentation (http://www.usea.org/Russia-Smart-Grid/Tuesday/REA%2010-11%20Slepkov%20Presentation.ppt%20(Eng.).ppt) accessed on April 11th 2012.
Status of development: 1 = Concept of policy approved by	3	The program started in 2011.	Russian Ministry of Energy presentation (http://www.usea.org/Russia-Smart-Grid/Tuesday/REA%2010-

RUSSIAN FEDERATION: State Energy Efficiency Program until 2020			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
government 2 = Policy fully approved by government, not yet started. 3= Policy fully implemented			11%20Slepkov%20Presentation.ppt%20(Eng.).ppt) accessed on April 11th 2012.
Coverage	All large energy users throughout the Russian Federation	-	Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/Russia.pdf) accessed on April 11th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	The State Program aims for a GDP energy intensity reduction of 13.5% by 2020 compared to 2007.	- Energy consumption of GDP by 2020 will reduce by 26,5% without government support due to structural changes, development of energy efficiency industries, new equipment implementation, reduction of consumption due to growth of tariff rates - To reach the 40% target, it is necessary to additionally reduce the GDP energy consumption with 13,5% by 2020 due to implementation of the State Program	Russian Ministry of Energy presentation (http://www.usea.org/Russia-Smart-Grid/Tuesday/REA%2010-11%20Slepkov%20Presentation.ppt%20(Eng.).ppt) accessed on April 11th 2012.
Overlap with other selected policies	No		

3.4.6 Japan

Table 19 Overview of Japanese policies

Japan Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Keidanren Voluntary Action Plan	Effort Defining Policy	1997-2010/2012	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Japanese Voluntary Emissions Trading Scheme (JVETS)	Effort Defining Policy	2005-2009	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Mandatory energy efficiency benchmarking in industry	Effort Defining Policy	2010-2015/2020	About 70% of final energy use in Japanese industry	Steel, Electricity, Cement, Paper & Pulp, Oil Refinery, Chemical sector	Act on the Rational Use of Energy	No	Yes	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Subsidies for GHG mitigation measures	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Mandatory Energy Management	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Fiscal incentives for energy efficiency	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed

Japan Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
								on April 10th 2012.
Subsidy scheme for energy efficiency	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Emission Credit Scheme for Small and Medium-Sized Companies	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Mandatory GHG Emissions Reporting	Supporting Measures	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Guidelines & protocols for energy management & energy audits	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Allocation, benchmarking and MRV methodologies, IT system, transaction contract forms	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Guidelines for benchmarking methodologies	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.

Japan Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
National Certificate for energy managers	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
Guidelines on which technologies are eligible	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
UNFCCC CDM rules & procedures	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.
GHG Emissions Calculation and Reporting Manual	Implementation Toolbox	-	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 10th 2012.

Table 20 Japan: Mandatory energy efficiency benchmarking in industry

JAPAN: Mandatory energy efficiency benchmarking in industry			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The Act on the Rational Use of Energy (amended in April 2010) has introduced mandatory energy efficiency targets in the form of benchmarks, to be specified in secondary legislation. It has also introduced 1% annual energy efficiency improvement obligation for all businesses. For designated sectors, targets have been set at the energy efficiency level of the best performing companies (top 10% - 20%) within that industrial sub-sector. These targets must be met in the medium (2015) and long term (2020). A higher level target can be adopted in the future if further energy-saving potentials can be taken into account.		IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 11th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	1	Benchmarks expressed in kl/t or MJ/t. The benchmarks are based on sector studies and are negotiated between government and the sector, although it is unclear whether international or domestic benchmarks are being used.	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 11th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Monitoring and enforcement by the Ministry of Economy, Trade and Industry. *Sanctions:* Publishing the company's name on a list of under-performers and imposing fines.	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 11th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented	3	The mandatory energy efficiency benchmarking in industry has started in 2009.	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 11th 2012.
Coverage	Iron & Steel, Electricity, Cement, Paper	In 2009 the Electricity, Iron & Steel and Cement sector has	IIP policy database

JAPAN: Mandatory energy efficiency benchmarking in industry			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
	& Pulp, Oil Refinery and Chemical sector.	been covered. Expansion to Chemical, Paper & Pulp and Oil Refineries were ongoing.	(http://iepd.iipnetwork.org/country/japan), accessed on April 11th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	- Reaching energy efficiency level in the benchmark - Energy intensity reduction (by at least 1% annually)	The benchmarks have been based on energy efficiency levels of the best performing companies (top 10% - 20%) in each sector. These targets must be met in the medium (2015) and long term (2020). The list of benchmarks can be found in http://iepd.iipnetwork.org/sites/default/files/policy_resources/Ensergy_Management_in_Japan_110930_IEEJ.pdf	IIP policy database (http://iepd.iipnetwork.org/country/japan), accessed on April 11th 2012.
Overlap with other selected policies	No		

3.4.7 South-Korea

Table 21 Overview of South Korean policies

Korea (South) Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
National Basic Energy Plan 2008-2030	Effort Defining Policy	2008-2030	-	Widely across industry, households and services, transport and public sector.	Rational Energy Utilization Act	No	Yes	APEC-VC Korea database (www.apec-vc.or.kr/?p_name=database) accessed on April 12th 2012.
Five-year voluntary agreements	Effort Defining Policy	1998-?	-	1323 firms in the business sector	Rational Energy Utilization Act	In line with the National Basic Energy Plan 2008-2030	Yes	Jones, R. S. and B. Yoo, "Korea's Green Growth Strategy: Mitigating Climate Change and Developing New Growth Engines", 2011. (http://dx.doi.org/10.1787/5kmbhk4gh1ns-en)
Mandatory negotiated agreements on energy efficiency	Effort Defining Policy	2010-2012	-	-	-	Replaced by Greenhouse Gas, Energy Target Management System	No	Jones, R. S. and B. Yoo, "Korea's Green Growth Strategy: Mitigating Climate Change and Developing New Growth Engines", 2011. (http://dx.doi.org/10.17

Korea (South) Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
								87/5kmbhk4gh1ns-en)
Greenhouse Gas, Energy Target Management System	Effort Defining Policy	2011-2015	about 70% or more of nationwide total emission, about 90% or over of the emission volume by the industries	over 1,500 facilities, of which 779 from the industry sector	Framework Act on Low Carbon, Green Growth	In line with the National Basic Energy Plan 2008-2030. Will act as precursor of national emissions trading system.	Yes	APEC-VC Korea database (www.apec-vc.or.kr/?p_name=database) accessed on April 12th 2012. Climate Policy Watcher (http://www.climate-policy-watcher.org/?q=node/126) accessed on April 12th 2012.
Emissions trading system	Effort Defining Policy	2015-?	>70% of total national GHG emissions	Installations emitting over 25,000 tCO_2e / year. Inclusio threshold will possibly be lowered to 15,000 tCO_2e / year in 2015.	- Approved by Legislation & Judiciary Committee of National Assembly - Passed with Bipartisan Support in the Plenary Session of National Assembly	Replaces the Target Management System	Yes	Korea environment institute (http://unfccc.int/files/bodies/awg-lca/application/pdf/20120517_korea_1117.pdf) accessed on Oct 17, 2012

Table 22 South Korea: National Basic Energy Plan 2008-2030

KOREA (SOUTH): National Basic Energy Plan 2008-2030			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The plan outlines future energy policy direction, such as the realization of low-carbon society, and calls for energy security increase, rational use of energy, and environment protection. The government will actively support the development and deployment of non-fossil energy such as new and renewable energy and nuclear, along with energy demand-side management. Climate change is also viewed as an urgent issue, and the government will facilitate the carbon market and promote the public energy saving activities. The plan sets various energy targets. The energy intensity target is 0.185 tonnes of oil equivalent (Toe)/USD 1000, and the target for new and renewable energy's share of total energy consumption is 11% for the year 2030.		IEA policy and measures database on Energy Efficiency (http://www.iea.org/textbase/pm/?mode=pm) accessed on April 12th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	1	Energy intensity target (per GDP)	IEA policy and measures database on Energy Efficiency (http://www.iea.org/textbase/pm/?mode=pm) accessed on April 12th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	2	The National Basic Energy Plan and target set by the Ministry of Knowledge Economy. The plan does not contain any enforcement measures, but energy policies in line with the plan may contain enforcement measures.	APEC-VC Korea database (www.apec-vc.or.kr/?p_name=database) accessed on April 12th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started.	3	The National Basic Energy Plan is in place since 2008.	APEC-VC Korea database (www.apec-vc.or.kr/?p_name=database) accessed on April 12th 2012.

KOREA (SOUTH): National Basic Energy Plan 2008-2030			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
3= Policy fully implemented			
Coverage	Widely across industry, households and services, transport and public sector.	-	Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/Russia.pdf) accessed on April 11th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	nearly 17 Mtoe by 2030	The energy intensity target is 0.185 tonnes of oil equivalent /USD 1000, which is 38 Mtoe according to a BAU scenario, an energy intensity reduction of 46% between 2007-2030. 44% should come from the industry, which is approximately 13% energy intensity reduction from a BAU scenario.	Enerdata and the Economist Intelligence Unit, "Trends in global energy efficiency 2011. An analysis of industry and utilities", 2011.
Overlap with other selected policies	Yes	Five-year voluntary agreements, Greenhouse Gas, Energy Target Management System	

Table 23 South Korea: Five-year voluntary agreements

KOREA (SOUTH): Five-year voluntary agreements			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The Ministry of Knowledge Economy (KEMCO) promotes five-year voluntary agreements with industrial groups; businesses that enter into voluntary agreements or invest in energy-saving technologies are entitled to financial and technical support and tax credits covering up to 20 percent of the investment cost.		Enerdata and the Economist Intelligence Unit, "Trends in global energy efficiency 2011. An analysis of industry and utilities", 2011.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS,	3	Voluntary energy saving and GHG emissions reduction targets	Korea Energy Economics Institute presentation (http://www.keei.re.kr/keei/download/seminar/071217/S1/S1-1.pdf) accessed on

KOREA (SOUTH): Five-year voluntary agreements			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)			April 12th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Targets, timelines and strategies are monitored by KEMCO. Since 2007 large energy consumers (over 2 ktoe / year) have to carry out mandatory energy audits every 5 years; in the case of small and medium sized enterprises (under 5 ktoe / year) up to 90 percent of the audit costs can be subsidized.	Enerdata and the Economist Intelligence Unit, "Trends in global energy efficiency 2011. An analysis of industry and utilities", 2011.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3= Policy fully implemented	3	The voluntary agreement system has been in place since 1998.	Jones, R. S. and B. Yoo, "Korea's Green Growth Strategy: Mitigating Climate Change and Developing New Growth Engines", 2011. (http://dx.doi.org/10.1787/5kmbhk4gh1ns-en)
Coverage	Industrial groups	-	Enerdata and the Economist Intelligence Unit, "Trends in global energy efficiency 2011. An analysis of industry and utilities", 2011.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Different targets for each participant.	By 2008, a cumulative total of 19 million tonnes of energy (toe) had been saved, equivalent to a 58 million tonne reduction in CO_2 emissions (around 10% of annual emissions). Cost savings during the decade amounted to 0.6% of GDP for the participating firms.	Jones, R. S. and B. Yoo, "Korea's Green Growth Strategy: Mitigating Climate Change and Developing New Growth Engines", 2011. (http://dx.doi.org/10.1787/5kmbhk4gh1ns-en)
Overlap with other selected policies	Yes	National Basic Energy Plan 2008-2030, Greenhouse Gas, Energy Target Management System	

Table 24 South Korea: Greenhouse Gas, Energy Target Management System

KOREA (SOUTH): Greenhouse Gas, Energy Target Management System			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	In 2011 the GHG, Energy Target Management System (TMS) replaced the Mandatory negotiated agreements on energy efficiency. The GHG, Energy Target Management System is a system in which the government imposes the target for GHG emission as well as the energy use to designated entities (companies with GHG emission and energy consumption in large volumes respectively) and by which the government checks on and manages the achievements of those entities. The TMS is a precursor to an emissions trading system, which will start in January 2015.		APEC-VC Korea database (www.apec-vc.or.kr/?p_name=database) accessed on April 12th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	Mandatory participation for energy-intensive companies, the target is reduction of emissions and energy.	IEA work 2011 by IIP (http://www.iea.org/work/2011/iip/Korea.pdf) accessed on April 12th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Designated companies should report the amount of emissions and energy use of the last 3 years to the government with third party verification by March, next year. In September, the government negotiates with companies to set the target. Throughout this process, companies are allocated the amount of emissions and energy use of next year. After that, companies should make a plan for meeting this target and submit it by December. Throughout the third year, companies work on reducing emissions and energy use, and submit the result report in March, the fourth year.	IEA work 2011 by IIP (http://www.iea.org/work/2011/iip/Korea.pdf) accessed on April 12th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not	3	Policy came into effect in March, 2011.	IEA work 2011 by IIP (http://www.iea.org/work/2011/iip/Korea.pdf) accessed on April 12th 2012.

KOREA (SOUTH): Greenhouse Gas, Energy Target Management System			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
yet started. 3 = Policy fully implemented			
Coverage	68% of national GHG emissions, over 1,500 facilities, of which 779 from the industry sector.	Any entity whose total GHG emission as well as total energy consumption of workplaces for the latest 3 years exceeds the baseline volume of 125,000 tonnes of CO_2, and exceeds the baseline volume of 500 TJ respectively. Based on the workplace scale, any workplace that's both GHG emission and energy consumption are exceeding 25,000 tons of CO2 and 100 terajoules respectively.	APEC-VC Korea database (www.apec-vc.or.kr/?p_name=database) accessed on April 12th 2012. Climate Policy Watcher (http://www.climate-policy-watcher.org/?q=node/126) accessed on April 12th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Different targets for each participant.	In the third year companies will work on reaching the set target. The expected outcome of this program is laying the foundation for accomplishment of national mid-term target for GHG emission.	APEC-VC Korea database (www.apec-vc.or.kr/?p_name=database) accessed on April 12th 2012.
Overlap with other selected policies	Yes	National Basic Energy Plan 2008-2030, Five-year voluntary agreements, Emission Trading System	

Table 25 South Korea: Emissions Trading System

KOREA (SOUTH): Emissions Trading System			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	In May 2012 the Korean government adopted a national Emissions Trading System, which will replace the GHG, Energy Target Management System (TMS). The Korean ETS will start in January 2015. The first two phases will last for 3 years, followed by subsequent phases of 5 years.		Korea environment institute (http://unfccc.int/files/bodies/awg-lca/application/pdf/20120517_korea_1117.pdf) accessed on Oct 17, 2012
Type of Effort Defining Policies:	2	Emissions Trading System	Korea environment institute (http://unfccc.int/files/bodies/awg-

1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)			lca/application/pdf/20120517_korea_1117.pdf) accessed on Oct 17, 2012
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Strict MRV requirements, including third party verification. Administrative and financial penalty on non-compliance. Penalties are up to 3 times average market price in the previous year.	Korea environment institute (http://unfccc.int/files/bodies/awg-lca/application/pdf/20120517_korea_1117.pdf) accessed on Oct 17, 2012
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented	2	Policy was approved by the National Assembly in May 2012. Currently, a Presidential decree is drafted in which detailed rules will be provided on the allocation methodology, definition of carbon leakage exposure, the use of offsets and early action credits, etc.	Korea environment institute (http://unfccc.int/files/bodies/awg-lca/application/pdf/20120517_korea_1117.pdf) accessed on Oct 17, 2012
Coverage	>68% of total national GHG emissions (>coverage of current TMS system), around 500 of the country'	Installations emitting over 25,000 tCO_2e /year. The inclusion threshold is possibly lowered to 15,000 tCO_2e /year in 2015. -eq/year in 2015 gradually	Korea environment institute (http://unfccc.int/files/bodies/awg-lca/application/pdf/20120517_korea_1117.pdf) accessed on Oct 17, 2012
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	- Should be consistent with the national mid-term target - Based on average of last 3 years emission records, with adjustments through negotiations between the government and covered entities		Korea environment institute (http://unfccc.int/files/bodies/awg-lca/application/pdf/20120517_korea_1117.pdf) accessed on Oct 17, 2012
Overlap with other selected policies	Yes	National Basic Energy Plan 2008-2030, Five-year voluntary agreements, Target Management System	

3.4.8 South Africa

Table 26 Overview of South African policies

South Africa Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Energy Efficiency Accord	Effort Defining Policy	2005-2015	More than 24% of the national electricity consumption	36 major industrial energy users and 8 industrial associations	Cabinet approval of the Energy Efficiency Strategy of South Africa in 2005	No	Yes	NBI report, "Assessment Study of the Energy Efficiency Accord", 2008.

Table 27 South Africa: Energy Efficiency Accord

SOUTH AFRICA: Energy Efficiency Accord			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The overall objective of the Energy Efficiency Accord is to reduce energy consumption and in this regard the Accord uses the National Energy Efficiency Strategy targets as a basis.		NBI report, "Assessment Study of the Energy Efficiency Accord", 2008.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	The Minister for Energy and Minerals, together with the participants, voluntarily committed themselves to individually and collaboratively work to implement the government target for energy savings.	IEA policy and measures database on Energy Efficiency (http://www.iea.org/textbase/pm/?mode=pm) accessed on April 12th 2012.

SOUTH AFRICA: Energy Efficiency Accord			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	2	One area where the Accord has not been effective is the lack of common reporting requirements as well as agreed and enforced measurement and verification methodology. Companies differed in their perception of energy savings due to lack of agreement on baseline determination and Business-As-Usual projections of energy demand.	NBI report, "Assessment Study of the Energy Efficiency Accord", 2008.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3= Policy fully implemented	3	In May 2005, following the Government's Energy Efficiency Strategy, a list of commitments was negotiated between both industry and government under the Energy Efficiency Accord.	IEA policy and measures database on Energy Efficiency (http://www.iea.org/textbase/pm/?mode=pm) accessed on April 12th 2012.
Coverage	36 major industrial energy users and 8 industrial associations	The accord members belong to the Industrial sector, Mining sector and Commercial sector.	NBI report, "Assessment Study of the Energy Efficiency Accord", 2008.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Industry target of 15% final energy demand reduction	The reference year is 2000. The target was set against the forecast baseline energy consumption for 2015, which is based on an annual economic growth rate of 2.4% from 2000.	NBI report, "Assessment Study of the Energy Efficiency Accord", 2008.
Overlap with other selected policies	No		

3.4.9 Canada

Table 28 Overview of Canadian policies

Canada (Federal) Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Federal Sustainable Development Strategy (FSDS)	Effort Defining Policy	2010 - ?	-	National coverage	Federal Sustainable Development Act	No	Yes	Environment Canada (http://www.ec.gc.ca/dd-sd/default.asp?lang=En&n=F93CD795-1) accessed on April 20th 2012.
Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations	Effort Defining Policy	2015 - ?		Power sector	Environmental Protection Act	No	No	Environment Canada (http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=4D34AE9B-1768-415D-A546-8CCF09010A23) accessed on Oct 17, 2012
2011-12 departmental sustainable development strategy (Industry)	Effort Defining Policy	2011-2012	-	-	-	Supports the Federal Sustainable Development Strategy	No	Industry Canada (http://www.ic.gc.ca/eic/site/sd-dd.nsf/eng/h_sd00561.html) accessed on April 19th 2012.

Table 29 Canada: Federal Sustainable Development Strategy

CANADA (FEDERAL): Federal Sustainable Development Strategy			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The Federal Sustainable Development Strategy (FSDS) has been designed to respond to the limitations of the previous approach to sustainable development planning and reporting.		Environment Canada (http://www.ec.gc.ca/dd-sd/F93CD795-0035-4DAF-86D1-53099BD303F9/FSDS_v4_EN.pdf) accessed on April 20th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	1	GHG emissions reduction target together with qualitative targets.	Environment Canada (http://www.ec.gc.ca/dd-sd/F93CD795-0035-4DAF-86D1-53099BD303F9/FSDS_v4_EN.pdf) accessed on April 20th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	2	No specific enforcement measures mentioned.	Environment Canada (http://www.ec.gc.ca/dd-sd/F93CD795-0035-4DAF-86D1-53099BD303F9/FSDS_v4_EN.pdf) accessed on April 20th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3= Policy fully implemented	2	The Progress report 2010-2013 published in 2011 reports that currently the systems to implement the FSDS is being set up.	Environment Canada (http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=1EBF1BCC-3074-4A1B-A776-66AA73A27B08) accessed on April 20th 2012.
Coverage	National coverage	-	Environment Canada (http://www.ec.gc.ca/dd-sd/F93CD795-0035-4DAF-86D1-

CANADA (FEDERAL): Federal Sustainable Development Strategy			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
			53099BD303F9/FSDS_v4_EN.pdf) accessed on April 20th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	One of the targets is a GHG reduction of 17% by 2020 compared to 2005. By 2020 Canada wants to produce 90% of electricity by non-emitting sources (from 77% in 2008).	Addressing climate change and clean air is one of the qualitative targets. Except for the power sector no clear industrial targets are set.	Environment Canada (http://www.ec.gc.ca/dd-sd/F93CD795-0035-4DAF-86D1-53099BD303F9/FSDS_v4_EN.pdf) accessed on April 20th 2012.
Overlap with other selected policies	No		

3.4.10 Indonesia

Table 30 Overview of Indonesian policies

Indonesia Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
National Master Plan for Energy Conservation (RIKEN 2005)	Effort Defining Policy	2005-2025	-	Central and regional government, commercial buildings, industrial sector and transportation sector	The RIKEN 2005 is a legal framework for improvement of energy efficiency and conservation	No	Yes	Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf) accessed on April 12th 2012.
National Energy Policy	Effort Defining Policy	2005-2025	-	-	-	Supports the National Master Plan for Energy Conservation	No	Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf) accessed on April 12th 2012.
Grand Strategy of Energy Conservation and CO2 Emission Reduction in Industrial Sector 2010 - 2020	Effort Defining Policy	2010-2020	-	Energy intensive industries such as the fertiliser, cement, pulp and paper and steel industries	President's Decree No. 28 Year 2008 about National Industrial Policy	In line with the National Master Plan for Energy Conservation	Yes	Ministry of Industry presentation (http://www.unido.org/fileadmin/user_media/PCOR/Panel2_%20Presentation_Ministry%2

								0of%20Industry%20Indonesia.ppt) accessed on April 12th 2012.

Table 31 Indonesia: National Master Plan for Energy Conservation (RIKEN 2005)

INDONESIA: National Master Plan for Energy Conservation (RIKEN 2005)			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The principle objective of the National Master Plan for Energy Conservation is to conserve natural energy resources and increase resilience in energy supply to support sustainable development.		Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf) accessed on April 12th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	Energy intensity reduction target	Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf) accessed on April 12th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	2	Fiscal incentives (tax deductions and soft loans) together with other instruments such as training and educational programs as well as energy audits are used to implement that plan.	Enerdata and the Economist Intelligence Unit, “Trends in global energy efficiency 2011. An analysis of industry and utilities”, 2011.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started.	3	The National Master Plan for Energy Conservation has been in place since 2005 and was the framework for the National Energy Policy (2006), Energy Law (2007) and President Instruction on Energy and Water Saving (2008).	Ministry of Energy and Mineral Resources presentation (http://eneken.ieej.or.jp/en/data/pdf/491.pdf) accessed on April 12th 2012.

INDONESIA: National Master Plan for Energy Conservation (RIKEN 2005)			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
3= Policy fully implemented			
Coverage	Central and regional government, commercial buildings, industrial sector and transportation sector	-	Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf) accessed on April 12th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	- National energy intensity reduction of 1% per year on average until 2025. - Energy saving potential for selected industries is 15-30%	The energy saving potential for the industry are expected to be reached under the National Master Plan for Energy Conservation. The National Energy Policy added a national target of energy elasticity of less than 1 in 2025.	Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf) accessed on April 12th 2012.
Overlap with other selected policies	Yes	Grand Strategy of Energy Conservation and CO_2 Emission Reduction in Industrial Sector 2010 - 2020	

Table 32 Indonesia: Grand Strategy of Energy Conservation and CO2 Emission Reduction in Industrial Sector 2010 - 2020

INDONESIA: Grand Strategy of Energy Conservation and CO_2 Emission Reduction in Industrial Sector 2010 - 2020			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The Grand Strategy of Energy Conservation and CO_2 Emission Reduction in Industrial Sector 2010 – 2020 consists of voluntary energy savings and conservation measures are being implemented by industry and commercial buildings that involve commercial financing. This implementation involved energy intensive industries such as the fertiliser, cement, pulp and paper and steel industries.		Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf) accessed on April 12th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	Voluntary energy savings and conservation measures	Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf) accessed on April 12th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	2	The government assists in implementing energy savings and conservation measures using amongst others energy audit trainings and socialization programs.	Embassy of Indonesia in Athens announcement (http://indonesia.gr/indonesia-preparing-energy-conservation/) accessed on April 12th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3= Policy fully implemented	3	**Phase 1 :** Implementation of Energy Conservation and CO_2 Emission Reduction in Industrial Sector; **Phase 2 :** Promotion of CO_2 emission reduction through several pilot project in energy voracious industries such as steel, pulp and paper industries; **Phase 3:** Establishment of Energy Services Company (ESCO) **Phase 4 :** Eco-Label Implementation	Ministry of Industry presentation (http://www.unido.org/fileadmin/user_media/PCOR/Panel2_%20Presentation_Ministry%20of%20Industry%20Indonesia.ppt) accessed on April 12th 2012.

INDONESIA: Grand Strategy of Energy Conservation and CO_2 Emission Reduction in Industrial Sector 2010 - 2020			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
		Currently in phase 1. Since 2010, assistances in energy conservation implementation have been conducted at 35 steel industries and 15 pulp & paper industries.	
Coverage	Energy intensive industries such as the fertiliser, cement, pulp and paper and steel industries.	-	Compendium of Energy Efficiency Policies of APEC Economies (http://www.ieej.or.jp/aperc/CEEP/CEEP-all.pdf) accessed on April 12th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	2% CO_2 emissions reduction in the industry in 2020	The industrial share of the emissions in total amount of CO_2 emissions is projected to be 41% in 2020.	Ministry of Industry presentation (http://www.unido.org/fileadmin/user_media/PCOR/Panel2_%20Presentation_Ministry%20of%20Industry%20Indonesia.ppt) accessed on April 12th 2012.
Overlap with other selected policies	Yes	National Master Plan for Energy Conservation	

3.4.11 Australia

Table 33 Overview of Australian policies

Australia Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
Carbon Pricing Mechanism (CPM)	Effort Defining Policy	2012-2050	60% of Australia'a GHG emissions	Stationary energy users, industrial processes, landfills and fugitive emissions from coal mining and natural gas extraction	Yes	Part of the Clean Energy Legislative Package	Yes	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.
Generator Efficiency Standards (GES)	Effort Defining Policy	2000-?	-	-	Yes	No	Yes	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.
Clean Energy Finance Corporation (CEFC) funding	Supporting Measure	2013-?	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.
Clean Technology Program (CTP)	Supporting Measure	2012-2018	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.
Energy Efficiency Opportunities Program (EEO)	Supporting Measure	2006-?	-	-	-	-	No	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.

Table 34 Australia: Carbon Pricing Mechanism (CPM)

AUSTRALIA: Carbon Pricing Mechanism (CPM)			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	Australia has committed to reduce its greenhouse gas emissions by 5% compared to 2000 levels by 2020. In June 2011, the Australian government introduced the Clean Energy Legislative Package, which includes various support measures to stimulate clean energy and provide support to safeguard competitiveness, economic growth and household purchasing power. The CPM is an effort defining policy under this policy. The scheme will start by introducing a fixed unit price on carbon, which will be followed by a cap-and-trade scheme after 2015. Linkage with the EU ETS is anticipated for the two trading phases: One-way link for 2015-18 with full linking by July 2018.		IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	2	Facilities with annual emissions > 25kt GHG emissions purchase and surrender tradable permits (Australian Carbon Credit Units – ACCU) for each tonne of GHG produced.	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	1	Government agency: : Clean Energy Regulator	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.accessed on April 10th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented	3	-	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.
Coverage	60% of Australia's GHG emissions	Approximately 500 entities covered as of July 2012. These	IIP policy database

AUSTRALIA: Carbon Pricing Mechanism (CPM)			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
		include waste disposal, mining, electricity generation, natural gas retailers and industrial processes.	(http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012..
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Reduction of GHG emissions of 5% compared to 2000 levels by 2020	Further reductions of 80% compared to 2000 levels by 2050	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012..
Overlap with other selected policies	Yes	Supported by CEFC, CTP, EEO	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.

Table 35 Australia: Generator Efficiency Standards (GES)

AUSTRALIA: Generator Efficiency Standards (GES)			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The Generator Efficiency Standards (GES) is a voluntary programme whereby a fossil-fuel electricity generator enters into a legally binding agreement with the Australian national government to strive towards best practice levels in fossil-fired electricity generation in terms of energy efficiency and to reduce GHG emissions. This covers all businesses that use fossil fuels to generate electricity (not just power plants). In return for participation, the government offers recognition and support in the form of technical support and covering auditing costs.		IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	Performance standards defined by the programme must be met once the company enters an agreement with the government	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.
Enforcement:	1	Government agency: Australian Greenhouse Office	IIP policy database (http://iepd.iipnetwork.org/country/austral

AUSTRALIA: Generator Efficiency Standards (GES)			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities			ia), accessed on October 8th 2012.accessed on April 10th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3 = Policy fully implemented	3	-	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.
Coverage	>85% of Australia's installed capacity	Facilities with electrical capacity >30 MW and electrical output >50 GWh/annum	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012..
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	Movement towards energy efficiency best practice levels and GHG emission reductions from energy supply for fossil-fuel electricity generation	-	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012..
Overlap with other selected policies	Yes	Supports CPM and is supported by CEFC, CTP, EEO	IIP policy database (http://iepd.iipnetwork.org/country/australia), accessed on October 8th 2012.

3.4.12 Brazil

Table 36 Overview of Brazilian policies

Brazil Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
National Policy on Climate Change (PNCM)	Effort Defining Policy	2009-2030	-	Electricity, industry, transport and buildings	Law no. 12,187, of 29th December 2009.	No	Yes	Legal sub-office of the president of Brazil (http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12187.htm) accessed on April 20th 2012.
National Plan on Climate Change (PNCM)	Effort Defining Policy	2008-2030	-	-	-	within the framework of the National Policy on Climate Change	No	Government of Brazil (http://www.mma.gov.br/estruturas/imprensa/_arquivos/96_11122008040728.pdf) accessed on April 19th 2012.
National Energy Efficiency Action Plan	Effort Defining Policy	-	-	-	-	within the framework of the National Plan on Climate Change	No	Government of Brazil (http://www.mma.gov.br/estruturas/imprensa/_arquivos/96_11122008040728.pdf) accessed on April 19th 2012.

Brazil Policy:	Effort Defining Policy, Supportive Measure or Implementation Toolbox:	Timeframe of policy:	Coverage (% of industrial energy use of country):	Coverage (ETS-like companies at risk of carbon leakage):	Governmental approval of policy:	Effect of policy fully dominated by other policy (which):	Include?	Used literature
National programme for the rationalisation of the use of oil and gas derivatives (CONPET)	Effort Defining Policy	1991- ? (target for 2011)	-	-	-	-	No	WRI SD-PAM database (http://projects.wri.org/sd-pams-database) accessed on April 19th 2012.

Table 37 Brazil: National Policy on Climate Change

BRAZIL: National Policy on Climate Change			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
Brief description	The National Policy aims, inter alia, at the reconciliation of social and economic development with protection of the climate system; reduction of anthropogenic greenhouse gas emissions in relation to their various sources; strengthening of anthropogenic removals by sinks of greenhouse gases in the country; and implementation of measures to promote adaptation to climate change by the three levels of government, with the participation and collaboration of the economic and social stakeholders, particularly those especially vulnerable to its adverse effects.		Brazil's 2nd national communications to the UNFCCC (http://www.mct.gov.br/upd_blob/0214/214078.pdf) accessed on April 12th 2012.
Type of Effort Defining Policies: 1 = Minimum Standards 2 = Market Based Mechanism (specify ETS, white certificates, …) 3 = Voluntary / Negotiated agreement (specify any penalty for not meeting targets)	3	Voluntary energy saving and CO_2 reduction targets at national level announced by the president of Brazil	Brazil's 2nd national communications to the UNFCCC (http://www.mct.gov.br/upd_blob/0214/214078.pdf) accessed on April 12th 2012.
Enforcement: 1 = Appropriate enforcement by authorities (where appropriate monitoring guidelines) 2 = No focus on enforcement by authorities	2	Enforcement not mentioned.	Brazil's 2nd national communications to the UNFCCC (http://www.mct.gov.br/upd_blob/0214/214078.pdf) accessed on April 12th 2012.
Status of development: 1 = Concept of policy approved by government 2 = Policy fully approved by government, not yet started. 3= Policy fully implemented	3	Policy has been in effect from 2009.	Government of Brazil (http://www.mma.gov.br/estruturas/imprensa/_arquivos/96_11122008040728.pdf) accessed on April 19th 2012.
Coverage	Electricity, industry, transport and	Under the policy framework sectoral climate change mitigation plans will be established for the following	Legal sub-office of the president of Brazil

BRAZIL: National Policy on Climate Change			
Indicator:	**Assessment:**	**Explanation:**	**Source:**
	buildings	sectors (only relevant sectors given): manufacturing industry and durable consumer goods industry; fine chemicals industry and basic chemicals industry; paper and cellulose industry; mining; civil construction industry.	(http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12187.htm) accessed on April 20th 2012.
Aimed effect (GHG emission reduction %, state absolute, or relative (include reference))	10% energy consumption reduction in 2030 Between 36.1% and 38.9% reduction of projected emissions by 2020	Energy consumption reduction target is a national target stated in the National Energy Efficiency Action Plan. Equivalent to savings of 106 TWh compared to a reference scenario. 30 million tons of CO_2 is avoided in 2030 in a conservative estimate. Emissions reduction target is stated in the National Policy on Climate Change.	Government of Brazil (http://www.mma.gov.br/estruturas/imprensa/_arquivos/96_11122008040728.pdf) accessed on April 19th 2012. Legal sub-office of the president of Brazil (http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12187.htm) accessed on April 20th 2012. Enerdata and the Economist Intelligence Unit, “Trends in global energy efficiency 2011. An analysis of industry and utilities”, 2011.
Overlap with other selected policies	No		

3.5 Conclusion: West-Pacific countries are moving strongly forward

Based on the overview of climate policies reviewed in this study, a qualitative assessment has been made of the policies which are developed and implemented by third countries to limit industrial greenhouse gas emissions.

We find that countries located in the West-Pacific area are moving strongly forward with respect to ambitious climate policies. Japan, South Korea, and Australia have significant policies in place, either with an Emissions Trading Scheme (South Korea, Australia) or ambitious energy efficiency benchmarks (Japan), covering the majority of national emission-intensive industries. All of these countries currently shape their policies possibly raising ambition. These measures could be considered qualitatively comparable to the EU ETS in terms of potential price signals and their mandatory nature.

China and India give signals of tackling climate change with several policy packages that are mandatory, although the stringency of the energy efficiency targets is not very clear for both countries. Policies in both countries are diverse and developing fast in terms of coverage and ambition. An assessment of whether these are comparable to the EU ETS would require further detailed technical analysis.

Brazil, Indonesia and South Africa show less strict policies: they use voluntary emission saving measures to fight climate change. Policy development is quite active in Indonesia but to a lesser extent in Brazil and South Africa. Canada, the US, and the Russian Federation lag behind and did not announce a coherent and ambitious policy framework for their national industries or a plan towards it yet. The policies of these countries would not be comparable to the EU ETS.

4 Comparison of GHG efficiencies between EU and third countries

In this Chapter greenhouse gas efficiencies[3] for several industrial sectors are compared between countries, preferably between EU and other (third) countries.

4.1 Introduction

This study has been based on publicly available literature, which has been assessed against the following four criteria to obtain a short list.

Data:

1. is ready to use (no data processing needed) based on the situation in 2000 or later;
2. concerns greenhouse gas/CO_2 efficiency and/or energy intensity/specific energy consumption (not: potentials);
3. covers industry (preferably split up into different sectors);
4. compares several countries / regions (comparative study).

The data in the shortlist was amended by references obtained through an extensive questionnaire amongst Member States, NGOs and industrial sector associations. The resulting list of references has been assessed on its usefulness for cross-country comparisons (Section 4.2). This yielded a list of sectors with relevant data sources, and a quality indication per data source. Next, the sources have been compared and discussed per relevant sector (Section 4.3). Finally, an extensive comparative table with greenhouse gas / energy efficiencies is listed for the different regions and sectors, based on the – unprocessed – data from the sources (Section).

4.2 Assessment of shortlisted data sources

4.2.1 Overview of assessment results

Below table provides an overview of the results of the assessment carried out on the identified references. A comprehensive discussion is provided afterwards.

[3] Greenhouse gas efficiency and intensity are used interchangeably in this Chapter. Also CO_2 efficiency is used in case this is equivalent to GHG efficiency.

Table 38 Greenhouse gas efficiency of industrial activities in EU and Non-EU

<table>
<tr><th colspan="3">Name of source: Greenhouse gas efficiency of industrial activities in EU and Non-EU</th></tr>
<tr><td colspan="2">Name:</td><td>TNO Built Environment and Geosciences, “Greenhouse gas efficiency of industrial activities in EU and Non-EU”, 2009.
http://ec.europa.eu/clima/policies/ets/leakage/docs/bmsh_6_11_09_tno_report_en.pdf</td></tr>
<tr><td colspan="2">Identified by :</td><td>Ecofys</td></tr>
<tr><td rowspan="5">Brief description:</td><td>Approach:</td><td>Statistical analysis per sector on country level (where available):
1. Data collection (IEA 2007, UNFCCC, UN, Eurostat 2009, international sector data).
2. Calculate direct emissions from energy use of industry multiplied by the appropriate emission factor.
3. Calculate indirect emissions from national average CO_2 efficiency.
4. Addition of direct and indirect emissions divided by production to obtain GHG efficiency.
Bottom-up approach applied if statistical data is not available:
1. Energy intensity analysis of individual processes and assessment of process mix per country.
2. Derivation of the average CO_2 emissions per unit energy per industry sector per country.
3. Calculate CO_2 efficiency by multiplying energy intensity by the average CO_2 emissions per unit energy.</td></tr>
<tr><td>Sectors:</td><td>Various sectors, according to International Standard Industrial Classification (Top-down), NACE2 and 3-digit (Bottom-up)</td></tr>
<tr><td>Scope:</td><td>Both direct and indirect (calculated with 2006 IPCC guidelines) GHG emissions, industry and country average, are separated and taken into account for 26 countries.</td></tr>
<tr><td>Available data:</td><td>• Iron and steel CO_2 efficiency per country (2005, both top-down and bottom-up approach).
• Non-ferrous metal:
- Copper CO_2 efficiency per country (no year indication, bottom-up).
- Nickel CO_2 efficiency per country (no year indication, bottom-up).
- Aluminium energy intensity per region (2007 from IAI, top-down) and CO_2 efficiency per country (calculation based on IAI statistics, bottom-up).
• Chemical and petrochemical:
- Ammonia energy intensity per country (IFA and IEA, top-down) and CO_2 efficiency per country (UNFCCC data, 2009, top-down / IPCC data, 2006 bottom-up).
• Pulp and paper CO_2 efficiency per country (2005, bottom-up) including biomass.
• Non-metallic minerals:
- Cement CO_2 efficiency per country (2005, bottom-up).</td></tr>
<tr><td>Remarks on methodology:</td><td>• The top-down approach uses electricity use statistics per sector per country.
• In statistical analysis the product mix per country is not taken into account (e.g. products from recycling).
• For electricity the national average CO_2 emissions factor has been used, while the electricity fuel mix may be different for different industries within a country.
• For the bottom-up approach equal energy efficiency and fuel mix per process type is assumed for all countries.</td></tr>
</table>

Name of source:	Greenhouse gas efficiency of industrial activities in EU and Non-EU	
		• Used iron and steel sector statistics (IEA) are of very limited quality, and process mixes are assumed for countries where not available. • For copper and nickel process mixes are assumed to be equal for all countries. In the CO_2 efficiency calculation the fuel mix of the entire non-ferrous industry per country is used for direct emissions. However, the indirect emissions are only dependent on the country's average electricity emission factor. Therefore only the direct emissions have added value. • Aluminium includes electricity fuel mix per region, but the average electricity fuel mix per countries is used, because the electricity data is not split by country. • Ammonia CO_2 efficiency is for some countries determined top-down, while for others bottom-up using European plant data. • For pulp and paper CHP and product mix is not taken into account. • For cement the differences in process and fuel mixes per country have been taken into account. The variations between countries mainly result from different clinker content.

Table 39 Tracking Industrial Energy Efficiency and CO2 Emissions

Name of source: Tracking Industrial Energy Efficiency and CO_2 Emissions		
Name:		International Energy Agency (IEA), "Tracking Industrial Energy Efficiency and CO_2 Emissions", 2007. http://www.iea.org/publications/freepublications/publication/tracking_emissions-1.pdf
Identified by :		Ecofys
Brief description:	Approach:	1. Energy data collection from IEA energy statistics and national energy balances. 2. Production data from various sources e.g. UN organisations, industry associations and consultants. 3. Energy intensity calculation based on collected energy and production data.
	Sectors:	Various sectors, according to International Standard Industrial Classification (Top-down), NACE2 and 3-digit (Bottom-up)
	Scope:	Energy intensity and emissions data exclude electricity unless mentioned otherwise.
	Available data:	Chemical and petrochemical: - Energy efficiency index/CO_2 emissions index per selected country over the whole sector (feedstock included, electricity excluded). - Energy intensity ammonia comparison per country/region (2005, 11 regions). Non-metallic minerals: - Thermal energy intensity of clinker per selected country (2003, 12 countries). - Electricity intensity cement per selected country (2003, 12 countries). - Total primary energy intensity cement per selected country (2003, 12 countries) - CO_2 efficiency including electricity and process emissions of cement per selected country (2003, 12 countries). Pulp and paper: - EEI for heat and electricity separately per selected country (2003, 13 countries). - Only CO_2 efficiency from indirect emissions per selected country (2003, 13 countries). Non-ferrous metals: - Energy intensity of metallurgical alumina per region (2004 from IAI, 5 regions). - Electricity intensity of primary aluminium smelting per region (2005 from IAI, 7 regions)
	Remarks on methodology:	• Chemical and petrochemical sector: "the present efficiency indicators should not be used for country comparisons" (p.88). • Pulp and paper: Product mix varies so much to a degree that results may be biased. In addition: "Data limitations, particularly related to the energy use for different process steps, make it impossible to construct detailed indicators for country comparisons" (p.52). • Cement GHG efficiency depends on clinker to cement ratio. • Cement data has to be extracted from a graph. In addition: "Care must be taken in interpreting the absolute values of data in this figure, due to the possibility that different system boundaries have been used and that in some cases it is not clear whether LHV or HHV have been used" (p.161).

Table 40 Global Industrial Energy Efficiency Benchmarking

Name of source: Global Industrial Energy Efficiency Benchmarking		
Name:		United Nations Industrial Development Organization (UNIDO), “Global Industrial Energy Efficiency Benchmarking”, 2010. http://www.unido.org/fileadmin/user_media/Services/Energy_and_Climate_Change/Energy_Efficiency/Benchmarking_%20Energy_%20Policy_Tool.pdf
Identified by :		Ecofys
Brief description:	Approach:	Collection of benchmark curves per industry sector, complemented by: 1. Collection of average energy intensity data per industry sector per world region or country. 2. Energy Efficiency Index (EEI) calculation per industry sector per world region or country using the IEA energy statistics. EEI is the actual energy consumption divided by the energy consumption if the best practice technology is assumed.
	Sectors:	Various sectors, according to International Standard Industrial Classification (Top-down), NACE2 and 3-digit (Bottom-up)
	Scope:	The comparison data is only given in energy intensity, not CO_2 efficiency. The data includes electricity usage unless mentioned otherwise.
	Available data:	All relevant comparison info per sector is in Annex I: • Refinery sector: - EEI benchmark per selected country/region (2003, 8 selected countries/regions) • Chemical and petrochemical sector: - Steam cracking process (HVC) energy intensity per selected country/region (2006, 6 selected countries/regions). - Ammonia energy intensity benchmark per selected country/region (2007, 9 selected countries/regions). • Non-ferrous metals: - Alumina energy intensity benchmark per selected country/region (2007 from IAI, 6 regions). - Aluminium smelting electric energy intensity benchmark per selected country/region (2007 from IAI, 6 regions). - Zinc energy intensity benchmark per region (2006, 8 regions). • Iron and steel: - EEI benchmark per selected country/region (2005, 9 regions). • Non-metallic minerals: - Clinker thermal energy intensity benchmark per selected country/region (2007, 9 selected countries/regions). - Cement electricity energy intensity benchmark per selected country/region (2007, 10 selected countries/regions). • Pulp and paper: - EEI benchmark per selected country/region, heat only and heat+electricity (2006, 8 selected countries/regions). Furthermore, energy intensity comparison data for the (sub) sectors Foundries (cast iron, alloy cast steel, non-ferrous) and Textiles (spinning, weaving) is given.
	Remarks on methodology:	• The benchmark curves of each (sub) sector represent the average energy intensity per selected country/region. • Refinery sector data is based on the Solomon benchmark curve for 2000 and accounts for 70% of total final energy use in the global refinery sector. • Steam cracking benchmark curve based on data from 2001, 2003 and 2005. In 2005 participation rate is 50% of the total global production.

		• Ammonia benchmark curve based on data from 2004-2009. • Aluminium benchmark curve based on IAI data, additional data for China from other sources has been added. China data contains unspecified other regions as well. • Iron and steel benchmark curve takes process mix of different regions into account and includes the most important end-products. • Cement benchmark curve based on CSI data, own estimation for China. • Due to energy integration in the pulp and paper sector, the EEI is very uncertain. • Foundries are not separately reported in international energy statistics. • Data has to be extracted from a graph.

Table 41 Current IAI Statistics 2010

Name of source: Current IAI Statistics 2010		
Name:		International Aluminium Institute (IAI), "Current IAI Statistics 2010", 2011. http://www.world-aluminium.org/Statistics/Current+statistics
Identified by :		Ecofys
Brief description:	Approach:	Data derived exclusively from voluntary reports of IAI member and non-member companies.
	Sectors:	• Metallurgical alumina production. • Primary aluminium production.
	Scope:	Energy intensity comparison data on regional level, electricity usage included, 2010.
	Available data:	• Energy intensity of metallurgical alumina production per region (2010, split in 5 regions). • Energy intensity of primary aluminium production per region (2010, split in 6 regions).
	Remarks on methodology:	• Best data available on the energy intensity of aluminium production. • Data reporting based on guidelines set by the IAI. • Comparison data is on a regional level and each region only covers selected countries. • Primary aluminium production data does not include power used in casting and carbon plants.

Table 42 Global Cement Database on CO_2 and Energy Information

Name of source: Global Cement Database on CO_2 and Energy Information		
Name:		World Business Council for Sustainable Development – Cement Sustainability Initiative (CSI), "Global Cement Database on CO_2 and Energy Information", 2009 http://wbcsdcement.org
Identified by :		Ecofys
Brief description:	Approach:	Data collection from the cement industry.
	Sectors:	Only the cement producing industry.
	Scope:	CO_2 efficiency comparison data on regional level, electricity usage excluded, on-site electricity production excluded, direct emissions biomass excluded. Electricity intensity comparison data on regional level.
	Available data:	• Total cement CO_2 efficiency calculated on company level per selected country/region (2009, 11 selected countries/regions) • Total cement electric energy intensity calculated on company level per selected country/region (2009, 11 selected countries/regions).
	Remarks on methodology:	• Company data reports based on guidance documents provided by the CSI. • 2009 data from companies representing 26% of the global cement production, 83% assured by independent third parties.

Table 43 Trends in global energy efficiency 2011

Name of source: Trends in global energy efficiency 2011		
Name:		Enerdata, the Economist Intelligence Unit and ABB, "Trends in global energy efficiency 2011, an analysis of industry and utilities", 2011 http://www.abb.com/cawp/gad02465/b9225505ced8f7d7c1257853004a7a00.aspx
Identified by :		Ecofys
Brief description:	Approach:	Data analysis based on Enerdata's world energy database, collected from more than 200 sources around the world including IEA, Eurostat, specialised institutions and national sources.
	Sectors:	Steel, paper and aluminium industry, according to International Standard Industrial Classification
	Scope:	Energy intensity comparison data on country/regional level, electricity usage included.
	Available data:	• Steel industry: energy intensity per selected country (2009, 10 countries) • Paper industry: energy intensity per selected country (2008, 9 countries). • Aluminium industry: energy intensity primary aluminium per region (IAI data for 2009, 6 regions).
	Remarks on methodology:	• Own statistical analysis based on primary energy data from the IEA and complemented by data from other sources. • Detailed industry data for the EU comes from the Odyssee database. • Aluminium data obtained from the IAI.

Table 44 Potential of best practice technology to improve energy efficiency in the global chemical and petrochemical sector

Name of source: Potential of best practice technology to improve energy efficiency in the global chemical and petrochemical sector		
Name:		D. Saygin, M.K. Patel, E. Worrell, C. Tam, D.J. Gielen, "Potential of best practice technology to improve energy efficiency in the global chemical and petrochemical sector", Energy, Volume 36, Issue 9, September 2011, Pages 5779-5790.
Identified by :		Ecofys
Brief description:	Approach:	Bottom-up estimations of energy intensity based on sources containing country-specific energy intensity data, various literature sources and personal communication with industry experts.
	Sectors:	Key chemicals in the chemical and petrochemical sector.
	Scope:	Average energy intensity comparison data on country level, electricity and feedstock energy use excluded.
	Available data:	• Steam cracking (HVC according to Solomon definition) energy intensity per selected country (2006, 13 countries). • Ammonia energy intensity per selected country (2006, 13 countries). • Methanol energy intensity per selected country (2006, 8 countries). • Chlorine energy intensity per selected country (2006, 13 countries). • Soda ash energy intensity per selected country (2006, 13 countries).
	Remarks on methodology:	• Estimations based on data collected from a large variety of sources with process differences per country taken into account: - For Ammonia differences in process energy due to feedstock mix. - For Chlorine differences in process shares. - For Soda ash differences in process types.

Table 45 Levelling the carbon playing field

Name of source: Levelling the carbon playing field		
Name:		Peterson Institute for International Economics / World Resources Institute, "Leveling the carbon playing field", May 2008.
Identified by :		Copperalliance & Eurofer
Brief description:	Approach:	Data based on various literature sources and authors' estimates. No further details provided.
	Sectors:	Steel, Chemicals
	Scope:	Direct and total emissions, 2005
	Available data:	• Steel: tons of CO_2 emissions per ton of steel, 2005 • Chemicals: energy and carbon intensity index, 2005
	Remarks on methodology:	• Steel: data based on "Steel Statistical Yearbook", 2006; "CO_2 Emissions from Fuel Combustion", IEA, 2007; and estimates by authors. • Chemicals: data taken from "Tracking Industrial Energy Efficiency and CO2 Emissions", IEA, 2007. This reference is already included in this assessment. Moreover, the chemicals sector is not further disaggregated into relevant subsectors, which makes the data too general to be useful.

Table 46 Product classification and its implication on competitiveness and carbon leakage. Aluminium

Name of source: Product classification and its implication on competitiveness and carbon leakage. Aluminium		
Name:		Climate Strategies, "Product classification and its implication on competitiveness and carbon leakage. Aluminium", 2011.
Identified by :		German Emissions Authority (Dehst)
Brief description:	Approach:	Data based on various literature sources and authors' calculations.
	Sectors:	Aluminium
	Scope:	Direct and indirect emissions, 2008
	Available data:	Greenhouse gas intensity for primary aluminium
	Remarks on methodology:	"The IAI provides data on the electricity consumption required by region to produce primary aluminium. Indirect emissions are estimated by disaggregating regional consumption data based on USGS production data and then applying country specific IEA emissions factors for electricity supplied by the grid to each country."

4.2.2 Quality of short-listed references for cross-country comparisons

In the assessed references different methods for data collection exist. We find that nearly all GHG intensities are derived from other data: energy use, production volumes, CO_2 intensity of energy generation etc. The collection of this data can be done bottom up (company data, sub sector data) or top down (from economical parameters, statistical sources).

How useful are the identified references to compare GHG efficiencies in industrial sectors between countries? Whether or not a source can be used for this purpose depends on many factors, amongst others:

- Homogeneous data sources vs mixed (all company data vs mix of company and higher level data)
- Primary vs secondary sources (own data collection or (combination of) other sources)
- Level of data aggregation
- Geographical level (country, region)
- Public sources, traceable information
- Explanation of methodology and sources
- Coverage of data (part of sector data covered or full sector covered)
- Data collection method (voluntary vs obligatory, use of protocols & guidances, etc)

In this desk-based assessment we have been aware of these different criteria and took them into account as much as possible within the constraints of this project. Special attention has been paid to: primary vs secondary sources, level of data aggregation, and the transparency and consistency of the methodology an sources.

In the next section the nine references are discussed one by one.

- The TNO report (TNO, 2009) contains several inconsistencies in the calculation approach: GHG efficiencies within some countries are calculated using statistics (top-down) while for other countries it is calculated using a bottom-up approach. This complicates the comparison of the data. Also the quality of the IEA statistics used, for example in the iron and steel sector, is of limited quality for the purpose of cross-country comparisons (see next point). We therefore regard the report as of limited value for the purpose of comparing GHG efficiencies between countries.
- The IEA report (IEA, 2007) determines energy and CO_2 indicators for various emission-intensive sectors based on amongst others IEA energy statistics. The report explicitly questions the usefulness of their data for country comparison purposes: “While such indicators may be adequate to capture aggregate energy and CO_2 trends, they are less suited to a detailed analysis of industrial energy efficiency developments over time or across countries, or for an examination of improvement potentials. This is because they do not take full account of product quality and composition, or the processing and feedstock mix, which can vary widely within a sub-sector” (p.45). Our conclusion is that this reference is of limited value.
- The UNIDO report (UNIDO, 2010) provides benchmarks for steam cracking and aluminium smelters based on actual company data and cement benchmarks based on CSI data. These data may be regarded as suitable for international country comparisons. For other sectors, estimates are made based on production statistics, international energy statistics and/or non-public sources. These data suffer from errors/inconsistencies in the data reported in energy statistics (also reflected in previous bullets). Especially for refineries and pulp and paper the report demonstrates explicitly the need for further investigation. For zinc the report uses data based on non-public sources, which are not available for further validation.
- The statistics provided by IAI (IAI, 2012) supplies energy intensities of alumina and primary aluminium smelting, based exclusively on voluntary reports of IAI member and non-member companies and collected using forms that clearly specify the data to be reported. The coverage of the data with respect to the total sector is not provided. IAI claims that “The IAI considers the figures shown to be reliable, but they may be subject to revision”. We would therefore recommend to validate (or even verify) the available data. The intensities are shown on regional level, instead of country level. This complicates cross-country comparisons, but could give a first order indication.
- The Global Cement Database on CO_2 and Energy Information (WBCSD –CSI, 2012) is a well-known source of information on clinker and cement energy intensities. The system collects company data based on a detailed protocol and guidances. The presented energy and carbon intensities seem very useful, at least for those countries where the coverage of the database is high (>50%): Europe, North and South America, Africa and India. Lower coverages are found

in the other regions, including China with a poor coverage (5%), leading to restraints for country comparative purposes of these data.

- The Enerdata report (Enerdata, 2011) provides energy intensities based on Enerdata's world energy database, collected from more than 200 sources around the world including IEA, Eurostat, specialised institutions and national sources. From a methodological point of view the report contains very limited information, e.g. it is unclear how the authors have dealt with issues around statistical (mis)reporting, data gaps, (in)consistencies between different data sources, and/or mismatches between different data sources. This makes it impossible to assess the usefulness of this report. The report may give a first indication of the situation, but further research would be required.
- Saygin et al. (2011) present both bottom-up and top-down estimations of energy intensity based on data collected from a large variety of sources and personal communication with industry experts. The energy intensity of different chemical products in different countries is based amongst others on the IEA report, which we also assess in this report, and of which we concluded that it is of limited value for cross-country comparison. Saygin et al state about their own work: "Two approaches were applied, namely Top-down and Bottom-up. The analysis via these two approaches is workable, but quality of the input data is critical and, in most cases needs to be improved. This especially concerns energy statistics, production data and SEC data both for the average current situation and for BPT". In other words, in most cases energy intensity data needs to be improved. In addition, the paper does not contain any GHG intensities. Therefore, the paper may provide some first order indications on energy intensities, that needs further improvement, and regarding GHG intensities it is of limited value.
- A clear methodology of how the Peterson Institute (Peterson / WRI, 2008) calculated the carbon intensity of the steel industry is lacking. The "black box" report can be classified in the same category as the Enerdata report. It would be advised to compare the figures provided at least with other data sources.
- The report of Climate Strategies (CS, 2011) on the aluminium industry is based on IAI data that is already included in this assessment. However, the data is converted to GHG intensity, which makes this a valuable additional reference to be included in this study.

4.2.3 Conclusion on short-listed references

Based on a desk-based assessment involving nine key references the following sources have been identified as initially suitable for country comparative purposes regarding the sectors mentioned:

- UNIDO (2010) iron and steel, steam cracking, primary aluminium, cement
- IAI statistics (2012) primary aluminium, alumina

- WBCSD-CSI (2012) clinker, cement (not all regions)
- CS (2011) primary aluminium

Regarding the other reports (Enerdata 2011, Peterson / WRI 2008, Saygin et al 2011) or part of reports it is unclear whether they can be used. For the TNO report (TNO, 2009) and IEA report (IEA, 2007) we conclude that they are not suitable for cross-country comparisons on GHG efficiencies.

Table 47 Overview of sectors and available references with GHG or energy intensities of different countries and regions.

Sector:	TNO	IAI	WBCSD-CSI	Ener-data	UNIDO	IEA	Saygin	Peterson / WRI	CS
Iron & Steel	X			X	X			X	
Copper	X								
Nickel	X								
Aluminium	X	X		X	X				X
Zinc					X				
Pulp & Paper	X			X	X	X			
Cement	X		X		X	X			
Steam Cracking					X		X		
Ammonia	X				X	X	X		
Methanol							X		
Chorine							X		
Soda ash							X		
Refineries					X				

Notes: A cross denotes that data is available.

Red = insufficient quality for cross-country comparisons;

Orange = unknown quality;

Green = sufficient quality, further research may be needed.

4.3 Comparison of GHG efficiencies

Following the assessment of the available references on GHG and energy intensities, we will now compare the efficiencies with each other, based on the most valuable data sources as much as possible.

First, a comparison is made between the average EU intensity and third countries. Then, a conclusion is drawn on the comparability of GHG efficiencies of European industrial sectors. Below the results per sector are discussed.

Iron and steel

Average GHG intensities within EU are comparable to that of US, Japan and South Korea, on the basis of two sources (TNO, Peterson/WRI). Two other sources (Enerdata, UNIDO) show that energy efficiencies in these regions are comparable as well. Brazil, China, India, and Russia are amongst the countries with the largest differences in GHG efficiencies, according to these sources. As indicated in the assessment of the data sources, these results should be interpreted with care: although the observations seem to be in line with each other, only the UNIDO report has been identified as suitable for cross-country comparisons in this study. A more in-depth study would be recommended to validate this result.

Aluminium

Primary aluminium smelting energy intensity is the highest in Europe compared to all other regions in the world, including China, based on 2010 data from IAI statistics. The UNIDO and Enerdata report confirm this finding. The most likely explanation is the use of old technologies in Europe. If converted to GHG intensities the emission factor to produce electricity in the respective regions should be taken into account. Calculations from Climate Strategies show that the GHG intensity in Europe is comparable to that of the Russian Federation, much higher than Norway (due to hydropower), and significantly lower than the USA and China. Other regions of interest have not been studied by Climate Strategies.

Pulp and paper

Out of four sources containing data on the pulp and paper sector, three have been assessed as insufficient for inter-country comparisons (TNO, IEA, UNIDO) while it is not clear whether the fourth reference can be used due to lack of transparency (Enerdata). Moreover, the UNIDO and Enerdata reports contain energy intensities which are in this case not useful for the purpose of comparing GHG intensities because of the high share of biomass use within the sector. The remaining reports (TNO, IEA) account for biomass emissions in different ways and are therefore not comparable with each other. The reports itself have been assessed already as insufficient for cross-country comparisons. Therefore we are not able to provide any useful cross-country comparisons for this sector.

Cement

Clinker is produced in a fairly homogeneous manufacturing process with more than 50% of emissions produced by process emissions. Within different regions of the world, except for the former Soviet Union, emissions per tonne of clinker are within +/-5% compared to the European value of 860 kgCO_2 / t clinker (2010 data, WBCSD/CSI).

GHG emissions per tonne of cementitious product[4] display more spread: Central America and Africa are within +/-5% of the European value of 646 kgCO_2 / t cementitious product. South America and India perform on average better than European installations (due to a lower clinker-to-cement ratio used), while the other regions show GHG intensities more than 5% higher than in Europe.

In interpreting these data care should be taken for those regions where the WBCSD / CSI database has a poor coverage, e.g. for China.

Also note that the reported emissions are excluding indirect emissions from electricity consumption. Only the IEA reports refers to total emissions including indirect emissions, although we would not recommend using these data due to "the possibility that different system boundaries have been used and that in some cases it is not clear whether LHV or HHV have been used".

In view of these considerations we recommend to further study the total carbon intensity of cement manufacturing in different regions around the world.

Steam cracking

The NW-European energy intensity of steam cracking is ~15.6 GJ / t high value chemicals (excluding electricity and feedstock energy consumption). This value is higher than the average of Japan and South Korea (both 12.6 GJ / t), but significantly lower (>5%) than for China, India, North America, Taiwan, Saudi Arabia, and Brazil.

Unfortunately, the European average intensity is not available in Saygin et al, which complicates a solid comparison. The UNIDO report uses the data from Saygin et al. and does not provide any additional information.

Ammonia

The energy intensity excluding electricity consumption is on average 16 GJ / t product (NW Europe), based on Saygin et al. This is comparable to the intensity of Taiwan. Brazil, Japan and Saudi Arabia have a lower energy intensity, while other regions shows more than 5% higher intensities. Note that these differences may be influenced

4 Cementitious products are all clinker volumes produced by a company for cement making or direct clinker sale, plus gypsum, limestone, CKD, and all clinker substitutes consumed for blending, plus all cement substitutes produced. Clinker bought from third parties for the production of cement is excluded.

by the amount of fuel versus electricity-driven processes, which both are used within this sector. The UNIDO report includes indirect emissions and reports a European average of 35.7 GJ / t product, which is in the same range (+/- 5%) of values for Saudi Arabia, Middle-East and North-Africa, North-America and India. Brazil, Taiwan and Japan are not mentioned explicitly in the report and would deserve some further analysis. Other regions, amongst others China, show larger energy intensities. For the values to be fully useful a transformation to GHG intensities would be required in order to take into account different fuel mixes and corresponding emission factors.

Methanol

Saygin et al reports a range of 10 to 12.4 GJ / t methanol for several European countries, which is comparable to other regions in the world (USA, Brazil, Canada, India, Saudi Arabia). Only China shows a big deviation with an energy intensity of 15 GJ / t, caused by a fully coal-based methanol production. This means that the GHG intensity in China is 2 to 3 times higher than compared to Europe, while for the other regions mentioned it is expected to be in the same range as compared to Europe.

Chlorine

A range of 0.4 – 2.3 GJ / t chlorine is reported by Saygin et al as the range of energy intensities for several NW European countries; no average European value is provided. Korea and Japan fit the European range well (both 1.9 GJ / t). China, Saudi Arabia and Taiwan are a bit beyond this range (2.7-2.9 GJ / t) while USA, Canada and Brazil have the highest energy per tonne of Chlorine in the world (4.4-4.7 GJ / t). Further study would be required to convert these values to GHG intensities.

Soda ash

A range of 11.6-12.6 GJ / t soda ash is reported by Saygin et al as the range of energy intensities for several NW European countries; no average European value is provided. Only China, India and Taiwan report notably higher energy intensities (~13.6-13.8 GJ / t). Other regions in the world show comparable or much lower energy intensities, with Canada and the USA, where soda ash is simply mined, going as low as 6.9 GJ / t soda ash. Further study would be required to convert these values to GHG intensities.

Refineries

For the refinery sector a comparison has been made in the UNIDO report by estimating the EEI for each country based on the best practice technology of 13 refinery processes and the refinery structure of each country. For Europe, North America and the OECD Pacific region an EEI lower than 1 is obtained , which implies they are better than best-practice technology. The report states: “These results point to limitations in the methodology and the data used. A country-level analysis is not possible for sectors such as the refinery sector where cogeneration and energy integration of the processes have significant impacts on levels of energy efficiency.” This means that on the basis of public literature no comparisons can be made at the moment.

4.4 Conclusion: Limited availability on carbon efficiencies complicates cross-country comparisons

Data availability of industrial GHG intensities that can be used for cross-country comparisons appears to be very limited. Without exception all industrial sectors face one or more serious issues in interpreting and comparing GHG intensities between EU and third countries across the world.

Sectors with the best data availability are cement and aluminium, due to sectoral benchmarking initiatives on a global level, and allow comparison of GHG intensities to some extent and between EU and at least some third countries.

The **cement** industry in Central America and Africa produces cement within +/-5% of the European emission intensity of cementitious products. South America and India perform on average even better than European installations, mainly due to their low clinker to cement ratio. Japan, Australia and New-Zealand show GHG intensities 6% higher than in Europe. Regarding clinker production, all third countries in this study, except for the former Soviet Union, show emissions per tonne of clinker within +/- 5% compared to the European average value of 860 kgCO_2 / t clinker.

Data for China are not useful due to poor data representativeness (only 5% of production covered). A serious limitation is that indirect emissions from electricity consumption are not taken into account yet. These would add roughly 10% of emissions per tonne of cement. Further research is needed to get a more reliable, country-specific and complete picture of the GHG intensity of cement manufacturing.

The GHG intensity of **aluminium** in Europe is comparable to that of the Russian Federation, significantly higher than Norway, and significantly lower than that of the USA and China. No GHG intensity data are available for other regions in the world, although energy intensities are. Due to large differences in the emission factor of electricity (the main energy input in primary aluminium smelting) across different regions in the world, energy intensity is not a sufficient indicator for cross-country comparisons of GHG intensities.

For steam cracking, methanol, chlorine and soda ash energy efficiencies for several countries are available. One complication is that there is no average European value to compare results with. Furthermore, additional study would be required to convert energy efficiency values to GHG intensities, which is for the complex chemical sector not a straightforward exercise.

For **iron and steel** most of the available data is of limited or unknown quality, preventing a solid comparison. The identified sources claim that both the average GHG intensity as well as the energy efficiency of the EU is comparable to that of US, Japan and South Korea. As indicated in the assessment of the data sources, these results should be interpreted with care: although the observations seem to be in line with each other, only one reference (UNIDO, 2010) has been identified as suitable for cross-country comparisons in this study. Further analysis would be recommended to validate these results.

Some sectors included in our analysis have no data available at all or have data of insufficient quality to allow cross-country comparisons. This holds for copper, nickel, zinc, pulp and paper, and refineries. For sectors not further mentioned in this study (e.g. lime, ferro-alloys, bricks, gypsum etc) no data have been found at all.

On a more general note, we conclude that most public data sources are not a good basis for cross-country GHG intensity comparisons due to serious flaws in combing data from different sources collected via different approaches. Exceptions consist of the aluminium and cement industry where company data is collected in a methodologically sound and transparent way for the purpose of benchmarking the sector. Another approach would be to dive into the processes and determine what factors influence the carbon intensity.

4.5 Overview of GHG efficiency data for different sectors and countries / regions

Colour legend of numbers:

Red = Greenhouse gas intensity

Dark blue = Energy intensity

Light blue = Energy Efficiency Index

Yellow = Electricity intensity

References used:

i. TNO Built Environment and Geosciences (2009): Greenhouse gas efficiency of industrial activities in EU and Non-EU.

ii. Peterson Institute for International Economics / World Resources Institute (2008): Levelling the carbon playing field.

iii. Climate Strategies (2011): Product classification and its implication on competitiveness and carbon leakage. Aluminium.

iv. International Aluminium Institute (2011): Current IAI Statistics 2010. http://www.world-aluminium.org/statistics/

v. WBCSD-CSI (2009): Global Cement Database on CO_2 and Energy Information.

vi. Enerdata, the Economist Intelligence Unit and ABB (2011): Trends in global energy efficiency 2011, an analysis of industry and utilities.

vii. UNIDO (2010): Global Industrial Energy Efficiency Benchmarking.

viii. International Energy Agency (2007): Tracking Industrial Energy Efficiency and CO_2 Emissions.

ix. Saygin et al. (2011); Potential of best practice technology to improve energy efficiency in the global chemical and petrochemical sector.

Table 48 Overview of GHG efficiency data for iron & steel, non-ferrous metals, pulp & paper, non-metallic minerals

	Iron and steel	Non-ferrous metals						Pulp and paper	Non-metallic minerals
		Copper	Nickel	Aluminium			Zinc		Cement
				Aluminium (product)	Metallurgic alumina	Primary aluminium			
Europe	EEI ~1.3[14vii]				~15.5 GJ/t-prod[10vii] 14.21 GJ /t-prod[8iv]	~15.8 MWh /t-prod[23vii] 15.9 MWh /t-prod[9iv]		EEI~0.45[15vii]	~4.7 GJ/t-prod[16vii] 646 kg CO_2 / t-prod[12v] 860 kg CO_2 / t-clinker[12v] 116 kWh /t-prod[13v]
EU	730 kg CO_2 / t-prod[5i] ~0.31 toe /t-prod[17vi] ~900 kgCO_2 /t-prod[6ii]					8500 kgCO_2 / t-prod[7iii]		1100 kg CO_2 / t-prod[20i] ~0.35 toe /t-prod[21vi]	
Western Europe							~15.5 GJ/t-prod[24vii]		

5 2005 data, indirect emissions included, top-down approach.

6 2006/2007 data, total emissions. Data extracted from graph, not exact.

7 2005-2008 data, total emissions. Data extracted from graph, not exact

	Iron and steel	Non-ferrous metals						Pulp and paper	Non-metallic minerals
Netherlands	700 kg CO_2 / t-prod[5i]		5386 kg CO_2 / t-prod[18i]	2064 kg CO_2 / t-prod[19i]				640 kg CO_2 / t-prod[20i]	760 kg CO_2 / t-prod[22i]
Belgium	680 kg CO_2 / t-prod[5i]	952 kg CO_2 / t-prod[18i]	6346 kg CO_2 / t-prod[18i]	2433 kg CO_2 / t-prod[19i]				1010 kg CO_2 / t-prod[20i]	750 kg CO_2 / t-prod[22i]
Germany	810 kg CO_2 / t-prod[5i]	964 kg CO_2 / t-prod[18i]	6426 kg CO_2 / t-prod[18i]	2463 kg CO_2 / t-prod[19i]				720 kg CO_2 / t-prod[20i] ~360 kg CO_2/t-prod[11viii]	740 kg CO_2 / t-prod[22i] ~700 kg CO_2 / t-prod[25viii]
France	640 kg CO_2 / t-prod[5i]	873 kg CO_2 / t-prod[18i]	5820 kg CO_2 / t-prod[18i]	2231 kg CO_2 / t-prod[19i]				820 kg CO_2 / t-prod[20i] ~450 kg CO_2/t-prod[11viii]	740 kg CO_2 / t-prod[22i]
Finland								~210 kg CO_2/t-prod[11viii]	
Italy	600 kg CO_2 / t-prod[5i]	854 kg CO_2 / t-prod[18i]	5696 kg CO_2 / t-prod[18i]	2184 kg CO_2 / t-prod[19i]				630 kg CO_2 / t-prod[20i] ~470 kg CO_2/t-prod[11viii]	730 kg CO_2 / t-prod[22i] ~700 kg CO_2 / t-prod[25viii]
Norway						~2200 kgCO_2 / t-prod[7iii]		~180 kg CO_2/t-prod[11viii]	
Spain	620 kg CO_2 / t-prod[5i]	1039 kg CO_2 / t-prod[18i]	6929 kg CO_2 / t-prod[18i]					940 kg CO_2 / t-prod[20i] ~630 kg CO_2/t-prod[11viii]	740 kg CO_2 / t-prod[22i] ~650 kg CO_2 / t-prod[25viii]
Sweden	690 kg CO_2 / t-prod[5i]	1184 kg CO_2 / t-prod[18i]	7894 kg CO_2 / t-prod[18i]	3026 kg CO_2 / t-prod[19i]				1500 kg CO_2 / t-prod[20i]	740 kg CO_2 / t-prod[22i]

	Iron and steel	Non-ferrous metals						Pulp and paper	Non-metallic minerals
								~130 kg CO_2/t-prod[11viii]	
Switzerland	180 kg CO_2 / t-prod[5i]		6075 kg CO_2 / t-prod[18i]	2329 kg CO_2 / t-prod[19i]				840 kg CO_2 / t-prod[20i]	740 kg CO_2 / t-prod[22i]
United Kingdom								~550 kg CO_2/t-prod[11viii]	
Non Western Europe							~33 GJ/t-prod[24vii]		
Poland	1120 kg CO_2 / t-prod[5i]	1212 kg CO_2 / t-prod[18i]	8079 kg CO_2 / t-prod[18i]	3097 kg CO_2 / t-prod[19i]				1500 kg CO_2 / t-prod[20i]	760 kg CO_2 / t-prod[22i]
Czech Republic	1260 kg CO_2 / t-prod[5i]	808 kg CO_2 / t-prod[18i]	5386 kg CO_2 / t-prod[18i]	2064 kg CO_2 / t-prod[19i]				1620 kg CO_2 / t-prod[20i]	760 kg CO_2 / t-prod[22i]
Romania	1670 kg CO_2 / t-prod[5i]							1040 kg CO_2 / t-prod[20i]	750 kg CO_2 / t-prod[22i]
Hungary	1100 kg CO_2 / t-prod[5i]	813 kg CO_2 / t-prod[18i]		2078 kg CO_2 / t-prod[19i]				670 kg CO_2 / t-prod[20i]	750 kg CO_2 / t-prod[22i]
Ukraine	1590 kg CO_2 / t-prod[5i] ~0.57 toe /t-prod[17vi]		5723 kg CO_2 / t-prod[18i]	2194 kg CO_2 / t-prod[19i]				620 kg CO_2 / t-prod[20i]	720 kg CO_2 / t-prod[22i]
North America	EEI~1.35[14vii]				~11 GJ/t-prod[10vii] 12.78 GJ /t-prod[8iv]	~15.5 MWh /t-prod[23vii] 15.1 MWh /t-prod[9iv]	~19.5 GJ/t-prod[24vii]	EEI~1.15[15vii]	~4.15 GJ/t-prod[16vii] 751 kg CO_2 / t-prod[12v] 903 kg CO_2 / t-clinker[12v]

	Iron and steel	Non-ferrous metals						Pulp and paper	Non-metallic minerals
									135 kWh /t-prod[13v]
USA	540 kgCO_2 / t-prod[5i] ~0.29 toe /t-prod[17vi] ~1000 kgCO_2 / t-prod[6ii]	830 kg CO_2 / t-prod[18i]	5533 kg CO_2 / t-prod[18i]	2121 kg CO_2 / t-prod[19i]		~11000 kgCO_2 / t-prod[7iii]		1360 kg CO_2 / t-prod[20i] ~720 kg CO_2/t-prod[11viii] ~0.7 toe /t-prod[21vi]	910 kg CO_2 / t-prod[22i] ~920 kg CO_2 / t-prod[25viii]
Canada	850 kg CO_2 / t-prod[5i] ~1200 kgCO_2 / t-prod[6ii]	911 kg CO_2 / t-prod[18i]	6850 kg CO_2 / t-prod[18i]	2626 kg CO_2 / t-prod[19i]				1280 kg CO_2 / t-prod[20i] ~300 kg CO_2/t-prod[11viii] ~0.87 toe /t-prod[21vi]	840 kg CO_2 / t-prod[22i] ~840 kg CO_2 / t-prod[25viii]
Mexico	870 kg CO_2 / t-prod[5i] ~1300 kgCO_2 / t-prod[6ii]	811 kg CO_2 / t-prod[18i]	5409 kg CO_2 / t-prod[18i]	2073 kg CO_2 / t-prod[19i]				780 kg CO_2 / t-prod[20i] ~0.21 toe /t-prod[21vi]	760 kg CO_2 / t-prod[22i] ~780 kg CO_2 / t-prod[25viii]
South America	EEI~1.55[14vii]				~10.5 GJ/t-prod[10vii] 9.81 GJ /t-prod[8iv]	~15.2 MWh /t-prod[23vii] 15.7 MWh /t-prod[9iv]	~17 GJ/t-prod[24vii]		~3.65 GJ/t-prod[16vii] 553 kg CO_2 / t-prod[12v] 819 kg CO_2 / t-clinker[12v] 105 kWh /t-prod[13v]

	Iron and steel	Non-ferrous metals						Pulp and paper	Non-metallic minerals
Brazil	1880 kg CO_2 / t-prod[5i] ~1050 kgCO_2 / t-prod[6ii] ~0.57 toe /t-prod[17vi]	1151 kg CO_2 / t-prod[18i]	7673 kg CO_2 / t-prod[18i]	2941 kg CO_2 / t-prod[19i]				1590 kg CO_2 / t-prod[20i] ~370 kg CO_2/t-prod[11viii] ~0.99 toe /t-prod[21vi]	710 kg CO_2 / t-prod[22i] ~710 kg CO_2 / t-prod[25viii] 592 kg CO_2 / t-prod[12v] 860 kg CO_2 / t-clinker[12v] 110 kWh /t-prod[13v]
Central America									638 kg CO_2 / t-prod[12v] 875 kg CO_2 / t-clinker[12v] 111 kWh /t-prod[13v]
Africa	EEI~1.8[14vii]				~16.5 GJ/t-prod[10vii] 15.38 GJ /t-prod[8iv]	~14.6 MWh /t-prod[23vii] 14.6 MWh /t-prod[9iv]	~17.5 GJ/t-prod[24vii]		~4.75 GJ/t-prod[16vii] 629 kg CO_2 / t-prod[12v] 825 kg CO_2 / t-clinker[12v] 97.6 kWh /t-prod[13v]
South Africa	2710 kg CO_2 / t-prod[5i]							960 kg CO_2 / t-prod[20i]	720 kg CO_2 / t-prod[22i]

	Iron and steel	Non-ferrous metals						Pulp and paper	Non-metallic minerals
Asia-Pacific	EEI ~1.2[14vii]							EEI~0.35[15vii]	
Pacific									~3.35 GJ/t-prod[16vii]
Asia+Oceania									
East Asia+Oceania					~11.5 GJ/t-prod[10vii] 10.26 GJ /t-prod[8iv]				686 kg CO_2 / t-prod[12v] 840 kg CO_2 / t-clinker[12v] 110 kWh /t-prod[13v]
Oceania						~14.8 MWh /t-prod[23vii] 15.0 MWh /t-prod[9iv]			
Australia							~18 GJ/t-prod[24vii]		
Asia						~14.7 MWh /t-prod[23vii] 15.4 MWh /t-prod[9iv]	~22.5 GJ/t-prod[24vii]		693 kg CO_2 / t-prod[12v] 842 kg CO_2 / t-clinker[12v] 108 kWh /t-

8 2010 data, electricity consumption included. Africa and South Asia are grouped together in Africa.

9 2010 data, electricity consumption only.

	Iron and steel	Non-ferrous metals						Pulp and paper	Non-metallic minerals
									prod[13v]
Japan	720 kg CO_2 / t-prod[5i] ~950 kgCO_2 / t-prod[6ii] ~0.32 toe /t-prod[17vi]	1381 kg CO_2 / t-prod[18i]	9209 kg CO_2 / t-prod[18i]					1200 kg CO_2 / t-prod[20i] ~410 kg CO_2/t-prod[11viii] ~0.3 toe /t-prod[21vi]	830 kg CO_2 / t-prod[22i] ~770 kg CO_2 / t-prod[25viii]
China	1850 kg CO_2 / t-prod[5i] ~2600 kgCO_2 / t-prod[6ii] EEI~1.4[14vii] ~0.54 toe /t-prod[17vi]	1288 kg CO_2 / t-prod[18i]	8583 kg CO_2 / t-prod[18i]	3290 kg CO_2 / t-prod[19i]	~24.5 GJ/t-prod[10vii]	~13500 kgCO_2 / t-prod[7iii]	~37.5 GJ/t-prod[24vii]	1050 kg CO_2 / t-prod[20i] EEI~0.7[15vii] ~0.25 toe /t-prod[21vi]	700 kg CO_2 / t-prod[22i] ~860 kg CO_2 / t-prod[25viii] ~4.1 GJ/t-prod[16vii] 656 kg CO_2 / t-prod[12v] 873 kg CO_2 / t-clinker[12v] 99.8 kWh /t-prod[13v]
India	2240 kg CO_2 / t-prod[5i] ~1900 kgCO_2 /	1312 kg CO_2 / t-prod[18i]	8744 kg CO_2 / t-prod[18i]	3352 kg CO_2 / t-prod[19i]				1640 kg CO_2 / t-prod[20i] EEI~1.5[15vii]	840 kg CO_2 / t-prod[22i] ~870 kg CO_2 /

[10] 2007 data graphically extracted, electricity consumption included, author's estimate based on 2009 report. China data contains unspecified other regions as well.

	Iron and steel	Non-ferrous metals						Pulp and paper	Non-metallic minerals
	t-prod[6ii] EEI~1.6[14vii]								t-prod[25viii] ~3.1 GJ/t-prod[16vii] 602 kg CO_2 / t-prod[12v] 838 kg CO_2 / t-clinker[12v] 91.6 kWh /t-prod[13v]
Thailand	470 kg CO_2 / t-prod[5i]							1080 kg CO_2 / t-prod[20i]	740 kg CO_2 / t-prod[22i]
Indonesia								1750 kg CO_2 / t-prod[20i]	730 kg CO_2 / t-prod[22i]
South Korea	640 kg CO_2 / t-prod[5i] ~900 kgCO_2 / t-prod[6ii] ~0.32 toe /t-prod[17vi]	1225 kg CO_2 / t-prod[18i]	8164 kg CO_2 / t-prod[18i]					930 kg CO_2 / t-prod[20i] ~350 kg CO_2/t-prod[11viii] ~0.23 toe /t-prod[21vi]	810 kg CO_2 / t-prod[22i] ~800 kg CO_2 / t-prod[25viii]
CIS									793 kg CO_2 / t-prod[12v]

[11] 2003 data graphically extracted, indirect emissions only, top-down approach. In this data set heat and electricity are both considered as indirect emissions. Biomass usage is considered to be zero-emission.

	Iron and steel	Non-ferrous metals						Pulp and paper	Non-metallic minerals
									985 kg CO_2 / t-clinker[12v] 132 kWh /t-prod[13v]
EIT	EEI~2.25[14vii]							EEI~1.95[15vii]	~6.25 GJ/t-prod [16vii]
Russia	2060 kg CO_2 / t-prod[5i] ~3400 kgCO_2 / t-prod[6ii] ~0.69 toe /t-prod[17vi]					~8000 kgCO_2 / t-prod[7iii]		1260 kg CO_2 / t-prod[20i]	730 kg CO_2 / t-prod[22i]
Turkey	450 kg CO_2 / t-prod[5i] ~0.18 toe /t-	981 kg CO_2 / t-prod[18i]	6539 kg CO_2 / t-prod[18i]	2507 kg CO_2 / t-prod[19i]				900 kg CO_2 / t-prod[20i] ~0.23 toe /t-	690 kg CO_2 / t-prod[22i]

[12] 2010 data, based on cementitious product unless otherwise specified, electricity consumption excluded, on-site electricity production excluded, direct emissions biomass excluded. Asia excludes China, India, CIS and Japan. South America excludes Brazil. Africa and Middle East are grouped together in Africa. Japan, Australia and New Zealand are grouped together in East Asia+Oceania.

[13] 2010 data, electricity consumption only. Asia excludes China, India, CIS and Japan. South America excludes Brazil. Africa and Middle East are grouped together in Africa. Japan, Australia and New Zealand are grouped together in East Asia+Oceania.

[14] 2005 data graphically extracted, indirect emissions included, author's estimate based on 2006 and 2009 reports. The process mix of different regions are taken into account and the most important end-products are included.

[15] 2006 data graphically extracted, heat and electricity consumption, author's estimate based on 2009 reports.

[16] 2007 data graphically extracted, heat consumption only, author's estimated based on 2009 reports. Africa and Middle East are grouped together in Africa.

	Iron and steel	Non-ferrous metals						Pulp and paper	Non-metallic minerals
	prod[17vi]							prod[21vi]	
Saudi Arabia									
Taiwan	~0.23 toe /t-prod[17vi]								

[18] No year indication, indirect emissions excluded, bottom-up approach.

[19] 2007 data, indirect emissions excluded because the bottom-up approach assumes equal

[20] 2005 data, indirect emissions included, bottom-up approach. Biomass emissions are considered to be non-zero emissions. Differences in process mixes per country are taken into account. The energy intensity and fuel mix per process type are assumed to be equal for all countries.

[22] 2005 data, process and indirect emissions included, bottom-up approach. Different process mixes per country are taken into account, but the process emission intensity is not country specific.

[17] 2009 data graphically extracted, electricity consumption included.

[21] 2008 data graphically extracted, electricity consumption included.

[23] 2007 data graphically extracted, electricity consumption only, author's estimate based on 2008-2009 reports.

[24] 2006 data graphically extracted, electricity consumption included, author's estimate based on 2009 report.

[25] 2003 data graphically extracted, electricity and process emissions included.

Table 49 Overview of GHG efficiency data for chemical and petrochemical products and refineries

	Chemical and petrochemical					Refineries
	Steam cracking	Ammonia	Methanol	Chlorine	Soda ash	
Europe	~15.6 GJ/t-prod[27vii]	35.7 GJ/t-prod[30vii]				EEI~8.85[28vii]
EU						
West-Europe		35.0 GJ/t-prod[31vii]				
Benelux	15.3 GJ/t-prod[32ix]	14.3 GJ/t-prod[33ix]	10.0 GJ/t-prod[34ix]	1.2 GJ/t-prod[35ix]	11.6 GJ/t-prod[36ix]	
Netherlands		1700 kg CO_2 / t-prod[29i]				
Belgium		3400 kg CO_2 / t-prod[26i]				
Germany	15.7 GJ/t-prod[32ix]	1800 kg CO_2 / t-prod[26i] 16.6 GJ/t-prod[33ix]	12.4 GJ/t-prod[34ix]	2.3 GJ/t-prod[35ix]	11.6 GJ/t-prod[36ix]	
France	15.4 GJ/t-prod[32ix]	1400 kg CO_2 / t-prod[26i] 16.5 GJ/t-prod[33ix]		2.3 GJ/t-prod[35ix]	11.6 GJ/t-prod[36ix]	
Italy	15.9 GJ/t-prod[32ix]	1200 kg CO_2 / t-prod[26i] 15.0 GJ/t-prod[33ix]		0.4 GJ/t-prod[35ix]	12.6 GJ/t-prod[36ix]	
Spain		1100 kg CO_2 / t-prod[26i]				
Sweden		1800 kg CO_2 / t-prod[26i]				
Switzerland		1700 kg CO_2 / t-prod[29i]				
Non West-Europe						
Central Europe		~41.0 GJ/t-prod[30vii] 43.6 GJ/t-prod[31viii]				
Poland		3400 kg CO_2 / t-prod[29i]				
Czech Republic		2400 kg CO_2 / t-prod[26i]				

	Chemical and petrochemical					Refineries
Romania		3400 kg CO_2 / t-prod[29i]				
Hungary		2400 kg CO_2 / t-prod[26i]				
Ukraine		2100 kg CO_2 / t-prod[26i]				
North America	~18.3 GJ/t-prod[27vii]	~37.0 GJ/t-prod[30vii] 37.9 GJ/t-prod[31viii]				EEI~0.9[28vii]
USA	18.3 GJ/t-prod[32ix]	1300 kg CO_2 / t-prod[26i] 17.3 GJ/t-prod[33ix]	11.4 GJ/t-prod[34ix]	4.7 GJ/t-prod[35ix]	6.9 GJ/t-prod[36ix]	
Canada	18.3 GJ/t-prod[32ix]	1900 kg CO_2 / t-prod[26i] 17.2 GJ/t-prod[33ix]	10.0 GJ/t-prod[34ix]	4.7 GJ/t-prod[35ix]	6.9 GJ/t-prod[36ix]	
(Mexico)		2800 kg CO_2 / t-prod[29i]				
South America		~36.0 GJ/t-prod[30vii] 36.0 GJ/t-prod[31viii]				EEI~2.0[28vii]
Brazil	~18.3 GJ/t-prod[27vii] 17.1 GJ/t-prod[32ix]	2800 kg CO_2 / t-prod[29i] 15.3 GJ/t-prod[33ix]	10.0 GJ/t-prod[34ix]	4.4 GJ/t-prod[35ix]	11.7 GJ/t-prod[36ix]	
Asia-Pacific	~12.6 GJ/t-prod[27vii]					
Pacific						EEI~0.8[28vii]
East Asia+Oceania						
Oceania		36.0 GJ/t-prod[31viii]				
Australia						
China	~17.1 GJ/t-prod[27vii] 16.7 GJ/t-prod[32ix]	3700 kg CO_2 / t-prod[29i] ~46.5 GJ/t-prod[30vii] 48.8 GJ/t-	15.0 GJ/t-prod[34ix]	2.7 GJ/t-prod[35ix]	13.8 GJ/t-prod[36ix]	EEI~4.4[28vii]

[26] No year indication, indirect emissions included. Top-down approach is applied.

	Chemical and petrochemical						Refineries
		prod[31viii] 28.9 GJ/t-prod[33ix]					
India	~17.1 GJ/t-prod[27vii] 16.7 GJ/t-prod[32ix]	3400 kg CO_2 / t-prod[29i] ~37.5 GJ/t-prod[30vii] 43.3 GJ/t-prod[31viii] 19.5 GJ/t-prod[33ix]	10.9 GJ/t-prod[34ix]	0.6 GJ/t-prod[35ix]	13.6 GJ/t-prod[36ix]		EEI~2.5[28vii]
Other Asia		37.0 GJ/t-prod[31viii]					
Japan	12.6 GJ/t-prod[32ix]	1600 kg CO_2 / t-prod[26i] 14.3 GJ/t-prod[33ix]		1.9 GJ/t-prod[35ix]	10.6 GJ/t-prod[36ix]		
Thailand		2800 kg CO_2 / t-prod[29i]					
Indonesia		2850 kg CO_2 / t-prod[29i]					
South Korea	12.6 GJ/t-prod[32ix]	2850 kg CO_2 / t-prod[29i] 21.3 GJ/t-prod[33ix]		1.9 GJ/t-prod[35ix]	10.6 GJ/t-prod[36ix]		
EIT		~40.5 GJ/t-prod[30]					EEI~1.5[28vii]
CIS		39.9 GJ/t-prod[31viii]					
Russia		1500 kg CO_2 / t-prod[26i]					
Turkey							
Taiwan	16.7 GJ/t-prod[32ix]	16.3 GJ/t-prod[33ix]		2.9 GJ/t-prod[35ix]	13.7 GJ/t-prod[36ix]		

27 2006 data, indirect emissions included, author's estimate based on data from 2001, 2003 and 2005. In 2005 participation rate was 50% of the total global production.

28 2003 data graphically extracted, author's estimate based on the Solomon benchmark curve for 2000, which accounts for 70% of total final energy use in the global refinery sector.

29 No year indication, indirect emissions included. Bottom-up approach is applied using European plant data, but fuel mix for direct emissions is taken into account.

30 2007 data, indirect emissions included, author's estimate based on data from 2004-2009 reports.

	Chemical and petrochemical					Refineries
Middle East		36.0 GJ/t-prod[31viii]				
Saudi Arabia	18.3 GJ/t-prod[32ix]	16.7 GJ/t-prod[33ix]	16.7 GJ/t-prod[34ix]	2.9 GJ/t-prod[35ix]	11.6 GJ/t-prod[36ix]	
Africa		36.0 GJ/t-prod[31viii]				
South Africa		2800 kg CO_2 / t-prod[26i]				
MENA		~37.0 GJ/t-prod[30vii]				EEI~1.9[28vii]

31 2005 data, electricity consumption excluded.

32 2006 data, electricity and feedstock energy consumption excluded. Output product are high value chemicals (HVC).

33 2006 data, electricity and feedstock energy consumption excluded. Differences in process energy due to feedstock mix are accounted for.

34 2006 data. electricity and feedstock energy consumption excluded.

35 2006 data, energy values refer to one tonne of chlorine production, but cover the electrolysis of sodium chloride as a whole, i.e. including the concentration of sodium hydroxide to 50% concentration. Differences in process shares across countries are accounted for.

36 2006 data, electricity and feedstock energy consumption excluded. Differences in process types across countries are accounted for.

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Support to the Commission for the determination of the list of sector and subsectors deemed to be exposed to a significant risk of carbon leakage for the years 2015-2019 (EU Emission Trading System)

Methodology for taking into account the commitments of third countries

Task 5 final report

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The views expressed in this study represent only the views of the authors and not those of DG CLIMA or any other organization.

Content

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List of abbreviations

CITL	Community Independent Transaction Log
CO_2 Eq	Carbon dioxide equivalents
COMEXT	Statistical database on trade of goods by Eurostat
CPA	Classification of Products by Activity
EEA	European Economic Area
ETS	Emission trading system
EU ETS	The European Union’s emission trading system
GHG	Greenhouse gas
GVA	Gross value added
HS	Harmonized System; nomenclature for trade data
IS	Iceland
LI	Liechtenstein
NO	Norway
PRODCOM	Survey measuring sales of products by manufacturers (PRODucts of the European COMmunity) published by Eurostat
SBS	Structural Business Statistics
TWh	Terra Watt hours
UN COMTRADE	Commodity Trade Statistics Database by UN Statistics Division

Executive summary

The carbon leakage provisions included in the Emissions Trading Directive (Directive 2003/87/EC) aims to protect European producers from a competitive disadvantage compared to producers in countries without carbon constraints. Article 10a (18(1)) of the Emission Trading Directive (2003/87/EC) states that the carbon leakage list shall be determined after taking into account a) the extent to which third countries representing a decisive share of global production commit to reducing GHG emissions in the relevant sectors to an extent comparable to that of the EU and b) the extent to which carbon efficiency in these countries is comparable to the EU. In a first step, the quantitative assessment of sectors at risk of carbon leakage carried out in 2009 did not differentiate between countries with firm commitments to reducing GHG emissions and countries without. In this report different methodologies to take commitments of third countries into account are elaborated and assessed in terms of their suitability. The methodological discussion is framed around three groups of countries: a) countries that are fully integrated into the EU ETS, b) countries with comparable efforts with linked carbon markets, c) countries with comparable efforts but no linking.

Based on the assessment it is recommended to include the countries that are fully integrated into the EU ETS into the calculation of all components of the two carbon leakage indicators (induced carbon costs and trade intensity), thus pursuing the so-called **bubble approach**.

For countries that conduct comparable efforts, it is recommended to adjust the methodology for the induced carbon cost indicator only with respect to the carbon price. More specifically, in case of carbon market linking the resulting EU ETS carbon price would be taken for the calculation of the induced carbon cost indicator while in case carbon markets are not linked the EU ETS price would not be affected and the carbon price entering the induced carbon cost calculation would not be adjusted. Only in case induced carbon costs are explicitly known for countries with comparable efforts that are not linked to the EU ETS, the price differential may be considered to be taken as a proxy for additional induced carbon costs in the EU. With respect to the calculation of the trade intensity indicator, it is recommended to only include trade between the EU and those countries that do not commit to comparable efforts. In other words, trade flows with comparable effort countries need to be deducted from imports to and exports from the EU (**deduction approach**).

While the bubble approach is more data and resource intensive than the deduction approach, it allows to account for a complete integration of those EU ETS countries that are not EU Member States. These countries follow the same rules and regulations not only for the EU ETS but also for most economic legislation within the European Economic Area and, thus, face the same carbon price and the same trade regulations both for EUAs and general commodities. A change in any of these regulations will affect all these countries in the same way. This implies that the ability to pass through additional costs, its effect on competitiveness and the consecutive risk of carbon leakage is the same for a given sector within all of these countries.

Should it not be possible to overcome resource and data constraints a simplified approach would be to treat these integrated countries in the same way as any other country with comparable efforts.

1 Introduction

The main goal of the carbon leakage provisions included in the Emissions Trading Directive (Directive 2003/87/EC) is to protect European producers from a competitive disadvantage compared to producers in countries without carbon constraints. Article 10a (18(1)) of the Emission Trading Directive (2003/87/EC) states that the carbon leakage list shall be determined after taking into account a) the extent to which third countries representing a decisive share of global production commit to reducing GHG emissions in the relevant sectors to an extent comparable to that of the EU and b) the extent to which carbon efficiency in these countries is comparable to the EU.

In a first step, the quantitative assessment of sectors at risk of carbon leakage carried out in 2009 did not differentiate between countries with firm commitments to reducing GHG emissions and countries without. The European Commission's decision on the list of carbon lekage sectors[1] states that the criteria for taking into account third countries had no effect on the carbon leakage list as the countries that commit to comparable efforts together did not represent a deciscive share and as the data required for the assessment of carbon efficiency was not available.

Norway, Iceland and Liechtenstein joined the EU ETS in 2008 and have to comply with the same rules and regulations as the EU Member States.[2] Switzerland and Australia are planning to link their separate emission trading schemes to the EU ETS. The link with the Swiss scheme would operate on the basis of mutual recognition of emission allowances in line with a bilateral agreement which should come into effect in the second commitment period of the Kyoto Protocol.[3] Australia and the European Commission announced on August 2012 their agreement on a pathway towards fully linking Emissions Trading systems. It is planned to establish an interim link in July 2015 allowing Australian operators using EU allowances for compliance, the full link is envisaged to start in July 2018.[4] And even though the climate conference in Copenhagen fell short of the expectations, other countries have committed themselves to climate policies, too. For key countries the comparability of their efforts is assessed under Task 4 of this project.

1 Commission Decision of 24 December 2009 determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage C(2009) 1025.

2 The linkage of the EU emissions trading system with Iceland, Liechtenstein and Norway took place through the incorporation of the EU ETS Directive (Directive 2003/87/EC) into the European Economic Area agreement in 2007. For more information, see http://www.eftasurv.int/internal-market-affairs/areas-of-competence/environment/emission-trading/.

3 The revised Swiss CO_2 Act — a precondition for the linkage — will enter into force on 1.1.2013 (see http://www.bafu.admin.ch/emissionshandel/05538/05540/index.html?lang=en).

4 http://www.climatechange.gov.au/media/whats-new/linking-ets.aspx

Summarizing three groups of countries undertaking comparable efforts can be distinguished:

a) countries not belonging to the EU but being part of the EU ETS;
b) countries running separate trading schemes linked with the EU ETS; and
c) countries with comparable efforts but without linking.

It may be helpful to recall the mechanisms underlying the indicators of the carbon leakage assessment: Induced carbon costs may change market activity both domestically and internationally. While domestically an increase in costs and prices will lead to a change towards less carbon-intensive consumption, internationally an increase in costs may result in distortions of competitiveness and carbon leakage but only in so far as increased costs cannot be passed through to prices. This cost-pass through capacity is determined by international demand-price elasticities and depends on foreign competition and trade patterns with parties that are not subject to climate policies. The indicator of trade intensity aims to approximate this.

Climate action in third countries can have an impact on induced carbon costs in the EU and the ability to pass-through costs. It thus tackles all dimensions of the EU ETS carbon leakage assessment and the methodologies may need adjustment to account for the activities in third countries.

In this report different methodologies to take commitments of third countries into account are elaborated and assessed in terms of their suitability per country group identified above. The groups are defined in chapter 2. The methodological impacts for third country considerations are assessed in chapter 3, both for the induced carbon cost indicator (chapter 3.1) and the trade intensity indicator (chapter 3.2). Conclusions can be found in chapter 4.

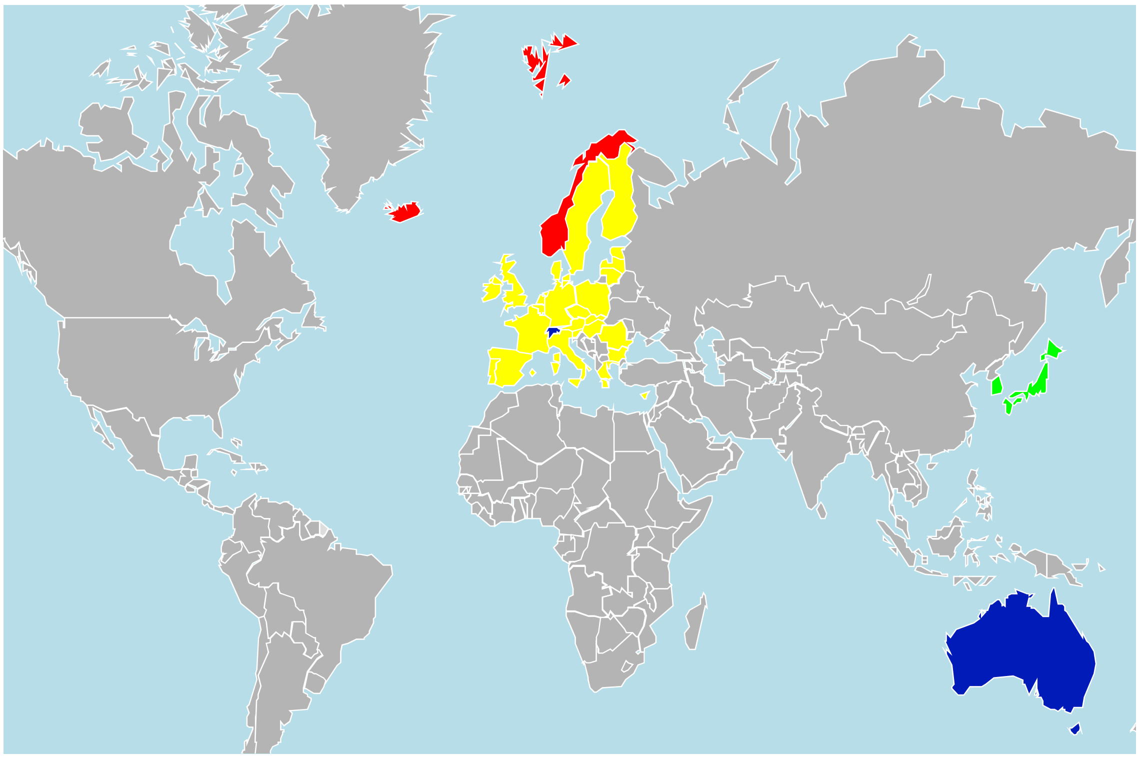
2 Country groups

As indicated above, three groups of countries undertaking comparable efforts can be distinguished:

1. countries not belonging to the EU but being part of the EU ETS;
2. countries running separate trading schemes linked with the EU ETS; and
3. countries with comparable efforts but without linkage.

In the following, we discuss these country groups in more detail, explaining the specific features of each group and providing examples for categorizing countries into these groups.

Figure 1 Overview of country groupings



Note: EU27 countries are coloured in yellow, other EU ETS countries in red. Linking countries are marked with dark blue and countries with comparable efforts with green.

Source: Figure by Öko-Institut

2.1 EU ETS countries

The group of EU ETS countries is considered to include all countries that participate in the EU ETS and thus follow the same rules and regulations. Currently, the EU ETS covers the present 27 EU Member States[5] plus three additional countries, Norway, Liechtenstein and Iceland. In addition to participating in the EU ETS, these three countries are part of the European Economic Area (EEA) which implies that they adopt all EU legislation to the single market except for legislation related to agriculture and fishery.

All EU ETS countries, therefore, face the same carbon price and the same trade regulations both for carbon prices and general commodities. A change in any of these regulations, e.g. leading to higher carbon price or different tariffs for trade of commodities, will thus affect all countries in the same way. This implies that the ability to pass through additional costs, its effect on competitiveness and the consecutive risk of carbon leakage is the same for a given sector within all of these countries.

Data availability may provide the reason to treat the non-EU countries that participate in the EU ETS differently from EU Member States. This is elaborated in more detail in the methodological sections below.

2.2 Countries with linking to the EU ETS

A second group of countries is considered to include those countries with comparable efforts that have an established emissions trading system, or are planning on establishing one, that is linked to the European Emissions Trading Scheme. Currently linking of the EU ETS is envisaged for Australia (which is also assessed more in-depths in Task 4) and Switzerland.

A full bilateral linking of trading schemes across countries and regions will result in a uniform carbon price, i.e. all participants face the same price signal. Restricted or unilateral trading (one-way trading, price limits, safety valves) may results in different carbon price in each market. However, the EU ETS carbon price will still change to account for the (restricted) linking of the markets.

While countries in this second group are closely linked to the EU in terms of carbon markets, they are considered to be independent in terms of rules and regulations on commodity markets. An exception is presented by Switzerland which is closely interlinked in economic agreements but differs with respect to their ETS. If countries are linked in terms of rules and regulations of trading on both carbon and commodity markets, they may be categorized under group 1.

Moreover, there might be cases, where sub-national bodies/regions are undertaking linking to the scheme (California). In principle, they can be categorized into this group,

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5 In addition, Croatia will join the EU ETS in 2013 and subsequently become a new EU Member State.

but data availability will be a high challenge and most probable only proxies could be used for calculation. This is particularly relevant for data on trade, as sub-national trade flows are usually not reported but summarized under national trade data. To illustrate, in the case of California, data would be needed on trade from California to other states within the US in addition to trade with countries outside the US. Such data is not available from international statistics and has not been retrieved from Californian statistical offices.

2.3 Countries with comparable efforts but no linking

Group 3 includes those countries that have been identified in Task 4 to undertake comparable efforts in terms of both GHG mitigation effort and GHG efficiency, but have no linking of carbon markets to the EU ETS. In particular, these were Japan and South Korea.

If both criteria in article 10a (18(1)) of the Emission Trading Directive are met, i.e. firm commitments of GHG mitigation and comparable greenhouse gas efficiencies, marginal abatement costs in these countries would be expected to be similar to those of EU producers. Thus, induced carbon costs would not differ and the ability to pass-through induced carbon costs should be assumed to be alike in these countries.

Data issues relating to this group are described in the following methodological section.

3 Methodological impacts for third country considerations

In this report, different methodologies to take commitments of third countries into account are elaborated and assessed. If third countries show comparable efforts and cover a decisive share of global production the risk of EU sectors to not be able to pass-through the induced carbon costs and resulting competitiveness distortions may be reduced, or might even be discarded in case all or almost all countries face the same situation (e.g. in case of a global carbon market or comparable efforts in the majority of partner countries).

Some distortions of competitiveness may still exist in relation to those countries that are not exposed to comparable efforts. In these cases, the risk of carbon leakage may remain - though to a limited extent - and adjustments to the methodology are needed for the assessment of induced carbon costs and trade intensity.

3.1 Impact on induced carbon cost

To assess the additional costs induced by the implementation of the EU ETS directive for a sector or subsector, the indicator of Induced Carbon Costs was developed. It is calculated based on the information on direct and indirect costs that result from carbon pricing as a proportion of gross value added. Methodological aspects of this calculation and data requirements for the indicator are elaborated in Task 1 of the current study[6].

$$InducedCarbonCost = \frac{DirectCosts + IndirectCosts}{GVA}$$

$$= \frac{(DirectEmissions - FreeAllocation + ElectricityConsumption * EF)}{GVA} * Carbonprice$$

where *EF* refers to the emissions factor.

Taking into account commitments of third countries, may require adjustments to the methodology approach and data collection. These will be elaborated in the following sections differentiated by the country groups as introduced above.

3.1.1 EU ETS countries

All EU ETS countries form a fully integrated emission trading market and follow the same regulations. In addition, the three countries that do not belong to the EU but take part in the EU ETS, i.e. Norway, Liechtenstein and Iceland, are part of the European Economic Area and thus experience the same competitiveness concerns with respect to third countries as the EU Member States. It, therefore, seems most reasonable from a methodological viewpoint to fully integrate the additional EU ETS markets into the

[6] The term “direct emissions minus free allocation” refers to the amount of emissions rights that needs to be purchased. It can also derived by applying the auctioning factor to direct emissions. However, the chosen illustration is considered to be more intuitive.

calculation of induced carbon costs. This implies adding the data on direct and indirect costs as well as on value added from the additional markets and recalculating the induced carbon cost. This approach may be considered a bubble approach where new markets become part of the EU ETS “bubble”. For any given sector, EU ETS induced carbon costs are calculated by the use of the following equation:

$$Induced\ CarbonCost = \frac{\sum_{i=country}(DirectEmiss_i - FreeAlloc_i + ElecCons_i * EF_{EUETS})}{\sum_{i=country} GVA_i} * Carbonprice_{EUETS}$$

$$= \frac{(DirectEmiss_{EUETS} - FreeAlloc_{EUETS} + ElecCons_{EUETS} * EF_{EUETS})}{GVA_{EUETS}} * Carbonprice_{EUETS}$$

where i = country, refers to individual EU ETS countries (i.e. EU plus NO, LI, IS). As before direct emissions (*DirectEmiss*) are measured in tonnes of CO_2 in a given sector for each of the EU ETS countries, free allocation (*FreeAlloc*) refers to the EUAs (equivalent to one of $CO_{2eq.}$) that are freely distributed in a given sector in each EU ETS country, electricity consumption (*ElecCons*) is measured in TWh for each country. The emissions factor (*EF*) in t CO_2/TWh is used to calculate indirectly induced costs related to electricity use and is applied uniformly across EU ETS countries and sectors. The carbon price refers to the uniform price of EUAs in €/t CO_2 and is multiplied with the sum of direct and indirect emissions of all countries for a given sector to derive the sum of direct and indirect costs for all EU ETS countries in a given sector. These total carbon costs are then put in proportion to the sum of GVA in this sector for all countries.

Data requirements and availability

The bubble approach requires additional information on data on direct emissions, free allocation, electricity consumption, GVA and impacts upon the emission factor and the carbon price.

Data for the additional markets on **direct emission** is most straightforward and can be collected from the CITL as for the EU27 markets. For those sectors where additional data sources are required the same approach can be followed as for the EU27 countries (compare discussion in Section 3.1 of the Task 1 report).

Data on **free allocation** will follow the same approach as in the Task 1 report.

Data on on **electricity consumption** to derive indirect emissions provides more of a challenge similar to the one for EU27 markets and may be collected via a questionnaire (compare Section 3.3.1 in the Task 1 report).

Data on **gross value added** for Norway (as well as Switzerland, Croatia and Turkey) can be collected from the the Structural Business Statistics which was used for the EU

ETS countries. Data for Iceland and Liechtenstein is not reported in the Structural Business Statistics, but can be collected from national statistical offices, however, not necessarily at the same level of disaggregation. It should be noted though that in scope of the 2nd trading period no stationary installations were covered in Iceland and the two installations in Liechtenstein are combustion installations and thus no data needed to be collected. In the 3rd trading period with the additional scope, this will change slightly e.g. when the Icelandic aluminium production will be covered.

Adjustments to **emissions factor for electricity** will need to take into account information on the power mix in the additional countries. In line with the recommended approach for deriving the electricity emissions factor (see Section 3.3.2 in the Task 1 report) country specific data on the average generation mix would need to be collected from individual sources. Data on electricity generation can be collected from Eurostat for Iceland, Norway, Switzerland, Croatia, the Former Yugoslav Republic of Macedonia, and Turkey.[7] Data on emissions from the electricity sector will then be used to derive the average emissions factor.

The **carbon price** assumption taken in the previous carbon leakage assessment was based on an analysis that did not take into account the additional markets that entered the EU ETS thereafter (Capros, 2008). In order to include the impact of these additional markets any of the methodologies described in Section 3.5 of Task 1 report can be applied as they are based on assessments including these countries.

Data requirements are quite substantial. Should data limitations restrict the application of this approach to an extent that it cannot be carried out, the additional markets can alternatively be treated as markets affecting the carbon price through trading but not affecting the other components underlying the calculation of induced carbon costs for the EU27, i.e. direct and indirect carbon costs in proportion to GVA. This approach, which is discussed in detail in the following section on linking countries, implies that market interactions are only considered with respect to the carbon price formation while the production and technology structure of the linked countries does not affect the induced carbon price calculation.

Given the fact that Iceland and Liechtenstein currently do not have industrial installations within the EU ETS, it may seem reasonable to apply the following simpler approach to including those countries. With the upcoming EU ETS scope extension, however, the picture will change slightly as at least Iceland’s aluminum production will enter the scheme.

7 Eurostat Statistics Supply, transformation, consumption - electricity - annual data [nrg_105a]

3.1.2 Linking countries

Countries with comparable emissions trading systems that are linked to the EU ETS but have no further market integration[8] affect induced carbon costs for EU ETS sectors only through an impact on the carbon price. When markets are linked a uniform carbon price will develop that may be lower or higher than the original EU ETS carbon price depending on the marginal cost of abatement in the linking countries. Low cost emission abatement options in the linking countries will lead to a lower price for emissions rights (EUAs) as marginal costs will be equalized. The carbon price projection used for the calculation of induced carbon costs should therefore reflect the nature of the additional abatement options available in the market. Moreover, the size of the additional markets plays a role. Linking with a market of very small size will not significantly affect the carbon price in the EU.

A distinction can be made whether the linking countries represent all partner countries and/or lead to a global carbon price scheme. If so, the uniform carbon price will lead to induced carbon costs that are similar in all countries and the ability to pass-through these additional costs to consumers without putting international competitiveness at stake will be alike in all countries. Therefore, no carbon leakage assessment is deemed necessary.

If linking countries do not cover such an extent, a risk of competitiveness distortion may remain and an adjustment to the carbon leakage assessment might be pursued.

The adjusted induced carbon costs equation for a given sector would be as follows

$$AdjustedInducedCarbonCosts$$
$$= \frac{(DirectEmiss_{EUETS} - FreeAlloc_{EUETS} + ElecCons_{EUETS} * EF_{EUETS})}{GVA_{EUETS}} * Carbonprice_{LinkedsSstem}$$

with *EU ETS* referring to all EU ETS countries as in the previous section and $Carbon\ Price_{LinkedSystem}$ referring to the uniform carbon price that will form via trading of emissions rights between the linking countries and the EU ETS countries.

Direct and indirect emissions intensity of the EU ETS sectors that also enter the calculation of induced carbon costs would not need to be adjusted in response to the linking of markets (rather it may change in the long term in response to the price signal). Competitiveness, and thus the risk of carbon leakage, is thus only reactive to the change carbon price.

To illustrate the latter point we can look at a specific example, e.g. Australia. If we included Australia also in the emissions intensity estimation (direct and indirect emissions and GVA) and this drove up induced carbon costs for a sector to a level that

[8] They experience different policy settings that affect competitiveness (e.g. tariffs, trade policies, environmental policies beyond the EU ETS etc.).

qualifies it as a carbon leakage sector (as could happen in the above proposed bubble approach), this would imply that it alters treatment of this sector in the EU ETS to prevent losses in competitiveness with no meaning for Australian sectors and their competitiveness. Unless there is extensive trading or a common economic market between the EU and Australia, it does not seem reasonable that emissions intensity of Australian production would impact treatment of EU ETS sectors on the other side of the globe.

The adjusted induced carbon costs provide an indicator for additional costs that firms may face and would want to pass-through to prices to remain competitive with firms in countries that do not undertake comparable efforts. The ability to pass-through costs may be approximated by the adjusted trade intensity (see section 3.2) and the combined indicators assess the risk of carbon leakage.

So far, we assumed that linking countries were able to trade emissions rights unlimitedly and bilaterally. However, we may see cases of restricted trading in terms of one-way trading, price limits or safety valves, etc. If these restrictions are binding, the EU carbon price will change to account for the (restricted) linking of the markets, but carbon prices in each market will still differ. The above methodology may then be adjusted to account for the price differential of the adjusted EU ETS price and the carbon price in the third market, or – in case separate markets link into the EU ETS – a weighted carbon price may be used. Weights could be deduced based on trading volumes or trade intensity with third markets or shares of global production.

3.1.3 Countries with comparable effort without linking

The dynamics with countries with comparable efforts but no linking of emissions markets are similar to the dynamics described in Section 3.1.2 with the important difference that the EU ETS carbon price remains unaffected as no linking of emissions trading with third countries takes place.

If some countries conduct comparable efforts in terms of GHG mitigation EU producers will face different settings in their trading countries. Those countries that undertake comparable efforts will face similar additional costs. However, as trading markets are not linked with the EU ETS no uniform carbon price will form and induced cost differentials are more likely to occur. In case, induced carbon costs are known for third countries with comparable efforts, the differential could be used as a proxy for the induced carbon cost indicator.

However, the main important issue is whether EU producers can pass-through induced carbon costs into international prices. For those countries that undertake comparable efforts, additional carbon costs will not differ from those for EU sectors. However, international market mechanisms may still put the ability to pass-through costs at stake and distortion of EU firms' competitiveness may result. The indicator of trade intensity will therefore be adjusted to assess this pattern. This is particularly relevant if trade intensity proved to be the decisive factor for a sector to be on the carbon leakage list. If, however, a sector is deemed to be at risk of carbon leakage solely due to the induced carbon cost indicator (>30%) and trade intensity is very low, it may need to be considered that a) countries with comparable efforts face similar carbon costs and b) international cost pass-through does not play a role (only domestic substitution processes matter). In this case, no risk of carbon leakage can be assigned and the indicator of induced carbon costs can be dropped.

Indirect trade patterns and indirect competition may restrain EU producers from doing so. Therefore, the risk of competitiveness distortion and possible carbon leakage is much better assessed via an adjustment of the indicator of trade intensity.

3.2 Impact on trade intensity

To assess the intensity of international competition a sector is facing and get an indication of the ability for a sector pass-through the induced carbon costs; the second criterion of the quantitative assessment is trade intensity. It measures the share imports and exports have compared to the domestic market. As long as all countries outside of the EU are treated as if no GHG reduction policies were in place, the formula according to the directive is as follows:

$$TradeIntensity = \frac{TradeVolume}{DomesticMarket} = \frac{Imports_{ExtraEU} + Exports_{ExtraEU}}{Production_{EU} + Imports_{ExtraEU}}$$

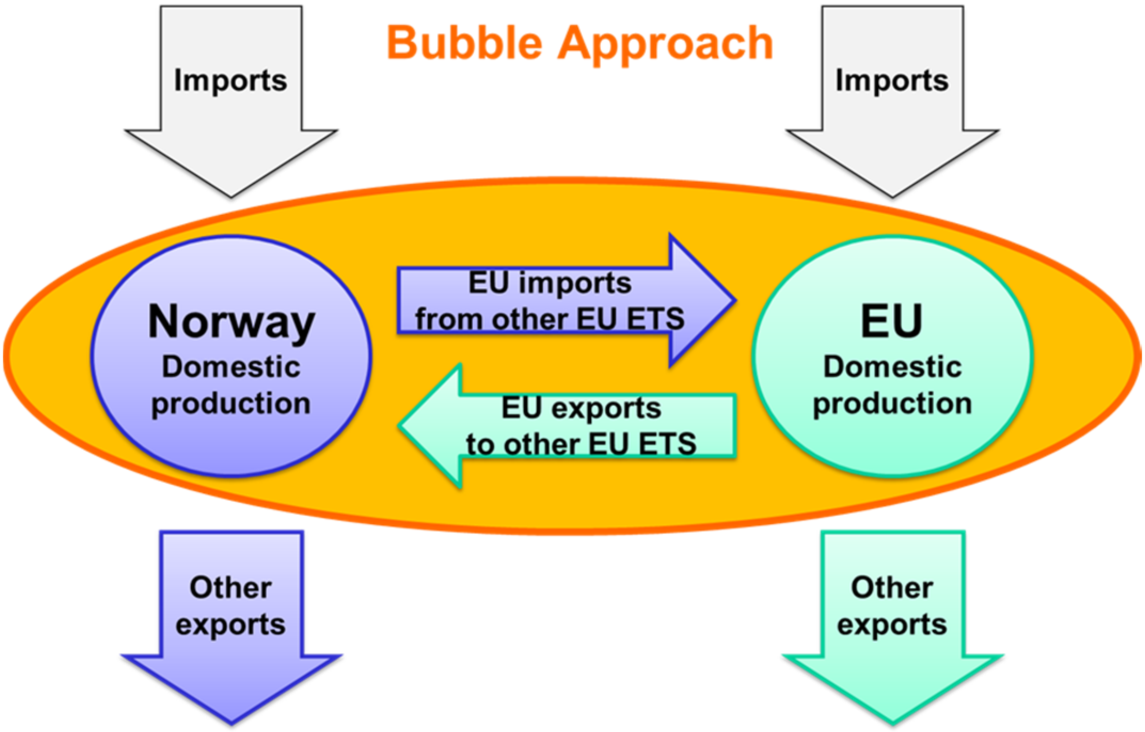
When other countries join the Emissions Trading Scheme, link their schemes to it or commit to other comparable efforts, there are several possibilities to adjust the formula to reflect the Trade Intensity for countries without comparable effort, only.

There are in principle two options to adjust the trade intensity indicator for countries with comparable efforts: either to exclude the trade volumes with those countries (Deduction Approach, section 3.2.2) when calculating the trade intensity or to include them into the calculation (Bubble Approach, section 3.2.1).

3.2.1 EU ETS countries

The three countries which joined the EU ETS to date (Norway, Iceland, and Liechtenstein) follow the same rules and regulations regarding emissions trading as any EU country and they form part of the European Economic Area. As their cases do not differ from the other EU countries; an option would be to treat them as any EU country when calculating trade intensity by including them into in a “bubble” together with EU countries (Bubble approach). This would mean that EU imports from and exports to these non-EU EU ETS countries would be treated as internal trade and both production data and trade from non-EU EU ETS countries to other countries outside the EU would be added to the calculation (see Figure 2).

Figure 2 *Graphic presentation of the Bubble Approach for Trade Intensity*



Source: Figure by Öko-Institut

The resulting formula would read as follows:

$$TradeIntensity = \frac{Imports_{ExtraBubble} + Exports_{ExtraBubble}}{Production_{Bubble} + Imports_{ExtraBubble}}$$

The $Imports_{ExtraBubble}$ would comprise imports to the EU ETS countries from countries outside the EU ETS ($Imports_{ExtraEU}$)[9] . The same pattern is followed when calculating $Exports_{ExtraBubble}$. Production data from EU27 and the other EU ETS countries is simply added up.

Data requirements and availability

For **EU trade data** the imports and exports to non-EU EU ETS countries need to be deducted from total EU27 imports/exports. This data is available at Eurostat COMEXT.

For **EFTA countries**[10] **trade data** is reported on the Eurostat homepage in national product classifications. As they are based on the Harmonized System (HS) nomenclature a conversion should pose no major problem. Alternatively the United Nations Sta-

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9 This implies that imports to the EU from non-EU EU ETS countries, i.e. from Norway, Liechtenstein and Iceland, need to be excluded but imports from third countries to these non-EU EU ETS countries need to be included.

10 Norway, Iceland, Liechtenstein and Switzerland

tistics Division - Commodity Trade Statistics Database (UN COMTRADE, http://comtrade.un.org) could be used.[11]

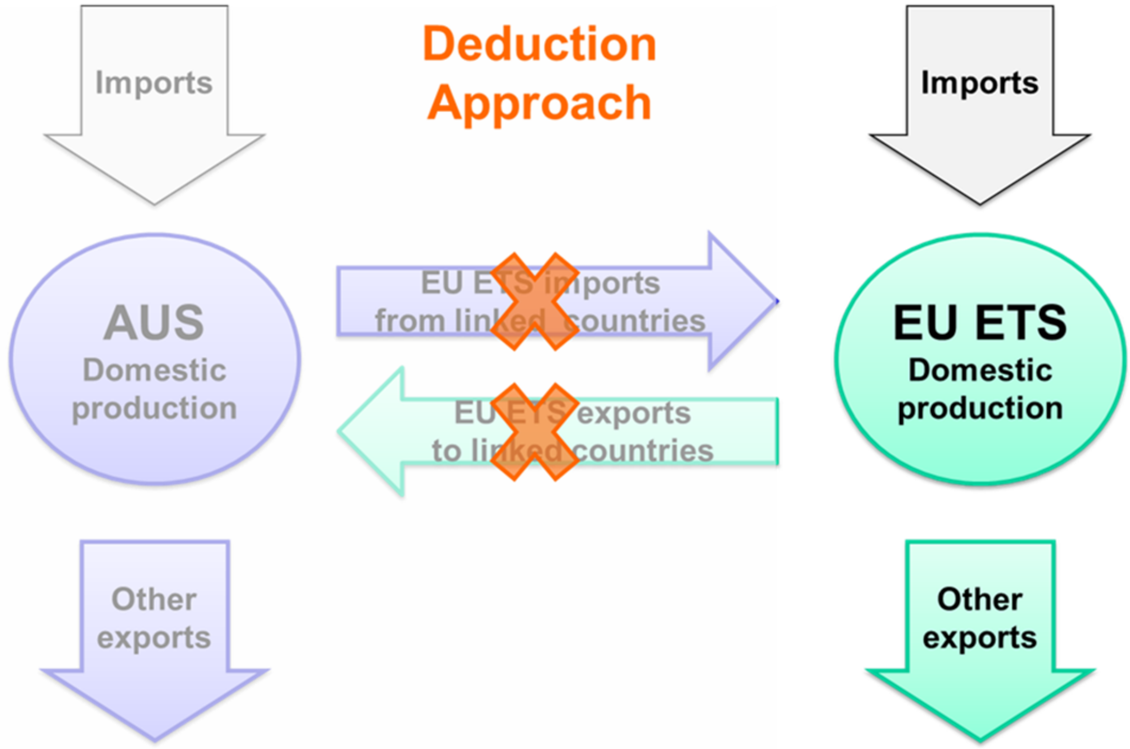
Furthermore **production data** that can be converted to NACE Rev. 2 is required for all EU ETS countries. Production data for Norway and Iceland (as well as Turkey and Croatia) is included in PRODCOM ANNUAL SOLD; the same data source has been used for EU countries. Where data was missing, the Structural Business Statistics were used, they also include data on Norway (as well as Switzerland, Croatia and Turkey). So for Norway and Iceland PRODCOM ANNUAL SOLD figures can be taken and – if occurring – Norwegian gaps can be filled by SBS data. No production data for Liechtenstein is available at Eurostat; the website of the statistical office of Liechtenstein is available at http://www.llv.li/amtsstellen/llv-as-home.htm. Production data is included in the national accounts (Volkswirtschaftliche Gesamtrechnung), but not disaggregated to industrial sectors. Probably the statistical office has background data allowing the attribution to industrial sectors; confidentiality concerns may impede their publication. Alternatively, if the data is not available, Liechtenstein could be treated in the same way as linking countries (deduction approach).

3.2.2 Linking countries and countries with comparable efforts

Countries that show comparable efforts in terms of mitigation efforts and link their trading schemes to the EU ETS face the same or similar competitiveness impacts in response to the mitigation effort as EU ETS countries. In order to account for this similarity and assess the trade pattern with those countries only that do not undertake comparable efforts (and thus potentially pose a competitiveness concern), the indicator of Trade Intensity can be adjusted by excluding trade with the linking/comparable efforts countries (deduction approach).

[11] Further information on UN COMTRADE and conversion tables are included in the final report and in the overview of data sources file provided to DG ENTR in the framework of the project: “SIM: Extension of Sustainable Industry Monitor” by AEA, Öko-Institut and Ecofys (AEA/Öko-Institut/Ecofys 2012; Öko-Institut 2012).

Figure 3 Graphic presentation of the Deduction Approach for Trade Intensity



Source: Figure by Öko-Institut

Whereas the relevant trade volume is reduced to trade with countries without comparable effort, the domestic market remains unchanged. Therefore the imports in the nominator are adapted while the imports in the denominator remain identical to the original analysis as they form part of the domestic market ($Production_{EUETS}$ + $ImportsExtra_{EUETS}$).

$$TradeIntensity = \frac{Imports_{CountriesWithoutComparableEfforts} + Exports_{CountriesWithoutComparableEfforts}}{Production_{EUETS} + Imports_{ExtraEUETS}}$$

From the total imports from countries outside of the EU ETS the imports from selected countries are deducted (see below). The same approach is used to calculate exports to countries without commitment.

$$Imports_{CountriesWithoutComparableEfforts} = Imports_{ExtraEUETS} - Imports_{Linking} - Imports_{Comparable\ Efforts}$$

Data requirements and availability

A major advantage of this approach is the data availability; a deduction of **trade data** with chosen partner countries is easily possible with Eurostat data in the COMEXT database (EU-Trade by CPA 2008).

Production data remains unchanged; so there is no need to tap additional data sources. Therefore the deduction approach could be used as a fallback option for non-EU EU ETS countries, too, where production data is not available.

3.2.3 Illustrative example: deduction approach

In order to illustrate the changes in trade intensity by applying the deduction approach an example calculation is carried out based on Eurostat data from COMEXT (downloaded in September 2012). The deduction approach is applied to account for efforts in different countries. In a first step, it is applied to deduct trade with the EFTA EU ETS countries (Norway, Liechtenstein and Iceland). It is then further extended to additionally account for mitigation efforts in Australia, in Switzerland, in both Australia and Switzerland, and finally also in Japan and South Korea. The assessment was carried out for 229 NACE sectors at 4-digit level. For 10 sectors no trade data was available[12] and for four sectors no production data was published[13].

In Table 1 the sectors are shown, for which the application of the deduction approach would lead to trade intensities below the two thresholds of 30% and 10%. For the EFTA EU ETS countries (NO, IS, LI) it can be seen that four sectors which qualify as carbon leakage sectors through trade intensity alone in the reference approach (no deduction), would no longer meet the threshold of 30% in the deduction approach (0811 Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate; 2015 Manufacture of fertilisers and nitrogen compounds; 2442 Aluminium production and; 2530 Manufacture of steam generators, except central heating hot water boilers). Another three sectors that would surpass the 10% threshold in the reference case would no longer meet the threshold (1092 Manufacture of prepared pet foods; 2511 Manufacture of metal structures and parts of structures; and 3103 Manufacture of mattresses).

If, additionally, the deduction approach is extended to Australia the manufacture of builders ware of plastic (NACE 2223) would drop slightly below the 10% mark. Applying the deduction approach to Switzerland instead of Australia another seven sectors would no longer meet the 30% threshold and three more sectors the 10% line. If both Australia and Switzerland would undertake comparable efforts in addition to the countries fully integrated into the EU ETS scheme, in total 13 sectors would no longer meet the 30% threshold and 6 sectors would no longer meet the 10% threshold (in particular, the manufacture of wine from grapes and striking of coins would no longer quality for

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[12] These are: 1330 Finishing of textiles; 1811 Printing of newspapers; 1812 Other printing; 1814 Binding and related services; 1820 Reproduction of recorded media; 2453 Casting of light metals; 2454 Casting of other non-ferrous metals; 2550 Forging, pressing, stamping and roll-forming of metal; powder metallurgy; 2561 Treatment and coating of metals; and 2562 Machining.

[13] These are: 0721 Mining of uranium and thorium ores; 1920 Manufacture of refined petroleum products; 2446 Processing of nuclear fuel; and 3040 Manufacture of military fighting vehicles.

the carbon leakage list through trade intensity alone in addition to the changes that were seen by applying the methodology to EFTA and Australia).

Further accounting for efforts in Japan and South Korea and applying the deduction approach, another 10 sectors would pass a threshold line compared to the reference case. For the group of all seven countries (NO, IS, LI, AU, CH, JP, KR), this implies that 30 sectors would not meet a threshold they would have met in the reference case: 10 sectors would fall below the 10% threshold and thus no longer qualify to be at risk of carbon leakage unless the induced carbon cost indicator surpasses 30%. Another 20 sectors would fall below the 30% threshold. Whether they would still qualify for the carbon leakage list or not would then depend on the criterion of induced carbon costs.

Table 1 Changes in trade intensity passing thresholds following the deduction approach for country groups

NACE-sector (rev.2)		Refe-rence	NO, IS, LI	NO, IS, LI, AU	NO, IS, LI, CH	NO, IS, LI, AU, CH	NO, IS, LI, AU, CH, JP, KR
0811	Quarrying of ornamental and building stone, lime	30.1%	28.8%	28.7%	28.0%	27.9%	27.7%
2015	Manufacture of fertilisers and nitrogen compound	30.0%	28.6%	28.4%	28.2%	28.0%	27.9%
2442	Aluminium production	36.9%	27.4%	27.1%	24.2%	23.9%	23.1%
2530	Manufacture of steam generators, except central	30.1%	29.6%	29.5%	29.1%	29.0%	25.1%
1393	Manufacture of carpets and rugs	33.7%	32.6%	32.1%	29.5%	29.0%	28.4%
1622	Manufacture of assembled parquet floors	37.8%	32.6%	32.5%	25.9%	25.8%	25.5%
2219	Manufacture of other rubber products	32.4%	31.6%	31.2%	29.9%	29.5%	27.1%
2370	Cutting, shaping and finishing of stone	31.6%	31.4%	31.1%	29.4%	29.1%	28.8%
2431	Cold drawing of bars	35.8%	35.0%	34.6%	29.5%	29.1%	28.0%
2752	Manufacture of non-electric domestic appliances	33.7%	32.1%	31.1%	29.6%	28.6%	27.8%
3109	Manufacture of other furniture	34.1%	32.7%	32.5%	29.3%	29.1%	28.6%
1102	Manufacture of wine from grape	35.9%	35.0%	32.4%	32.0%	29.3%	27.0%
3211	Striking of coins	37.4%	36.5%	30.2%	33.2%	26.8%	26.7%
2016	Manufacture of plastics in primary forms	34.7%	33.9%	33.7%	31.3%	31.1%	28.2%
2331	Manufacture of ceramic tiles and flags	32.9%	32.4%	31.9%	30.7%	30.2%	29.5%
2732	Manufacture of other electronic and electric wire	35.6%	33.9%	33.7%	31.1%	30.9%	29.7%
2830	Manufacture of agricultural and forestry machiner	36.0%	34.1%	33.0%	32.5%	31.3%	28.9%
2910	Manufacture of motor vehicles	33.8%	32.8%	31.9%	30.9%	30.1%	25.2%
2931	Manufacture of electrical and electronic equipme	31.1%	30.8%	30.6%	30.3%	30.1%	26.0%
3091	Manufacture of motorcycles	50.2%	49.9%	48.4%	47.9%	46.5%	28.4%
1092	Manufacture of prepared pet foods	10.4%	8.4%	8.3%	7.1%	6.9%	6.0%
2511	Manufacture of metal structures and parts of stru	10.5%	9.6%	9.5%	8.2%	8.1%	7.8%
3103	Manufacture of mattresses	10.1%	8.3%	8.1%	5.9%	5.7%	5.3%
2223	Manufacture of builders' ware of plastic	10.9%	10.2%	9.9%	8.5%	8.2%	7.9%
1042	Manufacture of margarine and similar edible fats	11.1%	10.6%	10.5%	9.8%	9.7%	9.4%
2432	Cold rolling of narrow strip	11.0%	10.6%	10.6%	9.1%	9.0%	7.8%
3101	Manufacture of office and shop furniture	12.8%	11.3%	11.1%	9.5%	9.3%	9.1%
1073	Manufacture of macaroni, noodles, couscous and	13.1%	12.7%	12.3%	11.8%	11.3%	9.3%
1084	Manufacture of condiments and seasonings	13.4%	12.5%	12.2%	10.8%	10.5%	9.9%
2592	Manufacture of light metal packaging	12.8%	12.3%	12.2%	10.3%	10.2%	9.9%

Note: Colour codes reflect thresholds. Trade Intensity over 30% are shown in red; 10% to 30% in blue; and under 10% in green.

Source: Eurostat COMEXT, calculation by Öko-Institut

The closer the trade relations with a certain country, the higher will be the impact when deducting trade with this particular country. If China alone was subject to the deduction approach, a total of 28 sectors would no longer meet a threshold line while if the US was the only country to be deducted, this would be the case for 17 sectors.

4 Summary and Conclusions

This report elaborates and assesses the methodologies of the carbon leakage indicator, induced carbon costs taking and trade intensity, taking into account commitments of third countries. The methodological discussion is framed around three groups of countries: a) countries that are fully integrated into the EU ETS, b) countries with comparable efforts with linked carbon markets, c) countries with comparable efforts but no linking. The following paragraphs summarize the main insights for each country group separately by indicator.

Induced carbon costs indicator

For countries of the first group that are fully integrated in terms of the rules and regulations of the EU ETS and of economic activity, it seems most reasonable to adjust all individual components of the induced cost indicator to account for the joint GHG efficiency of production (direct and indirect emissions in proportion to GVA) and the uniform carbon price on the market (bubble approach). Pursuing this approach, however, comes along with quite substantial data requirements. Data availability and quality for Norway has been identified to be similar to the EU countries while data for Liechtenstein and Iceland provide more of a challenge. Given that the latter two countries account for a very small share of emissions from stationary installations in a very limited number of sectors within the EU ETS, the data challenge reduces to those sectors (probably only aluminium).

For countries of the second group which imply linking on the emissions market but no further integration of commodity trading, it is proposed to only adjust the carbon price that enters the induced carbon cost indicator for the EU. Linking the EU ETS with carbon markets in other countries will lead to a change in the carbon price that EU firms face and will alter their induced carbon costs. It is thus recommended to use the uniform price for emissions rights that results from linking the markets. Should linking be restricted and prices remain different in the linked market, the resulting price on the EU market can be used for the calculation of the indicator. However, whether EU ETS countries can actually pass-through their additional costs to prices of internationally traded commodities so that competitiveness is not distorted and no risk of carbon leakage prevails is much better assessed via an adjustment of the trade intensity indicator (see below).

For countries of the third group, i.e. countries with comparable efforts but without linking of carbon markets, no further adjustment to the methodology of the induced carbon cost indicator in addition to the ones for the first and second group are recommended. If countries show comparable efforts in terms of GHG mitigation and GHG efficiencies their marginal abatement costs can be expected to be similar to those of the EU ETS. As in the case of the second group; the risk of carbon leakage is much better represented by an adjustment of the trade intensity indicator.

An overview of adjustments to the components of the induced carbon costs indicator that would be needed to account for third country efforts is provided in Table 2. As constraints with respect to data availability and/or required resources may occur, a simplified approach is included that can be applied uniformly to all countries with comparable efforts. For this simplified uniform approach, adjustments would be restricted to the EU ETS price which results from linking of markets while leaving all other components unchanged. It should be noted, however, that this simplification which only addresses integrated EU ETS countries precludes taking account of their emissions intensity and emissions factor, thus leaving out valuable information in the European Market.

Table 2 Overview of adjustments to the induced carbon cost indicator reflecting country groupings

	Induced carbon cost	
	Direct Emissions, Electricity consumption & emission factor, GVA	**Carbon Price**
Group 1: Integrated markets (EU ETS)	EU ETS countries	EU ETS price
Group 2: Linking countries (e.g. Australia)	No further adjustment	Adjusted EU ETS price (resulting from linked markets)
Group 3: Comparable efforts without linking	No further adjustment	No further adjustment
Simplified uniform approach	No adjustment	Adjusted EU ETS price (resulting from linked markets)

Source: Table by Öko-Institut

Trade Intensity Indicator

Countries that are fully integrated in the EU ETS can be treated in the same way as EU Member States countries in the determination of the carbon intensity by adding their domestic production to the domestic market and adjusting trade data to reflect trade of EU ETS countries with the rest of the world (bubble approach). The trade data needed to operationalize the calculation is readily available. Production data is available for both Norway and Iceland at the same source as for the EU27 countries, but not for Liechtenstein. If no production data would be available at the necessary level of disaggregation, Liechtenstein could be treated as countries with comparable effort and linked carbon markets.

Comparable efforts of countries outside of the EU, with or without linked carbon markets, can be reflected by reducing the trade volume accordingly while keeping the value of the domestic market unchanged (deduction approach). The trade volumes then covers the trade with countries without comparable efforts only; the required data is available at Eurostat.

An overview of adjustments to the components of the trade intensity indicator that would be needed to account for third country efforts is provided in Table 3. As constraints with respect to data availability and/or required resources may occur, a simplified approach is included that can be applied uniformly to all countries with comparable efforts. For this simplified uniform approach, adjustments would be restricted to accounting for trade flows between EU MS and countries with comparable efforts. It should be noted, however, that this simplification which excludes information on economically linked markets (such as the EU ETS market) compromises on the level of information detail that can be derived from the analysis.

Table 3 Overview of adjustments to the trade intensity indicator reflecting country groupings

<table>
<tr><th rowspan="2"></th><th colspan="2">Trade Intensity</th></tr>
<tr><th>Trade volume (imports + exports)</th><th>Domestic market (production + imports)</th></tr>
<tr><td>Group 1:
Integrated markets (EU ETS)</td><td>Trade from third countries to EU ETS</td><td rowspan="3">Production: Sum of EU ETS countries;

Imports: from third countries to EU ETS countries.</td></tr>
<tr><td>Group 2:
Linking countries (e.g. Australia)</td><td>Trade from unlinked countries to EU ETS countries</td></tr>
<tr><td>Group 3:
Comparable efforts without linking</td><td>Imports from countries without comparable effort to EU ETS countries</td></tr>
<tr><td>Simplified uniform approach</td><td>Imports from countries without comparable effort to EU MS</td><td>Production: Sum of EU MS;
Imports: from third countries to EU MS.</td></tr>
</table>

Conclusions and recommendations

Based on the analysis and discussion in this report, a number of conclusions and recommendations can be drawn. In order to account for efforts in third countries, the methodological adjustment of the carbon leakage indicators would be recommended as follows.

- EU ETS countries which are not part of the EU (NO, LI; IS) are most appropriately be included into the calculation (**bubble approach**) of all components for both indicators, induced carbon cost and trade intensity. This requires additional data which is partly available at Eurostat and would need to be completed by national sources.
- For countries with comparable efforts and linked carbon markets (but no full integration in the EU ETS), the **deduction approach** for the trade intensity indicator seems most appropriate. This ensures that the trade intensity reflects trade with countries without comparable efforts only. The effect on the induced carbon cost indicator is best reflected by using the **adjusted carbon price** in the EU ETS market that results from linking the carbon markets. When markets are linked with unlimited trade, carbon prices will tend to converge. If trade is limited by certain provisions, then prices will assimilate.
- Countries with comparable efforts but no linking can be treated similarly to linking countries. This implies using the **deduction approach** for the trade intensity indicator (i.e. deducing trade flows from or to countries with comparable efforts). For the induced carbon cost indicator **no further carbon price adjustment** would be taken. As these countries conduct comparable efforts and have comparable GHG efficiencies, induced carbon costs to their industries are expected to be of a comparable magnitude. However, as trading markets are not linked with the EU ETS no uniform carbon price will form and cost differentials may occur. In case, induced carbon costs are known for third countries with comparable efforts, the differential could be used as a proxy for the induced carbon cost indicator.

Table 4 summarizes the recommended approaches for the two indicators in order to account for efforts in third countries. Data requirements are most stringent for the bubble approach recommended for the integrated EU ETS countries, at the same time data availability and quality can be considered highest for these countries.

Alternatively, a simplified approach could be pursued which treats integrated markets in the same way as any other country with comparable efforts. Such a simplified approach would only require a) adjustments to the carbon price in the induced carbon costs indicator while leaving the other components unchanged and b) deducting trade flows with comparable effort countries.

Such a simplified approach, however, would compromise on the level of accuracy and information gained from the analysis. In particular, it would imply treating non-EU countries that participate in the EU ETS differently from EU Member States. As these countries follow the same rules and regulations for the EU ETS and for most economic legislation within the European Economic Area they face the same carbon price and the same trade regulations both for EUAs and general commodities. A change in any of these regulations will affect a sector's ability to pass through additional costs, its effect on competitiveness and the consecutive risk of carbon leakage in the same way for all these countries.

Table 4 Overview of changes to reflect country groupings when assessing induced carbon costs and trade intensity

		Induced carbon cost	**Trade Intensity**
3-step approach			
Step 1	**Group 1** **Integrated markets (EU ETS)**	Bubble approach	Bubble approach
Step 2	**Group 2** **Linking countries (e.g. Australia)**	Adjusted carbon price	Deduction approach
Step 3	**Group 3** **Comparable efforts without linking**	No further adjust-ment	Deduction approach
Alternative 1-step uniform approach	**All countries with comparable efforts**	Adjusted carbon price	Deduction approach

Note: Bubble approach means that all EU ETS countries are fully integrated in terms of data and analysis for all components. Deduction approach implies that trade to and from the specified country (group) would be deducted from EU trade flows with third countries.

Source: Table by Öko-Institut

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Support to the Commission for the determination of the list of sectors and subsectors deemed to be exposed to a significant risk of carbon leakage for the years 2015-2019 (EU Emission Trading System)

Literature Review

Task 6 final report

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Executive Summary

'The EU Emissions Trading System (EU ETS) is a cornerstone of the European Union's policy to combat climate change and its key tool for reducing industrial greenhouse gas emissions cost-effectively' (DG CLIMA, 2012). The unilateral policy has provoked considerable debate about the existence of carbon leakage, which in theory undermines the environmental integrity of the EU ETS. It has been argued that the EU ETS reduces the competitiveness of European firms (i.e. by imposing carbon costs) prompting the relocation of production and emissions outside of the region. However, alternatively it has been suggested that the EU ETS encourages firms to become more energy efficient and promotes innovation allowing European firms to have a competitive advantage in the future for the deployment of low-carbon technologies. The aim of the literature review is to provide more clarity on the evidence base for carbon leakage as a consequence of the EU ETS.

Carbon leakage is commonly defined as a leakage rate, which is calculated as the increase in foreign emissions divided by the decrease in domestic emissions due to a unilateral climate policy. For example, a carbon leakage rate of 50% would imply that half of the domestic mitigation effort has been offset by increased emissions abroad. It is important to acknowledge that carbon leakage can occur via several channels (Reinaud, 2008):

- **Short term competitiveness channel**: 'Where carbon constrained industrial products lose international market shares to the benefit of unconstrained competitors'.
- **Investment channel**: 'Where differences in returns on capital associated with unilateral mitigation action provide incentives for firms to relocate capital to countries with less stringent climate policies'.
- **Fossil fuel price channel**: 'Where reduction in global energy prices due to reduced energy demand in climate constrained countries triggers higher energy demand and CO_2 emissions elsewhere, all things being equal'.

The identification of sectors that are at risk of carbon leakage via these different channels is essential for designing policies to counter any unforeseen negative consequences of unilateral policy making. The European Commission applied trade intensity (i.e. the sum of imports and exports divided by the sum of production and imports) and carbon cost (i.e. the sum of direct and indirect carbon costs divided by Gross Value Added) indicators of carbon leakage (primarily via the short term competitiveness and investment channels) to determine a list of sectors that would be deemed to be at risk of carbon leakage and are eligible for the allocation of free allowances to protect vulnerable sectors. However, the list of sectors has been criticised for being too long (i.e. 77% of the covered ETS emissions from manufacturing are classified as being at risk of carbon leakage) due to the lenient thresholds applied in the assessment.

Alternatively cost pass though rates (i.e. the ability of a firm to pass through additional carbon costs from unilateral policies) can be calculated as a measure of potential risk to CO_2 pricing. The ability of a firm to pass through costs depends on the structure of the market, supply and demand elasticities and exposure to international trade. Although there is not yet a consensus within the literature, Oberndorfer et al. (2010) shows that with the exception of ceramic goods, the remainder of the products assessed are unable to completely pass through their costs into output prices. For firms that are unable to completely pass through their costs into output prices, the EU ETS may reduce their competitiveness and therefore it is necessary to assess potential rates of carbon leakage.

Carbon leakage rates have been calculated within the literature for several sectors that are expected to be at significant risk of carbon leakage (i.e. iron and steel, cement and aluminium) via ex ante modelling approaches (i.e. top down and bottom up models). Depending upon the modelling approach, the studies within the literature tend to focus on particular channels of carbon leakage. Carbon leakage rates range considerably in the literature from 2% to 73% for sectors covered by the EU ETS and primarily focus on the short run competitiveness and investment channels of leakage. The lower rates of leakage within this range tend to assume a relatively low carbon price and preventative measures such as free allocation or border tax adjustments while the more extreme carbon leakage rates assume a relatively high carbon price and no preventative measures. However, the underlying assumptions of the modelling approach (i.e. energy and trade elasticities) are of even greater importance in determining the rate of carbon leakage. It is evident that comparison between studies is problematic due to the lack of transparency in modelling approaches and this currently prevents the literature from providing a more definitive answer on the question of carbon leakage.

Interestingly, the results of ex-ante modelling are not validated in the most recent empirical ex-post studies, which generally fail to identify large negative impacts on the competitiveness of firms participating in the EU ETS. However the evidence base may currently still be subject to bias due to lack of consistent time series data on costs, prices and sector characteristics. Ex-post approaches will improve as the time-series increase over time and will provide more insights into the extent of the problem of carbon leakage in the future.

1 Introduction to the issue of carbon leakage

Following the outcome of the negotiations at the United Nations Climate Conference 2011 in Durban (COP 17), the prospect of an international agreement on climate change appears to be delayed until after 2020 at the earliest. As a consequence it is expected that a world of unequal carbon pricing will continue to exist for the foreseeable future with regions proceeding with unilateral policies to domestically or regionally reduce their greenhouse gas (GHG) emissions. However, such unilateral action (i.e. the EU ETS) may have unintended impacts on the economic competitiveness of the region and may undermine the environmental integrity of the unilateral policy itself by increasing GHG emissions outside of the regulated region (i.e. carbon leakage). The Pollution Haven Hypothesis is often cited by opponents of unilateral policies to reduce domestic GHG emissions claiming that firms experiencing added costs from environmental legislation will eventually relocate to an unregulated region in order to improve their profitability. In reality such a hypothesis may be too simplistic with other factors such as currency exchange rates, availability of skilled labour, fossil fuel prices and the ability of firms to pass through the additional carbon costs into product prices influencing the extent of carbon leakage.

Given the potential for adverse economic and environmental effects from unilateral environmental policies, various attempts have been made in the literature to assess the actual risk of carbon leakage, differentiated by sector, based upon metrics such as trade intensity and value at stake (COM 2009). Beyond this sector by sector analysis, econometric techniques have been applied in the literature to ascertain the pass through rates of additional carbon costs into product prices to determine which firms are especially at risk of carbon leakage. The literature reveals that certain sectors have passed through the opportunity cost of emission allowances in the EU ETS to actually receive windfall profits, which demonstrates that some firms have clearly benefited from the learning phase of the scheme (Sandbag, 2011). Furthermore, the concept of ‘technological spill-over’ may reduce the risk of carbon leakage as third countries implement the use of clean technologies (Kuik and Gerlagh, 2007)

In addition to identifying sectors at risk to unilateral action, the literature includes numerous attempts to quantify the extent of carbon leakage based upon either ex-post empirical analyses of changes in trading patterns and investment decision data (Reinaud, 2008) or ex-ante modelling exercises to assess the rate of carbon leakage which can be mainly categorised according to whether a general economic or a partial economic modelling approach is applied. However, a direct comparison of carbon leakage rates calculated in the literature is complicated by the fact that the models used are underpinned by a divergent range of methodologies and assumptions (i.e. marginal abatement cost curve, trade elasticities, existence of third country policies etc.) and different policy scenarios (i.e. environmental target, carbon price projection, coverage of countries and sectors, implementation of protectionist measures etc.).

The aim of the literature review is to provide further clarity to the debate by defining both the principle of carbon leakage and the various channels by which carbon leakage can occur (i.e. short term competitiveness, investment and fossil fuel channels). The risk of carbon leakage will be subsequently discussed reviewing attempts in the literature to identify sectors that may be especially exposed to carbon leakage and quantify the respective (potential) carbon leakage effects. Finally the literature review will attempt to compare, where appropriate, the estimation of carbon leakage rates in the literature by categorising studies that apply similar modelling approaches and assumptions and further outlining where gaps in the literature exist.

1.1 Definition of carbon leakage

Carbon leakage can be defined as a leakage rate, which is calculated as the increase in foreign emissions divided by the decrease in domestic emissions due to the climate policy considered. The term indicates the share of emission reductions that are 'lost' as a consequence of carbon leakage. There are several channels of sector-led carbon leakage initiated by uneven carbon constraints, the three most important include (Reinaud, 2008):

- **Short term competitiveness channel**: 'Where carbon constrained industrial products lose international market shares to the benefit of unconstrained competitors'.
- **Investment channel**: 'Where differences in returns on capital associated with unilateral mitigation action provide incentives for firms to relocate capital to countries with less stringent climate policies'.
- **Fossil fuel price channel**: 'Where reduction in global energy prices due to reduced energy demand in climate constrained countries triggers higher energy demand and CO_2 emissions elsewhere, all things being equal'.

Carbon leakage via any of these three channels[1] may be associated with a detrimental impact on the competitiveness of firms covered by the unilateral policy and may undermine its environmental integrity. However, the impact on international competitiveness and the risk and extent of carbon leakage is not uniform and may further depend upon other factors, such as trade regulations, transport costs, quality of the product, market position (monopoly, oligopoly), company structure (multinational vs. national firm), employment policy and costs. In light of these factors, producers may well be able to pass through their climate policy induced costs without losing a significant market share. The fossil fuel price channel is independent of competitiveness or location concerns and only has an environmental effect.

[1] Varma et al (2012) also distinguishes between three channels of leakage (i.e. investment leakage, trade leakage and energy price leakage).

1.2 Risk of carbon leakage

The identification of sectors that are at risk of carbon leakage is essential for designing policies to counter any unforeseen negative consequences of unilateral policy making. The risk of carbon leakage can be assessed in a variety of ways and the different quantitative and qualitative metrics applied by the European Commission will be discussed in the following sections.

1.2.1 Trade intensity and carbon cost

In the context of the EU ETS, the European Commission compiled a carbon leakage list to define which sectors would be eligible for the allocation of free allowances to protect vulnerable firms in the third phase of the scheme (COM, 2009a) based upon the trade intensity (i.e. the sum of imports and exports divided by the sum of production and imports) and carbon cost (i.e. the sum of direct and indirect carbon costs divided by Gross Value Added) indicators. According to Article 10a of the revised EU ETS Directive (2009/29/EC) a sector or sub-sector is deemed to be exposed to a significant risk of carbon leakage if:

- ‘the sum of direct and indirect additional costs induced by the implementation of this Directive would lead to a substantial increase of production costs, calculated as a proportion of the gross value added, of at least 5 % and
- the intensity of trade with third countries, defined as the ration between the total value of exports to third countries plus the value of imports from third countries and the total market size for the Community (annual turnover plus total imports from third countries), is above 10%’ (COM, 2009a).

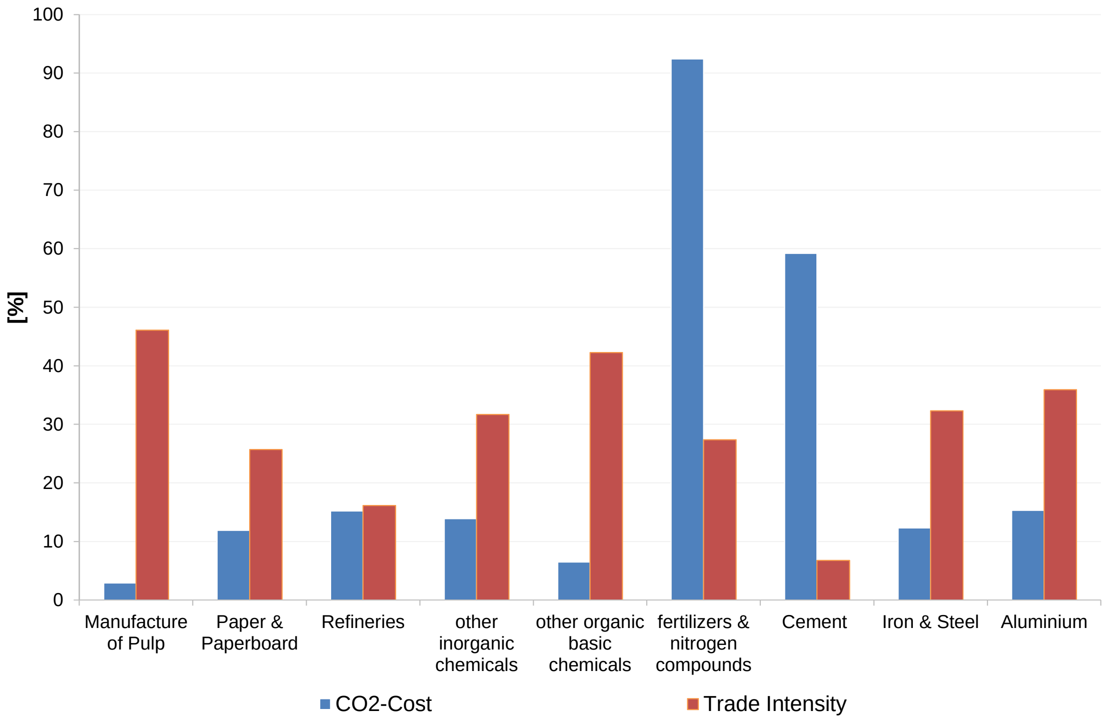
A sector or sub-sector is also deemed to be exposed to a significant risk of carbon leakage if:

- ‘the sum of direct and indirect additional costs induced by the implementation of this Directive would lead to a particularly high increase of production cost, calculated as a proportion of the Gross Value Added, of at least 30%; or
- the intensity of trade with third countries, defined as the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size for the Community (annual turnover plus total imports from third countries), is above 30%’ (COM, 2009a).

These criteria were applied at the sector level to assess the risk of carbon leakage (primarily for the short run competitiveness and investment channels) for European industry with the outcome of the assessment adopted by the European Commission in December 2009 (Figure 1). Based upon the trade intensity and carbon cost indicators used in the carbon leakage assessment, 77% of the covered ETS emissions from manufacturing are classified as being at ‘risk of carbon leakage’ (Carbon Trust, 2010). The aluminium sector, for example, is included within the carbon leakage list because the assessment calculated a trade intensity of 36% and a CO_2 cost as a proportion of GVA of 15% which both exceeded the threshold criteria. Although the aluminium sector is trade intensive; the carbon cost associated with aluminium production is considerably lower than the carbon costs associated with other sectors such as the production of fertilizers (>90%) or cement (>55%) reflecting the different circumstances of sectors on the carbon leakage list.

The quantitative assessment conducted by the European Commission (COM, 2009b) provides important insights into the vulnerability of industries in Europe to unilateral action to reduce GHG emissions. However, the list of sectors 'deemed to be at risk of carbon leakage' is often considered too extensive within the literature and Jürgens et al (2012) believes it is unclear whether the objective of the carbon leakage provisions is to minimise Type I errors (i.e. rejecting the addition of a sector to the carbon leakage list, when it should be accepted) or Type II errors (i.e. approving the addition of a sector onto the carbon leakage list, when it should be rejected). Jürgens et al (2012) emphasises that only Type I errors result in carbon leakage whereas Type II errors result in the over-compensation to sectors that are not at risk of carbon leakage. According to Droege and Cooper (2010), the list of sectors at risk of carbon leakage may include too many Type II errors and suggest that an inadequate choice or indicators and/or too low thresholds being applied in the assessment are primarily responsible. For example, the majority of sectors deemed at risk of carbon leakage qualify on the basis of the trade intensity indicator alone (Carbon Trust, 2010), which implies that the threshold for the indicator was possibly set too low.

Figure 1 Quantitative assessment of the main sectors at risk of carbon leakage



Source: COM (2009b)

1.2.2 Cost pass through

An alternative approach for assessing the carbon leakage risk involves an assessment of the ability of firms to pass through additional carbon costs from unilateral policies into their product prices, which is also considered in the determination of the carbon leakage list under Article 10a of the revised EU ETS Directive (2009/29//EC). The legislation states that 'the Commission shall assess, at Community level, the extent to which it is possible for the sector or sub-sector concerned, at the relevant level of disaggregation, to pass on the direct cost of the required allowances and the indirect costs from higher electricity prices from the implementation of this Directive into product prices without significant loss of market share to less carbon efficient installations outside the Community' (COM, 2009a).

The cost pass through rate can be generally described as the change in output price in response to a change in input costs. If costs are not passed through, then firms need to bear the additional costs and their profits will fall. If costs are passed through and result in higher product prices, this may affect production and competitiveness as follows: 1) domestic demand may be lost as consumers may decide to buy alternative and less expensive domestic substitutes or imported products (only the latter effect is associated with carbon leakage); 2) Export shares may be lost to countries that are not subject to comparable policies (Graichen et al., 2008). Whether these effects are likely and costs are passed through, and to which extent, depends mainly upon three factors outlined by Varma et al, (2012):

- **Market structure** refers to the number of firms in the market and the level of state intervention either by regulation or direct ownership. The structure of the market determines the level of competition between firms and influences the ability of firms to pass on additional CO_2 costs without losing market share.
- **Supply and demand elasticities** refer to the degree to which supply or demand of a product responds to a change in price. If the demand elasticity of a product is zero (i.e. rigid demand) then additional CO_2 costs can be passed through with no risk of a firm losing market share.
- **Exposure to international trade** also influences the ability of a firm to pass through additional CO_2 costs. For example, if the exposure of a firm to international trade is low then higher product prices due to passing through additional costs do not impact on the competitiveness of the firm.

The interaction between these factors determines a cost pass through capacity rate which ideally could be determined by empirically estimating demand-price elasticities for each good as well as Armington elasticities which reflect demand-price responses for international goods. These could then be aggregated to obtain a value for sectoral pass-through capacity (Jürgens et al., 2012). Even though elasticities values are often used in economic modelling to assess the pass-through capacity and potential carbon leakage (short term production, investment or fossil fuel leakage), they most often lack empirical foundations and vary widely across models.

In theory, under perfect competition industries can pass through 100% of their costs (compare Sijm et al., 2009). Extending the theoretical discussion further to estimate cost pass through for unilateral cost increases, De Bruyn et al. (2010) argue in the context of the EU ETS that even if initially the additional carbon cost is fully passed through, the impact of imports from other countries will ultimately lower the total price increase in sectors that are exposed to international competition. This argument is based upon the ‘Law of One Price’ principle, which assumes that markets are perfectly integrated with identical commodities having the same price internationally. However, as indicated by Armington (1969) perfectly integrated markets rarely occur as products produced in different countries are often imperfect substitutes due to product differentiation and transportation costs.

In the real world of less than perfect competition, less than perfectly integrated markets and uncertainty over supply and demand elasticities an empirical analysis of the input and output prices of products is necessary in order to translate theory of cost pass through into reality. Based upon empirical data from the first two phases of the EU ETS attempts have been made in the literature (Alexeeva-Talebi, 2010; Oberndorfer, 2010) to estimate the extent to which costs have been passed through into product prices. ‘The literature takes an ex-post perspective and analyses to what extent during Phase I and Phase II of the EU ETS, prices of various products at the EU market could be explained by price variation in CO_2 markets. Most of the literature uses a cost model where the price of products is being explained by prices of input factors, such as crude oil or energy.’ (Varma et al, 2012). Data requirements for such an estimation are quite challenging. While output or commodity prices can most often be collected from official statistics, data on input costs are sensitive to both competitors and suppliers and often are kept confidential. Besides the price and cost challenges, the results of these estimations also highly depend on the country coverage, the time horizon, availability of consistent and complete time series data and the actual specification of the (system of) equations to be statistically analysed.

An overview of the cost pass through rates that ex-post empirically have been observed within two studies for a range of products from various sectors is shown in Table 1

Table 1. The cost-pass through rate shows in how far an increase in CO_2 related costs has been passed through to product prices. The variation in cost pass through rates is partly a reflection of the methodology (i.e. different length of time series data for products, different specification of the statistically analysed equations[2] and unavailability of

[22] The statistical specification refers to the variables that enter the equations, i.e. the explanatory variables on the right hand side of the equation which are input costs (energy costs, intermediate input costs, labour costs and CO_2 costs) and the explained variable, output prices - retail or consumer prices -, on the left hand side. The econometric estimation will then reveal how a change in any of the explanatory costs affects the output price. It would perform well if the main explanatory variable are included, i.e. if prices for all variable inputs are included.

input costs for all products analysed). It also suggests that the theoretical 100% pass through rate advanced by Sijm et al. (2009) is based upon assumptions that in reality vary considerably sector by sector (i.e. market structure, elasticity of demand and international competition).

Table 1 Example of cost pass through rates in the literature

Reference	Product	Country	Cost pass through
Alexeeva-Talebi, 2010	Paper and paperboard	DE	0%
	Household and toilet paper	DE	>38%
	Dyes and pigments	DE	37%
	Other basic inorganic chemicals	DE	10%
	Fertilizers and nitrogen compounds	DE	16%
	Plastics in primary forms	DE	42%
	Perfumes and toilet preparations	DE	0%
	Other rubber products	DE	75%
	Hollow glass	DE	>60%
	Glass fibres	DE	27%
	Other glass, processed	DE	24%
	Cement, lime and plaster	DE	73%
Oberndorfer et al., 2010	Diesel	UK	50%
	Gasoline	UK	75%
	LPDE	EU	100%
	Ammonium	EU	50%
	Hollow glass	DE	20-25%
	Container glass	DE	0%
	Ceramic goods	EU	>100%
	Ceramic bricks	EU	30-40%

Note: LPDE: Low density polyethylene film

Sources: Alexeeva-Talebi, 2010; Oberndorfer, 2010; adapted by Öko-Institut

Oberndorfer et al. (2010) shows that with the exception of ceramic goods, the remainder of the products assessed are able to pass through only parts of their costs into output prices. Ceramic goods show a pass through rate of larger than 100% which is a result of certain market characteristics and can be interpreted as a complete pass through of policy induced carbon costs. Alexeeva-Talebi (2010) agrees that producers of cement, lime and plaster are capable of passing through the majority of additional costs and also identifies a wide range of cost pass through rates that exist across the different sectors (i.e. 0% to 75%). Both studies calculate rather different cost pass through rates for hollow glass, which reflects the use of different data sets, different lengths of their time series and/or different specification of their estimated equations (i.e. which input costs the authors consider in their estimation on the one hand side and which commodity prices (retail, consumer) are to be explained).

All in all it can be concluded that a correlation analysis aiming at singling out the effect of CO_2 pricing on product prices provides a major challenge. More robust insights might be gained by conducting more estimations based on similar assumptions and assessing the robustness of the results with the help of sensitivity analyses.

Insights might remain limited, however, for reasons of i) data constraints for cost data, ii) estimation bias because of missing data, iii) possible correlation in independent variables (for example, prices for gas and intermediate inputs), iv) exogenous shocks (such as unexpected price changes) and v) possible parallel changes in impact factors outside the EU ETS system boundary.

1.2.3 Comparability of third country mitigation effort / technological spill-over

According to Article 10a of the revised EU ETS Directive (2009/29//EC) any assessment of carbon leakage risk also needs to consider the ‘effect of climate change and energy policies implemented, or expected to be implemented outside the EU in the sectors concerned.’ Indeed the adoption of ambitious climate policies by third countries that are comparable to the efforts of the EU27 will certainly reduce the risk of carbon leakage. However, the definition of comparability of effort is politically difficult to agree upon in the context of UNFCCC international negotiations.

An extensive analysis on the indicators which may be used to assess the comparability of efforts and their application to various countries as well as their potential effect on the methodology to assess the risk of carbon leakage via the indicators as provided for in the EU ETS Directive has been conducted in different tasks of this study.

Beyond the comparison of absolute targets for emission reductions to assess comparability, the transfer of abatement technologies is an important discussion point in the UNFCCC negotiations between developed and developing countries, which may impact upon the carbon leakage risk of European industry. For example, Kuik and Gerlagh (2007) suggest that the risk of carbon leakage may be offset by another spill-over effect i.e. the transfer and diffusion of environmentally sound technology.

2 Approaches for estimating carbon leakage

Given the potential negative impacts of carbon leakage on both the competitiveness of European industry and the environmental credibility of the unilateral policy various attempts have been made in the literature to quantify the extent of the problem. The carbon leakage rate, defined as the ratio between a decrease in the emissions of a region with a climate policy and an increase in emissions of a region without a climate policy is widely used to measure carbon leakage effects. The approaches for estimating carbon leakage rates involve either ex-ante modelling or ex-post empirical analysis and are explained in more detail in the following sub-sections.

2.1 Description of ex-ante modelling

The majority of the literature so far adopts the ex-ante modelling approach to account for future developments in unilateral climate policies, frequently addressing the Pollution Haven Hypothesis in quantifying carbon leakage rates. The Pollution Haven Hypothesis states that countries without environmental regulations attract investment from energy intensive industries that result in carbon leakage disadvantaging countries with strong environmental regulations. The following modelling techniques are widely applied in the literature:

- **Partial bottom up models** are national or multi-regional models that do not cover the whole economy, but rather a specific market or set of markets, such as the steel market, aluminium market or energy technology market. In these models, it is usually assumed that demand is exogenously given. Similarly, the prices of all substitutes and complements and the income levels as well as the behaviour of consumers are exogenous to the model.
- **Top-down whole economy models** are multi-sector models that cover a country, region or multiple regions whereby all supply and demand markets are modelled simultaneously including feedback effects from one sector to the other. In equilibrium models, simulations are executed until all markets reach equilibrium where demand equals supply. In macro-econometric models market interactions are projected into the future based on observed past trends and behaviour.

These modelling approaches have different advantages and disadvantages that provide valuable insights into the carbon leakage debate. For example, the simulation of the entire economy in general equilibrium or macro-econometric models enables an analysis of all channels of carbon leakage and to evaluate the wider economic impact of unilateral climate policies (i.e. job losses, investments). However, the parameters selected in macro models (i.e. energy substitution elasticities, trade elasticities) strongly influence the outcome of the modelling exercise. Given that these parameters are not always clearly reported in the literature the credibility of some modelling exercises is uncertain. In contrast, the relatively more simple nature of partial models is easier to understand with a focus on particular sectors of the economy. However the approach is normally limited to assessing carbon leakage via the short trade competiveness and investment channels and is also dependent upon the assumptions of important modelling parameters.

2.2 Results of ex-ante modelling

The literature on carbon leakage rates in the context of the EU ETS tends to focus on the impact of the unilateral climate policy on regulated industrial sectors (i.e. iron and steel, cement and aluminium) with estimates in the literature ranging from 2% to 73% depending upon the modelling approach adopted, the underlying assumptions applied (i.e. trade elasticities, carbon price) and the specific design of the policy scenario (i.e. emission reduction target, inclusion of preventative measures). An overview of the range of carbon leakage rates resulting from the EU ETS, categorised by both sector and preventative measure, is outlined in Table 2.

Table 2 Carbon leakage estimate ranges by preventative measure for the iron and steel, cement and aluminium sectors in the EU ETS

	Iron and Steel	Cement	Aluminium
	[Leakage rates]		
No Measures	35% to 40%	19% to 73%	20%
Free Allocation	5%	9% to 50%	--
Border Tax Adjustment	2% to 29%	12% to 17%	--

Source: Kuik and Hofkes (2010), Carbon Trust (2010), Ponssard and Walker (2008), Demailly and Quirion (2008), Demailly and Quirion (2008), Compiled from the available literature by Öko-Institut (2012)

The compilation of the limited literature available in Table 2 shows that there remains a lack of consensus on the estimation of carbon leakage rates, with the variation fundamentally due to the use of different modelling approaches (i.e. world economy models / bottom up models) different modelling assumptions (i.e. trade and energy elasticities) and different policy scenarios (i.e. no measures / free allocation and border tax adjustment). In order to place the estimates in Table 2 into context, the following sub-sections will sort the carbon leakage rates based upon the methodological approach applied and supplement with additional studies assessing the impact of the Kyoto Protocol on carbon leakage rates.

2.2.1 Carbon leakage estimates from 'bottom up' models

The bottom up approach is normally limited to assessing carbon leakage via the short term competiveness and investment channels and is also dependent upon the assumptions of important modelling parameters.

Partial equilibrium models are often applied in the literature to assess the impact of the EU ETS on rates of carbon leakage for industrial sectors. Carbon Trust (2010) use the CASE II model, which represents four sectors: electricity, steel, aluminium and cement to estimate leakage rates using the assumptions of 100% auctioning of allowances, a carbon price of €15 and without the inclusion of any border adjustments. The outcome of the modelling exercise is a carbon leakage rate of 10% as a consequence of the EU ETS; however certain sectors experience much higher rates than the average (i.e. Aluminium 20%; Cement 20% and Iron and Steel 40%). Interestingly, Ponssard and Walker (2008) estimate a higher leakage rate of 73% for the cement sector than calculated by the Carbon Trust (2010) based upon an oligopoly competition model that also assumes 100% auctioning – however the carbon price of €50/t CO_2 is considerably higher than the €15/t CO_2 carbon price applied by the Carbon Trust (2010) and the modelling approach is also highly simplified.[3]

Summerton et al. (2010) apply a panel data econometric method to estimate trade elasticities for domestic demand, import demand and export demand for ten sectors that are deemed at risk of carbon leakage due to the EU ETS. These elasticities were then integrated into a partial equilibrium model that accounted for trading partner costs, cost pass through assumptions, carbon intensity of electricity of trading partners, carbon cost assumptions and policy assumptions. In the reference scenario, whereby the EU commits to a 20% GHG emissions reduction but the rest of the world makes no emission reduction pledge, the carbon price of €30/t CO_2 causes EU production in most sectors to fall by less than 1.5% In this scenario, the changes in production are converted into emissions to estimate the leakage rate based on the assumption that direct emission intensities are the same in the rest of the world as they are in the EU while indirect emission intensities differ to reflect different forms of electricity generation. The leakage rate is estimated to be low for the majority of sectors. Only four sectors (i.e. manufacture of inorganic basic chemicals, manufacture of ceramic tiles and flags, manufacture of bricks, tiles and construction products and manufacture of agricultural tractors) experience leakage rates in excess of 25%.

Several modelling exercises have demonstrated that the inclusion of preventative measures in the design of modelling scenarios results in lower rates of carbon leakage. For example, Demailly and Quirion (2006) assessed the impact of free allocation in the EU ETS on the carbon leakage rate for the cement sector using the GEO-CEMSIM model. The study evaluated the impact of grandfathering and output based allocation on the rate of carbon leakage and concluded that leakage rates were considerably higher under grandfathering (i.e. 50%) than under output based allocation (i.e. 9%).

[3] The Cement Trade and Competition (CTC) model represents a stylised EU country with two distinct regions ('coastal' and 'inland') each with a homogeneous cement market exhibiting Cournot-Nash equilibrium. Importantly the study assumes that all producers use similar kiln technology and kiln fuel (i.e. have the same CO_2 emissions intensity). The author concedes that the introduction of new abatement technology such as CCS (financially viable at a high carbon price) could significantly lower the leakage rate.

The relatively high value for the grandfathering scenario is partly a result of the modelling assumptions applied (i.e. no product differentiation, no climate policy outside the EU). Furthermore, although carbon leakage is lower under the output based scenario – domestic reductions are also lower under this approach. In a more recent study, Demailly and Quirion (2008) estimate a modest leakage rate of 5% in their central scenario for the iron and steel sector with the implementation of full free allocation unadjusted over time.

2.2.2 Carbon leakage rates from 'top-down' models

The simulation of the entire economy in top down models enables an analysis of all channels of carbon leakage and to evaluate the wider economic impact of unilateral climate policies.

Based upon the use of the GTAP-E model, Kuik and Hofkes (2010) adopts a general equilibrium modelling approach to examine the impact of introducing a border tax adjustment to reduce the rate of carbon leakage as a consequence of the EU ETS in the iron and steel and mineral sectors. Firstly the study estimates the 'sectoral leakage' defined as the 'increase of direct and indirect emissions in the foreign sector as a percentage of the reduction of direct and indirect emissions in the EU sector' for the iron and steel and mineral sectors under an EU ETS scenario[4] and two alternative options for border tax adjustments:

- Border adjustment based on the direct CO_2 emissions per unit of similar product in EU (BA-d)
- Border adjustment based on the average direct CO_2 emissions per unit of production in the foreign (exporting) country (BA-f)

Kuik and Hofkes (2010) find that carbon leakage rates for the iron and steel sector range declines from 35% under the EU ETS scenario (i.e. no measures) to 29% under the BA-d scenario and 2% under the BA-f scenario. The difference in the carbon leakage rate within the two scenarios reflects different assumptions on how border tax adjustments should be applied with a clear reduction in the rate of carbon leakage if the amount of allowances per unit of imported product is based on the average direct CO_2 emissions per unit of production in a foreign country.

Interestingly, the impact of border tax adjustments on the mineral sector is relatively less effective compared to the iron and steel sector in the study. Kuik and Hofkes (2010) suggest that this may be due to the fact that clinker and cement are, in economic terms, only a small part of the mineral products sector. The difference in the effectiveness of border tax adjustments may also be due to the different 'channels' of leakage associated with each sector. Kuik and Hofkes (2010) explain that border measures

4 The modelling approach assumes a simplified EU ETS consisting of the electricity sector, the mineral products sector and the iron and steel sector. Firms are allowed to trade allowances amongst themselves but not outside the ETS. Carbon price of 20 € assumed in the exercise.

mainly affect trade (i.e. short term competitiveness channel) and have no or limited effects on leakage through substitution (i.e. fossil fuel price channel). Kuik and Hofkes (2010) find that 94% of the leakage associated with the iron and steel sector in the modelling exercise is from volume effects (trade). In contrast, 33% of the leakage associated with the minerals sector in the modelling exercise is from substitution effects i.e. an increase in the CO_2 intensity of production in foreign countries.

In addition to the literature focused on the EU ETS, there are several important (and often conflicting) top down modelling exercises that analyse the impact of the Kyoto Protocol on the rate of carbon leakage for the Annex I grouping. The following studies provide further insights into the estimation of carbon leakage rates via the investment and fossil fuel price channels.

Babiker (2005) produced an outcome whereby the carbon leakage rate as a consequence of the Kyoto Protocol ranged between 25% and 130%. Different assumptions about production and competition in the energy intensive sector were set in the CGE modelling exercise, with the main reason for the higher estimate due to the inclusion of increasing returns to scale, strategic behaviour in the energy intensive industry and the assumption of homogenous products. Babiker (2005) suggest that 'significant relocation of energy-intensive industries away from the OECD may occur depending on the type of market structure' and provides supporting evidence for carbon leakage via the investment channel. Conversely, Kuik and Gerlagh (2003) use a GTAP-E model to show that the main reason for carbon leakage as a result of implementing the Kyoto Protocol would be due to a reduction in world energy prices rather than the relocation of industry outside the Annex I region. The central estimate calculated in the study for the carbon leakage rate from Annex I to Non Annex I regions is 11%, which is sensitive to important assumptions such as trade-substitution elasticities and fossil fuel supply elasticities.

Interestingly, Kuik and Gerlagh (2007) incorporate energy saving technologies and technological spillovers into their CGE modelling exercise and the outcome of the study is that 'carbon leakage becomes negative for moderate levels of international technology spillover'. Negative carbon leakage implies that a policy (i.e. the Kyoto Protocol) promotes the diffusion of low carbon technologies lowering the carbon intensity of production resulting in a net decrease in global emissions. Clearly such an analysis is highly dependent upon assumptions concerning the rate of technological spillover but nevertheless provides a different perspective on the carbon leakage debate.

2.2.3 General conclusions of ex-ante modelling

Given the lack of ex-post empirical evidence to estimate carbon leakage rates, policy makers have increasingly relied upon ex-ante modelling to inform decision making. Unfortunately the review of the literature has highlighted the variability that currently exists in the estimation of carbon leakage rates and the difficulty of drawing firm conclusions due to persistent doubts about the robustness of the results in the literature. For example, Varma et al (2012) emphasise that the majority of studies fail to disclose the elasticities (energy and trade) used in models to estimate carbon leakage rates. Although it is expected that the combination of energy and trade elasticities are likely to account for most of the variation in carbon leakage rates in the literature – this is currently not possible to ascertain due to the limited disclosure on methodologies. Furthermore, the extent to which some of the ex-ante modelling in the literature represents the real world is questionable. For example, it is often assumed that outside of the EU no climate policies are being implemented – such a simplification is inaccurate and may lead to higher carbon leakage rates than in reality.

The importance of energy and trade elasticities on influencing the carbon leakage rate are typified by the different modelling approaches adopted by Demailly and Quirion (2006) and the Carbon Trust (2010) that deliver counter-intuitive results. Given that both studies adopt a similar carbon price, one would expect that a scenario assuming the grandfathering of allowances (i.e. Demailly and Quirion, 2006) would result in a lower rate of leakage than a scenario that assumes 100% of allowances are auctioned (i.e. Carbon Trust, 2010). However, as Table 3 illustrates, the opposite is true with higher rates of carbon leakage modelled for the scenario assuming the grandfathering of allowances. Such a counter-intuitive result can be partly explained by the fact that the CASE II model used by the Carbon Trust (2010) attempts to account for product differentiation (based on the Armington elasticity) whereas the CEMSIM-GEO model used by Demailly and Quirion (2006) is more simplified and fails to account for product differentiation.

Table 3 Key assumptions of the Carbon Leakage rate estimations for the cement sector in the EU ETS

Measure	Reference	Model	Year	Carbon Price	Leakage Rate
No Measure	Carbon Trust, 2010	Case II Model	2016	15 €	20%
	Ponssard & Walker, 2008	CTC Model	--	20 €	70%
	Ponssard & Walker, 2008	CTC Model	--	50 €	73%
	Szabo et al, 2006	CEMSIM Model		50 $	29%
	Kuik & Hofkes, 2010	GTAP-E Model	--	20 €	19%
Output based (OB) Allocation	Demailly & Quirion, 2006	CEMSIM-GEO Model	2010	20 €	9%
Grandfathering Allocation	Demailly & Quirion, 2006	CEMSIM-GEO Model	2010	20 €	50%
Border Tax Adjustment (BA-d)	Kuik & Hofkes, 2010	GTAP-E Model	--	20 €	17%
Border Tax Adjustment (BA-f)	Kuik & Hofkes, 2010	GTAP-E Model	--	20 €	12%

Source: Compiled from the available literature by Öko-Institut (2012)

While it is difficult to compare studies due to the inherent differences in modelling approaches, it is important to acknowledge how further scenario assumptions such as the carbon price set and the implementation of preventative measures can influence the carbon leakage rate. This is particularly interesting for comparing scenarios within a study to provide further insights on how best to prevent carbon leakage and ensure that firms remain competitive. Table 3 provides an overview of the key assumptions and leakage results for the cement sector. For example, within the two scenarios in the Demailly and Quirion (2006) study it is evident that free allocation to firms based on current production (i.e. output based) rather than historic production (i.e. grandfathering) would lower leakage rates – but importantly the measure would also reduce levels of domestic abatement potentially undermining the environmental integrity of the EU ETS. Further evidence of the impact of preventative measures is provided by Kuik and Hofkes (2010) who show that the introduction of border tax adjustments can lower the rate of carbon leakage and made an important distinction between sectors on the effectiveness of the measure based upon the leakage channel that characterises a sector.

Although the studies by Babiker (2005) and Kuik and Gerlagh (2003) both provide evidence for carbon leakage for the Annex I group due to the Kyoto Protocol, there is a lack of consensus on both the magnitude of the leakage and the channel of leakage. There is also an alternative view expressed in the literature that climate policies may promote the diffusion of low carbon technologies resulting in negative leakage; however such an optimistic assumption by Kuik and Gerlagh (2007) is based on theoretical rather than empirical data and would need to be examined in more detail.

2.3 Description of ex-post empirical studies

Due to the still rather limited time horizon since the introduction of the EU ETS in 2005 and the lack of time series data not many studies have been conducted to ex-post quantify the effects of the EU ETS, in particular with respect to carbon leakage. In addition, the change of design from one trading period to the other as well as the change of other important economic factors such as economic development, energy prices and changes in the law requires a decomposition of the effects and subsequently attributing them to the driving factors. The following ex-post techniques are widely applied in the literature:

- **Econometric approaches:** Econometric models are empirical in nature with model relationships determined by statistical estimates based on historical (usually time-series) data sets. Econometric equations are used to estimate elasticities (e.g. the increase in price from an increase in costs, or the reduction in demand from an increase in price), usually in percentage terms. The inputs are data sets which combine cases with and without the changes, so that the differences can be analysed. These differences can be either over time (e.g. before and after introduction of the ETS), over sector (e.g. those inside and outside ETS coverage), or in different geographical areas (e.g. inside and outside Europe). The empirical basis means that they are dependent on large and accurate data sets with which to form their parameters.
- **Survey / interview approaches:** Data is usually collected by completing surveys that consist of both open-ended and closed questions to provide both qualitative and quantitative data. Surveys are normally conducted without the presence of a researcher, whilst an interview approach would involve directly asking a subject open-ended and / or closed questions. In addition, interviews can be semi-structured allowing for more spontaneous questions to be answered as the discussion evolves.

These ex-post approaches have different advantages and disadvantages that provide valuable insights into the carbon leakage debate. The econometric approach enables theories to be tested based upon empirical data, however the method requires a sufficiently large set of either time series or cross-sectional data and a careful specification of the model equations. Qualitative methods such as surveys and interviews are capable of capturing key trends or developments that are often more difficult to obtain via the use of simplified indicators. However, depending upon the research question, the advantage of qualitative approaches can also be a limitation as it is difficult to make assumptions beyond the opinions captured for a specific group of participants.

2.4 Results of ex-post empirical studies

Given the relatively short time period that the EU ETS has been in operation, the amount of empirical data remains limited but is growing and recently published articles have been attempting to verify the findings of ex-ante modelling. Based upon different sources of empirical data (i.e. trade data, employment data, qualitative data) and different ex-post analysis techniques (i.e. econometric analysis, surveys) several authors have attempted to assess the impact of the EU ETS on various aspects of competitiveness (i.e. trade, employment, innovation) and an overview of the findings are illustrated in the matrix in Table 4.

Table 4 Matrix of ex-post empirical studies assessing the impact of the EU ETS on the competitiveness of European firms

	Impact of the EU ETS		
	Negative	**Neutral**	**Positive**
Trade	Constantini and Mazzanti (2012)	Sartor, (2012) Reinaud (2008)	--
Employment, output and profit	Abrell et al (2011) Commins, Lyon, Schiffbauer and Tol, (2011)	Martin, Muûls, de Preux and Wagner (2012b)	--
Innovation	--	--	Calel and Dechezlepretre (2012) Martin et al. (2011)

Source: Compiled from the available literature by Öko-Institut (2012)

The compilation of the literature available in Table 4 shows that there remains a lack of consensus on the impact of the EU ETS on various aspects of competitiveness. In order to place the matrix in Table 4 into context, the following sub-sections will discuss how different measures of competitiveness - applied in various studies using different methodologies - may provide further evidence of carbon leakage.

2.4.1 Evidence of carbon leakage from econometric analysis

Econometric approaches have been applied in the literature to evaluate the impact of carbon leakage via the short term competitiveness channel based on empirical data with mixed results. For example, Sartor (2012) examined the effects of the EU ETS carbon price on net imports of primary aluminium in the EU by applying an econometric technique to empirical data on trade, industrial production, exchange rates, CO_2 spot prices and EU coal and natural gas cost data. The econometric model was designed based upon the following logic:

'The higher the cost of CO_2 in any given economic quarter, the higher the electricity prices for EU smelters (who are not on long-term contracts) and hence the greater the chances they will reduce production (either marginally or by shutting down) and hence that domestic demand will be increasingly met by imports from non-EU ETS countries' (Sartor, 2012).

The econometric analysis failed to identify a statistically significant effect of CO_2 pricing on the net imports of primary aluminium and therefore Sartor (2012) concluded that there is no evidence to suggest that the carbon price has caused a net increase in imports of primary aluminium during the first 6 and a half years of the EU ETS. However the outcome of the study has several important caveats that may impact upon the future implications of this finding. Firstly although no evidence of carbon leakage is currently available from the empirical data evaluated it is likely that the majority of aluminium producers have been on long-term electricity contracts and have therefore been insulated from electricity price rises due to CO_2 pricing. Secondly, Sartor (2012) suggests that for aluminium producers, whom are no longer on long-term electricity contracts, technical constraints make it too expensive to vary production levels in the short run unless the carbon price was significantly higher than historic levels.

Reinaud (2008) comes to a similar finding based on several econometric tests on trade flows and their relation to the EU ETS. Reinaud (2008) completed a linear regression on a quarterly dataset from 1999-2007 for net imports of aluminium into the EU27 on the year-ahead EUA price and other control variables. In contrast to the economic theory that a higher carbon price would result in an increase in net imports of electricity intensive aluminium from countries without climate policies, the analysis by Reinaud (2008) failed to confirm the assumption that CO_2 prices impacted upon EU primary aluminium trade flows. The existence of long-term electricity contracts was also used by Reinaud (2008) to explain the results, however Martin et al (2011) comments that the 'negative effect is not necessarily causal, because the research design did not discriminate between the impact of the EU ETS and a secular, upward trend in net imports.'

In contrast to the previous econometric studies, Constantini and Mazzanti (2012) recently published results suggesting that the EU ETS had a negative impact on the economic performance of the majority of firms participating in the scheme, at least in the short run. The study assessed the impact of Phase I of the EU ETS on net imports from EU15 countries into over 100 destination countries and for a wide range of industries based upon a gravity equation framework. The results showed that the EU ETS had a negative impact on trade in all industries with the exception of medium-low technology industries, where in some circumstances the effect may be positive. However the results are far from conclusive and Martin et al (2011) states that an important limitation of the study is that the 'variable of interest was defined in a way that would make it impossible to distinguish the EU ETS impact from other macro level shocks.'

Based upon an econometric model, Abrell et al (2011) assess the impact of the EU ETS on the value added, the profit margin and employment of participating firms over Phase I and the start of Phase II for a sample of European firms using performance data from the AMADEUS database. Although this study does not directly link the impact of the EU ETS to carbon leakage, reduction in value added, profit margins and employment may indicate the potential for carbon leakage via the investment channel over the longer term. In order to assess the impact of the EU ETS on the firms' performance, Abrell et al (2011) measured the difference between the state of the firms after being subject to the EU ETS against the counterfactual situation (i.e. the performance of the firms if they had not been under regulation). Given that this counterfactual situation is not observable, it was necessary to estimate it by means of comparison to a control group (i.e. non-participating firms). This involved matching each EU ETS firm with only one firm in a non EU ETS sector, which shared similar characteristics.

The outcome of the study was that there was no statistically significant impact on a company's value added and profit margins as a result of firms participating in the EU ETS. However, with regards to employment, Abrell et al (2011) found a statistically significant slight decrease in employment at EU ETS firms of 0.9% between 2004 and 2008. Although the study provides interesting insights, the authors accept that their 'practice of taking control firms only from non-regulated sectors was problematic because of the possible non-random selection of which sectors were regulated under the EU ETS' (Martin et al, 2011). Based upon a similar econometric approach using firm level panel data, Commins et al (2011) produce alternative findings that suggest that the EU ETS actually had a negative impact on productivity and profits (in the order of 6%) for European firms between 1996 and 2007 while the impact of the EU ETS on employment and investment was not statistically significant. These two studies demonstrate that different assumptions and modelling priorities result in potentially conflicting outcomes.

2.4.2 Evidence of carbon leakage from survey analysis

Within the literature, qualitative techniques have been increasingly applied in the form of semi-structured interviews and surveys in order to collect ex-post data on the impact of the EU ETS on the competiveness of European firms. Although the qualitative approaches are associated with limitations in establishing causality, the following studies still provide important insights into the competitiveness issues related to the EU ETS.

The evidence of carbon leakage via the short term competitiveness channel has been assessed in the literature. Kenber, Haugen and Cobb (2009) conducted a survey of nine companies that primarily owned installations directly covered by the EU ETS, which aimed to establish whether a market-set price for carbon has influenced the companies' ability to remain internationally competitive. The survey results found that 'the EU ETS has not resulted in significant costs to business to date, especially when compared to the impact of other factors such as energy price fluctuations and the economic downturn'. Importantly the survey concluded that so far 'there has been no major impact on companies' competitiveness: they have not relocated their operations, reduced their workforce, or lost market share as a result of carbon pricing'. Lacombe (2008) came to a similar conclusion following interviews with managers at five European refining companies i.e. that the EU ETS had a limited economic impact on firms. Lacombe (2008) attributed this finding mainly to the weak incentives provided by the EU ETS via the low CO_2 price towards the end of Phase I. It is important to acknowledge that given the size of the survey sample, the results should not be considered representative.

Evidence of carbon leakage associated with the investment channel has been considered by Martin, Muûls, de Preux and Wagner (2012) whom conducted a larger study consisting of 761 interviews with managers in six European countries. In response to carbon pricing, the managers were asked whether or not the company intended to either downsize operations or relocate abroad until 2020. Furthermore, for managers representing firms in the EU ETS the interview was structured to determine the importance of the continuation of free allowances post 2012 in their decision making. Based upon the interview responses the authors compiled 'downsizing risk scores' that captured the subjective risk of downsizing with and without free allocation. The outcome of the study was that the downsizing risk was generally low, with the majority of firms reporting no impact on where to locate business activity based upon future carbon pricing. However, the downsizing risk score was higher for firms participating in the EU ETS compared to non-ETS firms. Furthermore, the authors identified that a high level of variation existed amongst the firms in the EU ETS with regards to the downsizing risk associated with carbon pricing and the effectiveness of free allocation as a preventative measure.

The literature also includes studies that examine the potentially positive impacts of the EU ETS such a product innovation, which with high rates of diffusion, could reduce carbon leakage. Martin et al. (2011) completed semi-structured interviews with approximately 800 European manufacturing firms (450 of which were regulated by the EU ETS) and concluded that the EU ETS had a positive effect on process innovation (i.e. operational innovations) but not on product innovation (i.e. technological advancement). However, future emission reductions from technological change may still be encouraged by the EU ETS with Calel and Dechezlepretre (2012) estimating that the scheme may be responsible for up to 30% of the increase in low carbon patenting of regulated companies since 2005.

2.4.3 General conclusions of ex-post empirical analysis

The main limitation of the ex-post empirical analysis approach is the lack of empirical data that is currently available; although this will continue to improve over time. The econometric analyses conducted by both Sartor (2012) and Reinaud (2008) appear to question the validity of the Pollution Haven Hypothesis identifying that - based upon the existing data - it is not possible to detect a negative impact on trade due to the EU ETS. Several ex-post surveys in the literature support the findings of the econometric studies (Kenber, Haugen and Cobb, 2009; Lacombe, 2008) – at least in the short term. However, with the introduction of auctioning in Phase III of the EU ETS and the end of long-term electricity contracts the short term empirical findings by both Sartor (2012) and Reinaud (2008) may no longer be valid. Future research analysing longer time series may therefore come to alternative conclusions.

There appears to be a lack of consensus within the literature on the risk of European firms downsizing or relocating in response to carbon pricing. For example, Abrell et al (2011) and Commins et al (2011) adopt a similar econometric approach using panel data from the AMADEUS database yet disagree on the impact of the EU ETS on employment levels. This may reflect the different sample sizes used in the studies and also the method for categorising firms participating in the EU ETS. However, it is likely that the different outcomes are due to the design of the econometric models used by both studies and the assumptions applied. The study by Martin, Muûls, de Preux and Wagner (2012) support the lack of consensus on the issue by discovering the variation that exists amongst firms covered by the EU ETS on their perceived risk of downsizing or relocating due to CO_2 pricing.

Empirical data has also been used to provide evidence for an alternative economic theory referred to as the Porter Hypothesis, which implies that more stringent environmental policies can lead to higher productivity and enhanced competitiveness if implemented correctly. In the context of the EU ETS, the Porter Hypothesis has been a central theory in the debate about the effectiveness of emissions trading schemes to provide the right financial incentives to drive innovation in low carbon technologies. Indeed research by Calel and Dechezlepretre (2012) and Martin et al (2011) suggest that the EU ETS may have had a positive impact on innovation. If these operational and technology innovations induced by the EU ETS are diffused beyond the region – carbon leakage may be diminished as production abroad becomes more efficient. However, many argue that the over-allocation of emissions permits in the EU ETS has failed to so far create the necessary price signal to encourage low carbon investments amongst firms (Kenber, Haugen and Cobb 2009; Lacombe, 2008; Reinaud, 2008).

3 Conclusions

The risk of carbon leakage may result as a by-product of unilateral environmental policies and may undermine the creditability of the policy depending upon the extent of the problem. The rate of carbon leakage that can be attributed to a unilateral policy such as the EU ETS is the key question for policy-makers in determining the effectiveness of unilateral environmental policies to reduce GHG emissions without harming the competitiveness of regulated industries. In order to determine the rate of carbon leakage due to a unilateral environmental policy, the literature has identified various ways by which the problem may occur (i.e. short term competitiveness, investment and fossil fuel channels) and established a range of important indicators (i.e. trade intensity, CO_2 cost and the ability to pass through additional costs) to assess the risk of carbon leakage for particular regions and sectors. This improved understanding of carbon leakage in the literature has been accompanied by the development of economic theories (i.e. Pollution Haven Hypothesis) that have impacted empirical analyses aiming to quantify the rate of carbon leakage of unilateral environmental policies.

Given the limited availability of empirical data, there is a reliance on ex-ante modelling to inform policy makers on the impact of the EU ETS on carbon leakage. With regards to the potential scale of carbon leakage, rates range considerably in the literature from 2% to 73% for sectors covered by the EU ETS and primarily focus on the short run competitiveness and investment channels of leakage. The lower rates of leakage within this range tend to assume a relatively low carbon price and preventative measures such as free allocation or border tax adjustments while the more extreme carbon leakage rates assume a relatively high carbon price and no preventative measures. However, the underlying assumptions of the modelling approach (i.e. energy and trade elasticities) are of even greater importance in determining the rate of carbon leakage. Interestingly, the results of ex-ante modelling are not validated in the most recent empirical ex-post studies, which generally fail to identify large negative impacts on the competitiveness of firms participating in the EU ETS. However the evidence base may be subject to considerable bias due to lack of consistent time series data. As more data points become available over time and more data may be collected, further research may reveal more detailed insights.

Given the complexity of the carbon leakage problem, and the necessity for modelling approaches to simplify the real world in order to comprehend it, the rates of carbon leakage calculated by studies in the literature are often not comparable with one another. This is due to considerable differences in the type of model used in ex-ante approaches (i.e. general equilibrium, partial equilibrium and econometric models) which often assess different ‘channels’ of carbon leakage, The wide range of carbon leakage rates evident in the literature are in part also due to the assumptions chosen within the modelling exercises for important key parameters (i.e. economic behaviour, trade elasticities, carbon price etc.). An additional layer of complexity involves the setting of policy scenarios (i.e. emission reduction targets, coverage of sectors/regions, coverage of

GHGs, time horizon) all of which influence rates of carbon leakage and make comparison between studies with different policy scenarios challenging.

The higher rates of carbon leakage identified in the literature seem to be associated with rather simple assumptions (i.e. homogenous products) that may not accurately reflect the real world and therefore over-estimate the extent of the problem. However, the lower rates of carbon leakage, especially for the EU ETS, often assume preventative measures such as free allocation that will not continue indefinitely into Phase III of the EU ETS and therefore may under-estimate the extent of carbon leakage. In order to reach a better consensus on this issue, it will be necessary for the models used and the assumptions taken to be documented in a more transparent manner and possibly for greater collaboration between academia and industry to agree upon certain parameters set in the modelling exercises. Furthermore, empirical ex-post approaches will need to be improved and utilise longer time series to provide more robust assessments of the risk of carbon leakage.

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