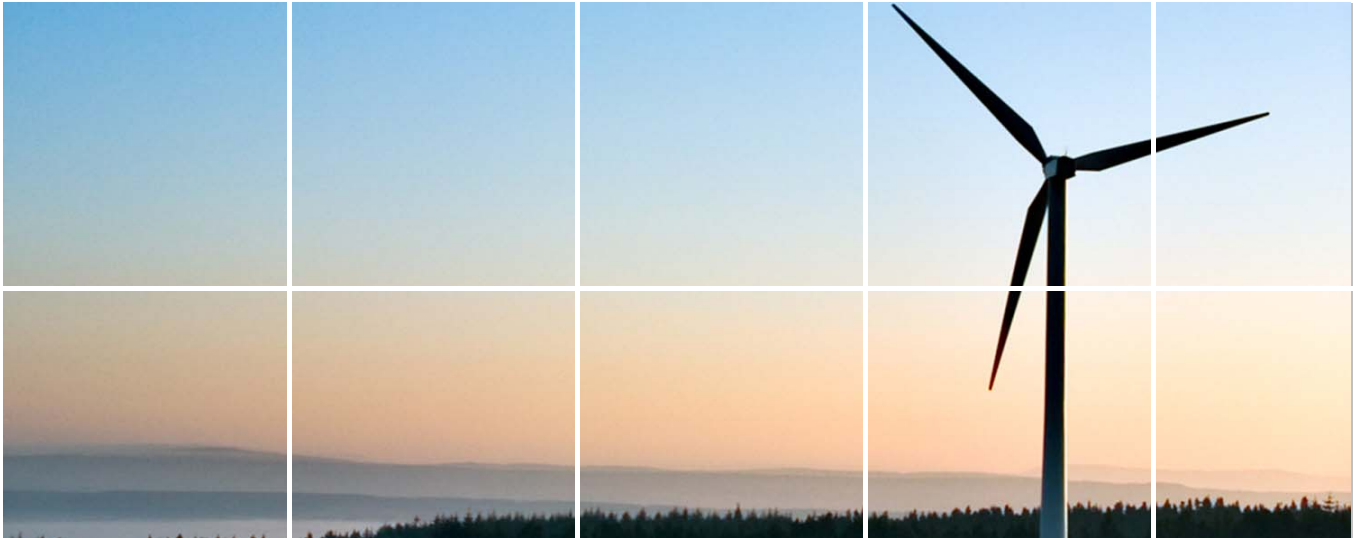




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Scoping paper “The potential for CDM induced leakage in energy intensive sectors”

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1 Summary of the key findings

This paper focuses on a very specific aspect of the competitiveness discussion for three energy-intensive sectors: aluminum, cement and steel. It analyses how incentives provided by the CDM – *might* alter relative production costs across regions, and thus lead to competitiveness concerns, related but distinct from those raised by the ETS. Prospective crediting programs, such as sectoral crediting, could have effects of a similar nature, though they are not analyzed here.

The potential for emissions leakage is a function of the risk of activity shifting and the emissions intensity of that activity. For example, CDM could lead to shifting of production activity if increased profits from CDM projects (where CDM revenues exceed the incremental costs associated with the project) lead to increased production at CDM plants at the expense of production in non-CDM plants. This would lead to emissions leakage if the production shifted from a country with a binding emissions limit, such as the EU, to the CDM plant. It could also lead to emissions leakage if production shifted from a facility in a country without a binding limit that has less-GHG intensive production than the *baseline* emissions intensity of the "receiving" CDM plant. In either case, to induce shifts in production from other facilities, CDM revenue would need to exceed the incremental abatement costs (net of any energy savings) associated with the project, and profits would need to be high relative to the marginal cost of production.

The analysis reveals that the cement and primary steel sectors will most likely remain the largest sources of CERs among energy-intensive industries, absent the development of radically new methodologies for aluminium and secondary steel, which seems unlikely. The analysis indicates that CER revenues, on their own, are unlikely to provide a major incentive for activity shifting, unlike the well documented case of adipic acid production. In the particular case of adipic acid, CDM project activities yield revenue on a similar scale as adipic acid production costs, whereas for aluminium, cement, and steel, this analysis finds that potential CDM revenues would amount to only a fraction of production costs (from 1% to 7% at 10 euros per ton, or 2% to 21% at the high price of 30 euros per ton).

The decision on whether to shift production is a complicated decision with many factors. Our analysis and interviews suggest that, given the cost benefit of free, output-based allocation of allowances in the EU for energy-intensive, trade-exposed industry and the cost of intercontinental transportation, in most cases the CDM is unlikely to provide a significant incentive for activity shifting from the EU to developing countries. However, special cases may exist and further research may be warranted. For example, some emissions abatement activities may be strongly cost-negative, increasing the potential profits from CDM projects if those extra revenues (e.g., due to reduced energy costs from clinker substitution in cement-making) can be realized.

Based on the high level data and cost estimates, the paper finds little evidence to suggest that the CDM has provided sufficient profit or production cost advantages to result in significant shifts in global aluminium, cement, or steel production. Still, some special cases exist, including the possibility that crediting projects for increasing the use of clinker substitutes might lead to the reduced production of low-carbon cement elsewhere in a given country/region, if the supply of clinker substitutes is limited. To substantiate this, case-specific research would be required.

Key areas for further research and analysis include:

- the production, use, and trade in cement substitutes (e.g. slag and fly ash) in order to characterize the potential scale of leakage risk;
- the extent of reduction in emissions intensities associated with actual CDM projects and actual production cost data (from economic models) in order to refine our assessment of relative incentives (profits/production cost); and,
- economic assessment of leakage impacts of carbon pricing in the EU ETS (or in other developed regions), and whether results from those studies can be parameterized or adapted to the differential economic incentive provided by the CDM.
- examination of the potential impact of new and reformed mechanisms (including sectoral crediting) on competitiveness/carbon leakage and compliance costs.

This scoping paper is organized in four parts.

- Part I provides a brief review of the state of discussion on competitiveness and carbon leakage respectively, in relation to the ETS and beyond. It also introduces the different potential impacts that the CDM can have on competitiveness.
- Part II explores possible pathways for GHG emissions leakage induced by the CDM in emissions-intensive industry, specifically iron and steel, aluminium, and cement including a description of potential pathways of leakage and distinction between activity-shifting and emissions leakage. It further discusses the level of CDM project activity in these sectors, followed by a discussion of the costs of production and emissions abatement in these sectors.
- Part III introduces possible reform options and discusses them as to whether they have the potential to address existing shortcomings of the CDM. Possible solutions are i) reformed CDM, ii) sectoral crediting and iii) sectoral trading possibly under a binding sectoral agreement. .
- The final part IV sums up and presents conclusions as well as suggesting further research steps that can help arrive at more definitive conclusions.

2 Part I: Competitiveness concerns: a driver for CDM reform?

While the term has never been defined, roughly speaking 'competitiveness' takes a micro (i.e. firm or sector-specific) perspective, meaning the ability to sell, keep or increase market share, profits or stock-market value or all at once. This ability depends on the sectors, which are very differently affected as a result of the ability to pass-through carbon costs, which depends in turn on trade exposure and carbon-intensity. The debate on competitiveness has revealed that a number of trade-exposed sectors or sub-sectors could be negatively affected by the ETS (e.g. Climate Strategies, 2007; Ellerman, Convery and de Perthuis, 2010: p. 195 and European Commission, 2010a) and subsequently lose market share, profits and/or stock market value.

On the other hand, other factors may mitigate leakage risks and maintain competitiveness. Companies can seek to lower their compliance cost by recourse to flexible mechanisms such as offset programmes, and CDM in particular. Thus, lowering compliance costs may improve competitiveness of industry in the EU.

2.1 Overview

The potential for emissions leakage is a hotly debated topic in discussions of global climate policy (e.g. Dröge et al. 2009). Most concerns have been raised, and studies conducted, regarding the potential for climate policy in developed countries to increase carbon (and energy) prices and thereby lead to shifts in industrial production to areas without a carbon price, leading to "leakage" of jobs, economic activity, and emissions (European Commission 2009; US EPA, US EIA, and , US Treasury 2009). A related possibility is that increased revenues from the CDM or other GHG offset mechanisms could create a similar effect, lead to an increase in production at CDM facilities at the expense of production in non-CDM facilities. If the production shifts from non-CDM facilities with lower emissions rates (per ton product) than the baseline emission rate of CDM facilities, then emissions leakage would occur. Carbon leakage can also occur in countries whose emissions targets exceed their expected emissions, for example through production increases. This would for example be the case if CERs encouraged more production of GHG to access credits. Previous studies found evidence of CDM-induced leakage in adipic acid production, but not nitric acid production (Schneider, Lazarus, and Kollmuss 2010; Kollmuss and Lazarus, 2010).¹ In this scoping paper however, this is treated as a 'perverse incentive'.

In the EU/EEA under the ETS, the incentive for efficient abatement arises from the 'opportunity cost' of using allowances. Passing through the greenhouse gases (GHG) costs in the form of an allowance price will create a consumer incentive to reduce the use of GHG-intensive goods. At the same time, it will increase producers' cash flow to invest in abatement technologies. The price signal will be distorted, however, if GHG costs cannot be passed through domestically or globally. In this case, the market structure, especially price elasticity of demand, inhibits globally-trading industries' ability to pass-through fully or even partially. As a result (European and global) product prices will not reflect the 'opportunity costs' of allowances and therefore the EU cost of carbon. For example, if firms in a European industry cannot pass through the allowance price partly or fully, they eventually end up 'paying' for the costs of the allowance price.² Failure to pass through erodes benefits the carbon benefits from CO₂ abatement as consumers do not see the price signal. In addition, this erodes producers' competitiveness and transfers

¹ Note, however, that a carbon price in developed countries would apply to all emissions whereas the carbon price in the CDM applies only to emission reductions. Accordingly, the potential for leakage due to the CDM is likely lower than due to a carbon price in developed countries.

² Full pass through is typically not possible in trade-intensive product markets where prices are set globally.

the allowance value abroad. Ultimately this could lead to carbon leakage³, which undermines the environmental effectiveness and possibly political acceptability.

The IEA (2008) has defined carbon leakage as the “ratio of emissions increase from a specific sector outside the country (as a result of a policy affecting that sector in the country) over the emission reductions in the sector (again, as a result of the environmental policy)”. According to the same study, the three most important reasons for carbon leakage initiated by uneven carbon constraints are: *i)* the short-term competitiveness loss, where carbon-constrained industrial products lose international market shares to the benefit of unconstrained competitors; *ii)* loss of investment, where differences in returns on capital provide incentives for firms to relocate capital to countries with less stringent climate policies; and *iii)* impacts due to fossil fuel effect, where reduction in global energy prices due to reduced energy demand in climate-constrained countries triggers higher energy demand and CO₂ emissions elsewhere. This latter aspect will not be treated in this scoping paper.

Studies on the loss of competitiveness under asymmetric carbon policies that could lead to carbon leakage of internationally trade-exposed, GHG-intensive industries is related to GHG mitigation costs (i.e. CO₂ costs have a significant impact on product prices) and at the same time high trade intensities. The latter means that EU industry can see its markets being challenged by foreign competitors as a result of uneven carbon policies. That can be through the need to surrender allowances for the direct emissions or the higher input prices as a result of increased power prices as a result of carbon policies imposed on the power sector. Although the risk of carbon leakage generally affects only a small portion of the GDP and a limited number of industries, impacts are most likely to be felt on a regional, sectoral and installation level. In addition, there may be knock-on effects for the down-stream supply chain of affected industry. Moreover, finally, the risk of carbon leakage will evolve over time, for example due to changes over time of the way sectors operate (e.g. sourcing strategies, changing transport costs, or changes of the world trade regime).

Empirically, carbon leakage under the ETS could not be measured to date. Phase 1 from 2005-07 for which ex-post analyses exist has limited relevance because the shortness of the period, the low and then collapsing carbon price and the level of over-allocation as well as the fact that this period was a pilot phase with rules subsequently having changed (see Ellerman, Convery and de Perthuis, 2010, pp. 195-234).

In the third phase (2013-2020), competitiveness is addressed by partial free allocation, which constitutes a form of compensation or, as some argue, a subsidy, potentially creating an incentive to continue producing in Europe. This compensation is justified on grounds – as was argued before that if firms in a European industry cannot pass through the allowance price partly or fully, they eventually end up ‘paying’ for the costs of the allowance price. This will be further dealt with in Part II on sectoral analysis on selected CDM projects.

2.2 Improving competitiveness with the CDM

The CDM is also meant to assist companies in the EU to lower their compliance cost by using CERs and therefore improve competitiveness. One of the two objectives of the CDM has been to ‘assist Parties included in Annex I in achieving compliance’ (Article 12(2) of the Kyoto Protocol). While the Kyoto Protocol makes no explicit mention of cost-efficiency, nevertheless in the EU and elsewhere the CDM has been interpreted as a means to achieve reductions in the EU in a cost-effective way. Recital 19 of the revised ETS Directive describes the mechanisms as “important to achieve the goals of both reducing global greenhouse gas emissions and increasing the cost-effective functioning of the ... scheme” (European Union 2009)

³ Carbon leakage occurs when there is an increase in GHG emissions in one country as a result of emission reductions in another country subject to a more stringent climate policy, mostly due to production relocation. Carbon leakage can also occur in countries whose emission targets exceed their expected emissions. If a long-term target such as under the ETS exists – e.g. an annual reduction rate – this leakage will only be temporarily or “borrowed” and will be even out over time. If no such long-term target exists, this kind of leakage will be real.

The extent to which the CDM (and other mechanisms) is able to positively affect competitiveness of industry in Europe by reducing compliance costs remains complex and depends on numerous conditions. First, a positive impact is only given if costs of developing a project lead to CERs being cheaper than EUAs and that sufficient volume is available to have an effect on the EUA price. This again will depend on which kind of CER credits are allowed under the ETS and volume of available eligible CERs, rules in host countries or the transaction costs for creating and importing CERs. The actual extent to which the use of off-set credits can reduce the EUA price and therefore compliance costs is difficult to assess with certainty because it would require an assumed BAU calculation of a baseline, i.e. what the EUA price would have been without the use of credits. However, ex-ante modelling studies exist, especially from the European Commission. The extended impact assessment on the 2004 Linking Directive calculated that unlimited use of JI and CDM credits would halve the expected allowance price to €13 per tonne of CO₂ (which is in the range of the current allowance price), thereby saving the EU €700 million (European Commission 2003). The 2008 impact assessment for the ETS concluded that allowing the use of JI/CDM credits in the ETS by 2020 equal to 5% of 2005 emissions would lower the carbon price from €39-€30 (European Commission 2008: pp. 14). The same document concluded that a EU unilateral independent commitment of 30%, by allowing CDM could be achieved at roughly the same costs as a 20% commitment without access to CDM (European Commission 2008: pp. 15).

Much of this is theoretical at the moment as EUA prices are expected to remain low because of the economic crisis. For example, according to the International Energy Agency World Energy Outlook 2009 (IEA 2009a: 182, the economic crisis has reduced GHG by 3% in OECD countries. This shifted the EU-15 – bound by a collective reduction commitment of 8% - from roughly -6% reductions in 2008 to around 9% reductions compared to 1990. For the EU-27, the IEA concluded that the business as usual development of the EU's emissions, i.e. under the current 20% reduction pathway would see them fall to 16% below 1990 levels by 2020. All projections agree that EUA prices will be significantly lower than original pre-crisis estimates, which the Commission set at around €32 (2008 prices) per tonne of CO₂ for the third phase 2013-20. The Commission's own estimates have been revised to €16 in 2020 (European Commission 2010b). Point Carbon (2010) forecasts a price of €15 to €28 (but €30 to €50 if the EU moves to a 30% emissions reduction goal); the UK Parliament Committee on Climate Change (CCC, 2009) has estimated €20 in 2020. Estimates can vary, depending for example on measures regarding CDM and JI or the design of auctioning rules.

Reducing price volatility?

Price volatility is another element of competitiveness. While price volatility is an integral part of any market, if it is 'high', it generally has a detrimental effect on investment. Lower investment could accelerate carbon leakage as production is shifted to other regions, where production processes may result in higher GHG emissions. So far volatility – outside the pilot phase – has been rather limited. Whether this might change in the future is unclear. We propose to ask to stakeholders on whether they expect a major risk of price volatility. If so, this section could be expanded. If not, it might be deleted.

Long-term perspectives

The situation changes in a long term perspective. The overall objective of the ETS is to "promote GHG reductions in a cost-effective and economically efficient manner" (Art. 1 of the ETS Directive, see: European Union 2009). This means that the over-arching objective is cost-effectiveness of a politically given target. On first view, this could be interpreted as a call for the lowest possible EU allowance price, for example including as many offsets as possible – provided they reflect real reductions to reach a given objective. While this is true in the short-term, for example to reach the 2020 targets, it masks the fact that over the long-term – 2050 and beyond – an efficient climate change policy will need to accelerate the development and diffusion of new and breakthrough technologies.

If not, the EU risks being locked-in into high-carbon technologies, which, once carbon carries a higher price – explicitly through taxation or emissions trading or implicitly through regulation – will result in its industry becoming uncompetitive. Therefore the ETS as well as other EU climate policies will need to be evaluated against their capacity to ensure the development and deployment of new low-carbon technologies, i.e. innovation in the broader sense. Innovation however depends on many factors. First of all it is driven by profitability, i.e. companies will invest in new processes and products if they are deemed almost immediately generating profits. The EUA price is an important element in this calculation but only one among others; other parameters such as a life cycle analysis, the total cost of ownership (TCO)⁴ but also investment years and cash issues, including access and the cost of capital, matter in a decision whether to invest or not.

⁴ TCO is a kind of financial estimate designed to help enterprise managers assess direct and indirect costs, i.e. a form of full cost accounting.

3 Part II: Sectoral analysis on selected CDM projects

Section Summary

This section describes potential pathways for activity shifting and emissions leakage due to the CDM. This section also presents a sample quantitative assessment of the relative incentives for activity shifting in selected trade-exposed industrial sectors.

Key findings include:

- The potential for emissions leakage is a function of the risk of activity shifting and the emissions intensity of that activity
- Some emissions abatement activities may be strongly cost-negative, increasing the potential profits from CDM projects. Our analysis suggests that clinker substitution in the cement sector and waste gas capture in the steel sector are two such abatement activities, both of which have experienced significant CDM activity to date.
- The decision on whether to shift production is a complicated decision with many factors. Our analysis and interviews suggest that, given the output-based allocation of allowances in the EU for energy-intensive, trade-exposed industry and intercontinental transportation costs, in most cases the CDM is unlikely to provide a significant incentive for activity shifting from the EU to developing countries. However, special cases may exist and further research may be warranted.

and thus demand, for fossil fuels. Given the limited impact of CDM on global or regional fossil fuels, especially due to activities in the sectors in question, we do not touch on this question in this paper.

In this paper, we do not distinguish between production from new and existing facilities. In the near term, CDM activities would be more likely to affect production at other existing facilities. However, over the longer term, sustained CDM incentives could well affect the investment and the location of new production facilities. Production facility investment and location are highly complex decisions that can be affected by a wide number of factors, in addition to relative marginal costs of production.

Figure 1. Effect on Global Emissions of a Shift in Production from non-CDM to CDM Plants

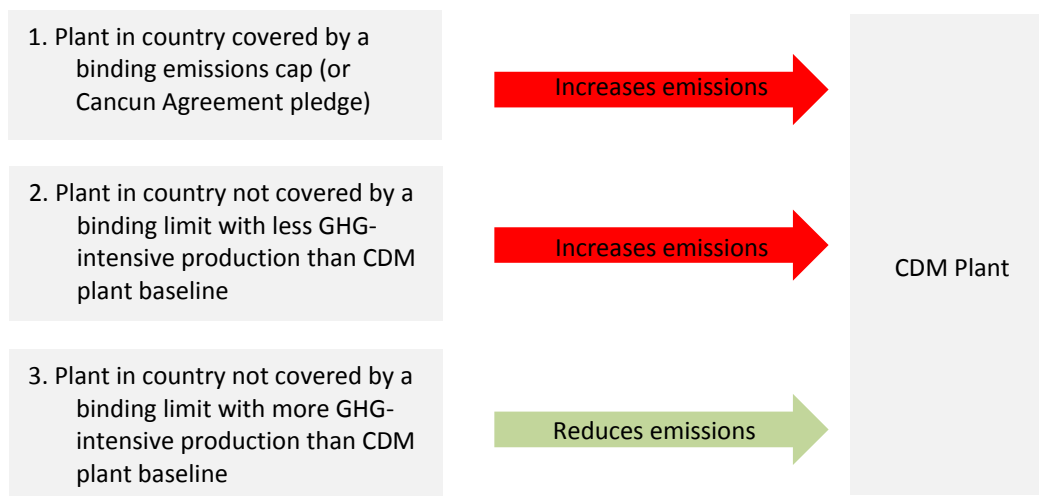
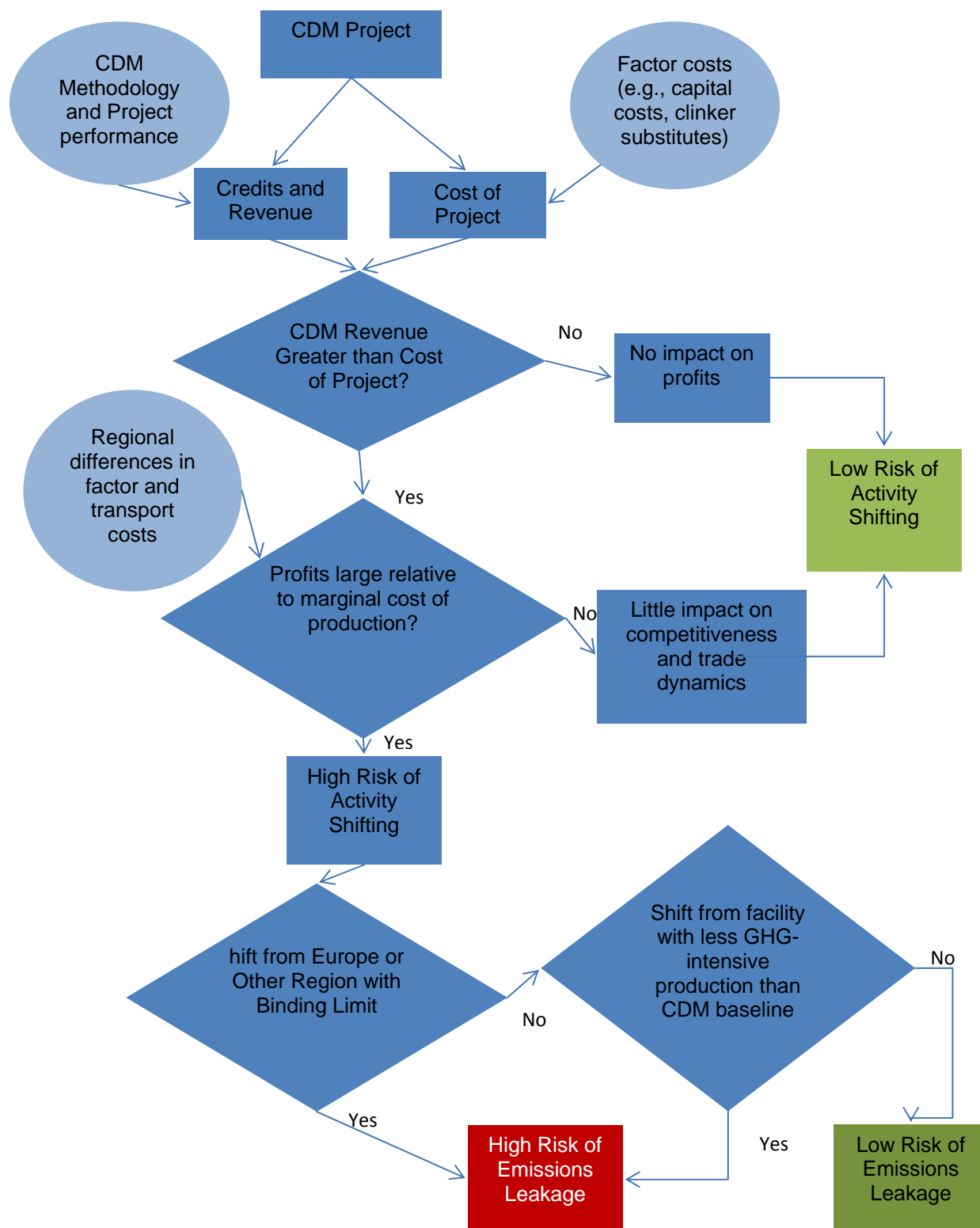


Figure 2 displays the pathway for leakage in more detail, including the factors to consider and key conditions that might lead to leakage under the CDM. One can consider that the scale of potential

⁵ We do not address energy market leakage that could arise when reduced energy (or other factor) use at CDM plants depresses energy (or other factor) prices, leading to increased demand for them and increased emissions.

emissions leakage is a function of both the risk of activity shifting and the emissions intensity of that activity.

Figure 2. Pathway for Emissions Leakage under the CDM



As displayed in Figure 2, three key considerations in assessing the potential for leakage are:

- **CDM revenue relative to the size of the cost of the project.** To induce shifts in production from other facilities, CDM revenue should, to first order, exceed the incremental abatement costs (net of any energy savings) associated with the project. If expected CDM revenue is large relative to the cost of the project, then large economic rents (profits) are possible. (Note that if a project is clearly non-additional, then its incremental costs might be as low as the transaction costs of a CDM project, or less than 1 euro/CER. Furthermore, the incremental costs might conceivably be negative – i.e. the project may lead to energy or other cost savings that effectively decrease production costs. If such projects occur because of CDM, e.g. by overcoming barriers, then the incentive could be as large as the sum of the cost savings and the CER revenue. We return to this below.)
- **Resulting profits relative to the marginal cost of production.** If CDM revenue does exceed the cost of the project, are these profits – which could be translated into lower effective production costs -- large relative to the marginal cost of production? If so, a significant incentive may exist for shifting production from one region to another to capture CDM revenues.
- **Where would the production shift from?** If activity shifts from a region with a binding emissions limit, emissions leakage will very likely result, as the emissions released at the CDM plant for the added production would not otherwise have occurred – yet emissions in the developed country will likely be unchanged.⁶ If activity shifts from a facility in a region without a binding limit but with less-GHG intensive production than in the CDM plant's baseline, then leakage would also likely result.

We will explore each of these key considerations below after first reviewing the status of CDM activity in three key industrial sectors.

3.2 CDM Activity

Table 1 summarizes the current state of aluminium, cement, and steel projects in the CDM. In particular, we estimate near-term and future (2020) CDM activity based on current activity in the UNEP Risoe Centre's CDM pipeline database (UNEP Risoe Centre 2011). The UNEP Risoe Centre classifies projects in the CDM pipeline by *Project Type* and *Project Sub-type*. We then characterize each project type and sub-type as belonging to the aluminium, cement, or steel industry, conducting further research into particular CDM methodologies or projects, where needed, to perform the classification. We also forecast CDM activity in particular project types and sub-types based on UNEP's methods,⁷ noting, however, that past trends of CER issuance may not be indicative of future trends, especially given the EU's intention not to buy CERs (except from least developed countries) registered after 31 December, 2012.

⁶ The decrease in production in the country with a binding limit will reduce emissions, freeing up room under the cap for other emissions to increase.

⁷ UNEP applies their method in their pipeline spreadsheets only at the *Project Type* level. We apply the same method at the *Project Sub-type* level to enable sufficient disaggregation for classification into Aluminium, Cement, or Steel sectors.

Table 1. Summary of CDM Pipeline for Projects in the Aluminium, Cement, and Iron and Steel Industries; SEI Analysis based on UNEP Risoe Centre (2011)

Sector	Project Type	Project Sub-Type ⁸	Number of Projects in Pipeline ⁹	Methodologies Used by These Projects	Expected Annual CER Flow From All Projects Currently in Pipeline (MtCO ₂ e) ¹⁰	Forecast 2020 CER Flow Based on Recent Project Inflow Rates (MtCO ₂ e) ¹¹	Developing Country Mitigation Potential (MtCO ₂ e in 2020)
Aluminium	EE Industry	Non-ferrous metals	3	AM59, AMS-II.B., AMS-II.D. ¹²	0.6	2.4	~20 to 90 ¹³
	EE Own Generation	Non-ferrous metals heat	11	ACM2, ACM4, ACM12, AMS-III.AG., AMS-III.Q.	0.3	1.3	
	PFCs and SF6	PFCs	6	AM30, AM59	0.6	1.8	
Cement	Cement	Clinker replacement	49	ACM3, ACM5, ACM15, ACM33, AMS-III.Q.	5.2	13.2	4 to 17 ¹⁴ 372 ¹⁵
	EE Industry	Cement	13	AMS-I.D., AMS-II.D., AMS-III.B.	0.1	0.3	
	EE Own Generation	Cement heat	178	ACM1, ACM2, ACM4, ACM12, AM24, AM49, AMS-I.C., AMS-I.D., AMS-II.D., AMS-III.Q.	8.3	21.6	
Iron & Steel – Primary	EE Industry	Coke oven	2	AMS-III.Q., AMS-III.V.	0.1	0.3	634 ¹⁵
		Iron & steel	9	ACM12, AM66, AMS-II.D., AMS-III.Q.	0.3	1.2	
	EE Own Generation	Coke oven gas	64	ACM2, ACM4, ACM12	8.7	22.0	
		Iron & steel heat	148	ACM2, AM4, ACM12, AMS-I.C., AMS-I.D., AMS-II.D., AMS-III.Q.	20.3	38.4	
Iron & Steel - Secondary	EE Industry	Iron & steel	~2	AMS-II.D.	<0.1	0.1	
	EE Own Generation	Iron & steel heat	~2	ACM4, ACM12	0.2	0.4	

⁸ UNEP Risoe Centre classifies projects according to *Project Type* and *Project Sub-type*, a classification we repeat here. We then classify *Project Type* and *Project Sub-type* by *Sector*, in some cases after reviewing the methodologies used by projects flagged by UNEP Risoe as belonging to a particular *Project Type* or *Project Sub-type*.

⁹ Per <http://cdmpipeline.org/cers.htm>, 2011, excluding projects that have been withdrawn, had validation terminated or negative, or rejected.

¹⁰ Per the UNEP Risoe Centre's method for forecasting CER volumes based on past issuance success rates, registration delays, and other factors. Accordingly, this expected CER flow is somewhat lower than the stated "first period CERs/year" as listed in the pipeline database.

¹¹ Based on the average new project inflow rate observed in 2008 through 2010 continuing through 2020 and accounting for factors as in previous footnote.

¹² Includes all methodologies for this sub-type, as >97% of the CERs are improvements to an aluminium smelter while the rest are undetermined.

¹³ Rough estimate based on figure 5.20 in IEA (2010) and assuming that 2/3 of abatement potential is in developing countries, that ¼ of abatement potential is in indirect emissions savings.

¹⁴ 4.2 per the US EPA's assessment of non-CO₂ emissions mitigation (US EPA 2006). Emissions reductions are for the Technology-Adoption baseline (which assumes global aluminium producers reduce PFC emissions intensity per IAI commitments), in non-Annex I countries, in 2020 (with breakeven costs for aluminium production at 10% discount rate and 40% tax rate).

¹⁵ Per McKinsey & Company's version 2.1 cost curve (2010), as accessed in the online *Climate Desk* application, for the year 2020 for the regions Brazil, Mexico, Rest of Latin America, China, India, Rest of Developing Asia, South Africa, Rest of Africa, and Middle East

As indicated in Table 1, the cement and primary steel sectors have been much larger sources of CERs than the aluminium or secondary steel sectors. In addition, absent the development of radically new methodologies for aluminium and secondary steel (unlikely at this point), these same sectors can be expected to continue to be the dominant sources of CERs from energy-intensive heavy industry, as shown in the projections out to 2020. This finding suggests that these sectors may warrant a closer assessment of leakage potential.

3.3 Costs of Production and GHG Abatement

As Figure 2 indicated, the costs of implementing CDM projects and the costs of producing each material are important for understanding potential incentives for leakage.

As a proxy for costs of implementing CDM projects, we turn to cost analysis by McKinsey and Company (McKinsey & Company 2010) and the US EPA (US EPA 2006). Abatement costs (in euros per ton CO₂e) for measures implemented in developing countries and analyzed by these researchers are presented in Table 2. We present results for two different discount rates (where available), since private sector investors may use discount rates of 10% (or more), higher than that used (4%) in McKinsey's core results. As seen in the table, costs for clinker substitution in the cement sector and for co-generation (from captured waste gases) in the steel sector are options with strongly negative costs in developing countries and might therefore be measures with a high potential for significant profits.

Table 2. Cost of Abatement Measures in 2020 (Euros/tCO₂e)

Sector and Abatement Measure	EU-27 ¹⁶		Developing Countries ¹⁷	
	4%	10%	4%	10%
Discount rate:				
Aluminium				
PFC ¹⁸	N/A	€11-13 ¹⁹	N/A	€10-11 ²⁰
Cement				
Alternative fuels	€5	€11	€5	€11
Clinker substitution	-€26	-€36	-€19	-€29
Waste heat recovery	-€10	€82	-€45	€10
Steel				
Co-generation (waste gas capture)	-€138	-€109	-€95	-€86
Energy efficiency	€29	€43	€14	€54
Process improvements and fuel-switching ²¹	€38	€43	€19	€34
Switch BOF to EAF	€207	N/A	€133	€124
CCS	N/A	N/A	N/A	N/A

If profits are large relative to the (marginal) cost of production, then industries may have incentive to increase production at facilities where CER revenues lead to significant profits, at the expense of other facilities, leading to activity shifting.

We explore this question further in two steps: first, by looking at CDM revenues relative to approximate production costs, and then by comparing these revenues relative to the costs of the projects. For potential CER issuance in each sector, we use a combination of sector-specific reports by other analysts and our own review of CDM Project Design Documents for a common project activity in each sector. As seen in the table, potential CER revenues would represent a small fraction of estimated production costs (1% to 7%) at 10 euros per ton (a rough estimate of the prices paid for primary CERs, discounted for

¹⁶ Per McKinsey & Company's version 2.1 cost curve (2010), as accessed in the online *Climate Desk* application, for the year 2020 for the regions France, Germany, Italy, United Kingdom, and Rest of EU27 (with the exception of Aluminium PFC).

¹⁷ Per McKinsey & Company's version 2.1 cost curve (2010), as accessed in the online *Climate Desk* application, for the year 2020 for the regions Brazil, Mexico, Rest of Latin America, China, India, Rest of Developing Asia, South Africa, Rest of Africa, and Middle East (with the exception of Aluminium PFC).

¹⁸ Per the US EPA's assessment of non-CO₂ emissions mitigation (US EPA 2006). Abatement costs presented are for the range between the Technology-Adoption baseline (which assumes global aluminium producers reduce PFC emissions intensity per IAI commitments) and No Action baseline, in 2020. Note that we do not currently have abatement cost estimates for other abatement options in the aluminium sector.

¹⁹ For EU-15.

²⁰ For Non-Annex I countries.

²¹ Includes direct casting, smelt reduction, and coke substitution.

delivery and other risks). At higher CER prices (e.g., 30 euros per ton), CER revenue could represent 2 to over 20% of production costs.

Table 3. Potential Scale of CER Revenue Relative to Product Value (per Ton of Product) in 2020

Sector	Approximate Production Costs ²² (EUR/ton product)	Common CDM Project Activity	Potential CER Yield (tCO ₂ e/ ton product)	Average CER Revenue (EUR/ton product and as % of production costs)	
				@ €10/ton CO ₂ e	@ €30/ton CO ₂ e
Aluminium	1,500	PFC reduction	3 ²³	30 (2%)	90 (6%)
Cement	14	Clinker substitution	0.1 ²⁴	1 (7%)	3 (21%)
Steel	450	Waste gas capture and cogeneration	0.3 ²⁵	3 (1%)	9 (2%)

Table 3 suggests that CER revenues, on their own, are unlikely to provide a major incentive for activity shifting, as was found, for example, in the case of adipic acid production (Schneider, Lazarus, and

Sector	Approximate Production Costs (EUR/ton product)	Common CDM Project Activity	Potential CER Yield (tCO ₂ e/ ton product)	Average CER Revenue (EUR/ton product and as % of production costs)	
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Aluminium	1,500	PFC reduction	3	30 (2%)	90 (6%)
Cement	14	Clinker substitution	0.1	1 (7%)	3 (21%)
Steel	450	Waste gas capture and cogeneration	0.3	3 (1%)	9 (2%)

Kollmuss 2010). In the case of adipic acid, CDM project activities have yielded 82 CERs per ton of adipic acid produced. Since adipic acid costs 650 to 1,500 Euros per ton to produce, the value of CER revenue is on a similar scale as production cost.

However, the data presented here for aluminium, cement, and steel are coarse approximations, using CER yields from a limited review of CDM project design documents, and it is possible that facilities that start out at much higher emissions intensities than those in the CDM projects reviewed could potentially see CER revenues at a significantly higher fraction of their production costs. Furthermore, if multiple types of abatement measures (e.g., clinker substitution and kiln efficiency upgrades) were pursued simultaneously and issued CERs, the CER yield per ton of product could be greater.

Furthermore, as indicated in Table 2, economic returns of some project types – particularly clinker substitution in cement production and waste gas capture and cogeneration in iron and steel production – could be particularly high. For example, Table 4 shows that, if cost savings from clinker substitutions

²² Production cost for cement is from Cook (2009) for China, the largest single-country importer of cement to the EU in the last decade, converted from USD to EUR at the rate of 0.7 EUR = 1 USD. Production costs for aluminum and steel are approximated here by looking at the value and weight of aluminum and steel imports into the EU in 2009 per the UN's Comtrade database (UN Statistics Division 2011) of 2650 and 799 USD per ton, respectively, and assuming that production costs are 80% of revenues, which appears to be a reasonable average based on review of company financial statements (cost of revenue divided by total revenue) of large companies in each sector as available on www.morningstar.com. Because production costs in developing countries may be less than the average production costs of all imports to the EU, the estimates of production costs for the aluminum and steel sector here may be overestimated.

²³ A CER yield of 3 t CO₂e is possible when reconstructing a plant from a very high-emissions intensity anode type (e.g., Søderberg) to a low-intensity anode type (e.g., point-fed prebake). For example, project CDM3608 has done just that. However, most PFC-reduction projects in the aluminum sector yield roughly a tenth as many CERs.

²⁴ McKinsey (2009) reports abatement potential in developing countries of about 0.1 tCO₂e per ton of cement in 2015 due to clinker substitution. This is a reasonable average given a brief review of three CDM projects (CDM0325, CDM0433, and CDM6853).

²⁵ Average CER yield reported by Wooders et al (2009) for steel sector projects in China and India is 0.1 to 0.2 tCO₂e per ton steel. However, some projects (e.g., CDM0269, CDM4041) yield 0.3 tCO₂e or more. We use a figure of 0.3 tCO₂e per ton of steel to be conservative.

were realized as in McKinsey's assessment, then, when also considering CER revenues, profits could exceed 40% of production costs should CER prices offered to project developers reach 30 euros.²⁶

Table 4. Potential Scale of Project Profits (per Ton of Product) for Selected Abatement Measures

Sector	Abatement Measure	Approximate Production Costs ²⁷ EUR/ton product	Cost of Abatement Measure ²⁸ EUR/ton product	Average CER Revenue EUR/ton product		Profit (Revenue – Cost) (EUR/ton product and as % of production costs)	
				@€10/ton CO ₂ e	@€30/ton CO ₂ e	@€10/ton CO ₂ e	@€30/ton CO ₂ e
Aluminum	PFC Reduction	1,500	30	30	90	0 (0%)	60 (4%)
Cement	Clinker Substitution	14	-3	1	3	-4 (28%)	-6 (42%)
Steel	Co-generation (waste gas capture)	450	-26	3	9	-29 (6%)	-35 (7%)

Manufacturers considering shifting or relocating production are faced with a complex decision involving many variables, however. For example, consider the hypothetical case of a manufacturer with facilities in both the EU and North Africa. In the EU, the manufacturer faces a carbon cost in the EU-ETS, whereas in Africa the facility could implement a CDM project and sell CERs. Figure 3 displays the relative incentives provided by the EU-ETS and CDM for a hypothetical, inefficient cement manufacturer in the EU considering relocating production to a CDM plant.

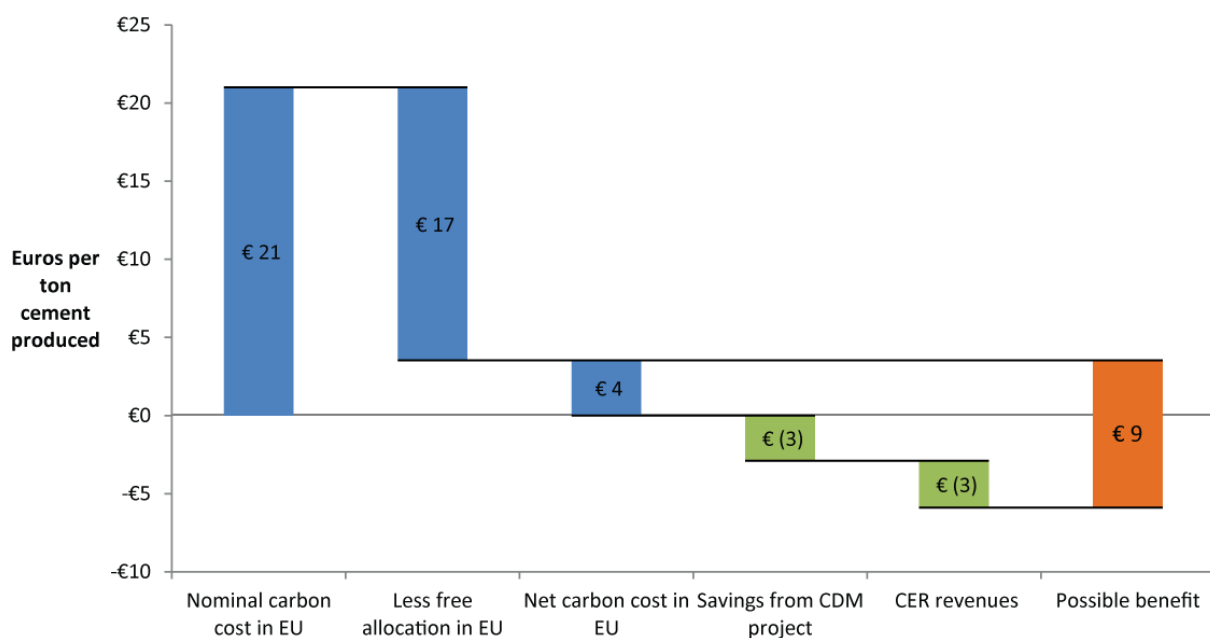
²⁶ As a point of comparison, the CDM Executive Board estimates that expected returns (profits) on equity, or capital, for manufacturing industries in most developing countries average between 12 and 16%. While not directly comparable to profits in Table 4, which are expressed as function of production costs, this range suggests the level of profit commonly expected from investments. By that measure, profits listed here for particular emissions abatement measures could be substantial, especially for the cement sector. Expected return on equity range taken from http://cdm.unfccc.int/Panels/meth/meeting/10/046/mp46_an10.pdf.

²⁷ Production cost for cement is from Cook (2009) for China, the largest single-country importer of cement to the EU in the last decade. Production costs for aluminum and steel are approximated here by looking at the value and weight of aluminium and steel imports into the EU in 2009 per the UN's Comtrade database (UN Statistics Division 2011) of 2650 and 799 USD per ton, respectively, and assuming that production costs are 80% of revenues, which appears to be a reasonable average based on review of company financial statements ("cost of revenue" divided by total revenue) of large companies in each sector as available on www.morningstar.com.

²⁸ At 10% discount rate and assuming the abatement potentials from

Sector	Approximate Production Costs (EUR/ton product)	Common CDM Project Activity	Potential CER Yield (tCO ₂ e/ ton product)	Average CER Revenue (EUR/ton product and as % of production costs)	
				@ €10/ton CO ₂ e	@ €30/ton CO ₂ e
Aluminium	1,500	PFC reduction	3	30 (2%)	90 (6%)
Cement	14	Clinker substitution	0.1	1 (7%)	3 (21%)
Steel	450	Waste gas capture and cogeneration	0.3	3 (1%)	9 (2%)

Table 3.

Figure 3. Possible Relative Incentives Provided by EU-ETS and the CDM for Shifting Production of Cement from an Inefficient Plant in the EU-ETS to a CDM Plant in a Developing Country²⁹

²⁹ We calculate the nominal carbon cost in the EU assuming an allowance price of 30 Euros, emissions for the hypothetical plant at the 90th percentile of 0.921 tCO₂e per ton of clinker (Ecofys, Fraunhofer Institute, , and , Öko Institut 2009), and a clinker-to-cement blending ratio of 76% (CSI 2009). We calculate the free allocation based on a benchmark of 0.766 tCO₂e per ton clinker (European Commission 2011). Savings from CDM project and CER revenues are as in Table 4.

Are these potential increased profits – €9 in this example – enough to cause manufacturers to relocate production activity? An in-depth exploration or modeling analysis of the complicated dynamics and decisions faced by manufacturers in where to locate production was beyond the scope of this study. Several other factors would need to be considered, such as the ability of EU producers to pass through carbon costs to consumers in the EU and the relative transportation and production costs between the EU and CDM host countries.³⁰ One previous analysis that explored similar questions for cement found costs for transporting cement between Europe and North Africa of about €30/ton (Cook 2009). If producing cement cost €16/ton less in North Africa than in the EU,³¹ then the costs of shifting production to Africa would be €14/ton, greater than the possible benefit of €9/ton presented in Figure 3. This simple (and limited) comparison suggests that, given transportation costs, manufacturers would be unlikely to shift production of cement based on the relative incentives provided by the EU-ETS and the CDM. Further insights can perhaps be gained by looking at modeling exercises of the effects of EU-ETS on competitiveness, but none could be identified that specifically considered the effect of the CDM. One modeling exercise of the cement sector under the EU-ETS found that at EUR prices of €30/ton and a free, output-based allocation covering more than 75% of the cement sector emissions (which also describes the case explored in Figure 3), production impacts and leakage were “insignificant” (Demailly and Quirion 2006). However, considering the additional incentive, or opportunity cost, of the CDM, the effect on profits of the hypothetical, inefficient plant in Figure 3 would more than double, leading to what could be a “severe” leakage risk for some plants, at least in those authors' assessment.³²

³⁰ In addition, the incentives may be different for the decision to shift production between existing facilities and the decision to build a new facility in a developing country, a factor we did not explore in our analysis.

³¹ €16/ton is the difference in production costs between the EU and China in Cook (2009) and is assumed here to be the same as for North Africa, which was not reported in that study.

³² Considering the opportunity cost of the incentive provided by the CDM, the free allocation in Figure 3 for a plant with emissions at the 90th percentile covers about 65% of carbon costs. Based on Figure 7 and Figure 10 in Demailly and Quirion (2006), this translates to an impact on production and profits of about 10%, where those authors characterize anything over 5% as “severe”.

4 Part III: Reform Options

Within the EU as well as the UN negotiations, various options for reform have been discussed. At this stage they remain hypothetical with many (most) design options still undecided. This makes it impossible to assess in detail whether they may be able to address competitiveness/leakage issues and other issues that have been addressed in Part I. In most cases, the key element is the baseline and associated crediting rules, which will be decisive as to incentives and rewards. A brief overview of new mechanisms will show this.

- *Reform within the Clean Development Mechanisms:* Programmes of Activities (PoAs) are a programmatic version of the CDM, registering a set of activities of the same type under a single umbrella. Sectoral benchmarking in the CDM credits emissions reductions below the baseline based on a pre-determined benchmark for a sector or a sub-sector. Expansion of the scope to sectoral and programmatic activities could help to strengthen the CDM and address more mitigation opportunities. It is unclear on whether this reform could address leakage.
- *Sectoral crediting:* A sectoral crediting mechanism (SCM) credits emissions reductions from a covered sector against a threshold possibly below the business as usual (BAU) scenario. The main difference from the CDM is to expand the coverage moving beyond offsetting. An SCM based could be based on a no-lose target or not. A no-lose targets means that the host country will be rewarded for its over-performance in the sector above the threshold but will not be penalized for its under-performance, hence 'no-lose'. There are a variety of design options. The baseline can be negotiated as part of an international agreement between parties or domestically set on the basis of a sectoral benchmark. For example, the baseline could be based on the EU benchmarks used for free allocation under the ETS. The baseline could be expressed in absolute emission levels, the carbon intensity or technology penetration rates. A technical merit of sectoral crediting is to circumvent the additionality test on a project basis. An SCM assesses the performance of a whole sector performance instead of individual activities. On the other hand, from a firm perspective, its individual over-performance will not necessarily lead to direct rewards if other firms in the same sector do not live up to the promise they made. Hence, another variation is i) credits are issued to the host country, which benefits participating firms or installations via a cap-and-trade scheme, benchmarking exercise or other domestic measures; or ii) credits are issued directly to these firms or installations.

Sectoral trading refers to a cap-and-trade scheme applied to a whole sector or a sub-sector within a country (e.g. an ETS for aviation), and in this respect it can be regarded as a step beyond sectoral crediting based on no-lose targets towards an economy-wide cap-and-trade. Such a move can be done by gradually tightening the negotiated baselines and converting them into absolute caps. If the baselines are already expressed in absolute terms, such a conversion would be technically easier. Sectoral trading aims at addressing countries that are not yet ready to take on binding economy-wide targets but are prepared to take on binding targets in key sectors, such as power and industry. Emissions allowances will be allocated to the host country's government, reflecting binding sectoral targets. Governments will be responsible for reducing emissions in particular sectors to a pre-determined level. This level would be the basis for cap-setting in a domestic sectoral trading scheme. The government will then decide how to allocate emissions allowances within the relevant sector. If the government has taken on a binding target for the sector, the sectoral cap-and-trade scheme would be mandatory in principle. There are a number of challenges: for example, boundary setting and consideration of specific circumstances of a country, a sector, or a technology in baseline setting. Presumably the industry structure and boundary may vary from country to country, as pointed out in the context of sectoral crediting.

5 Part IV: Recommendations for Further Research

Through our review of high level data and cost estimates, we have found little evidence to suggest that the CDM has provided sufficient profit or production cost advantages to result in significant shifts in global aluminium, cement, or steel production, or any consequent leakage of emissions. Furthermore, in limited interviews to date -- with a noted analyst of carbon leakage, a long-time CDM expert, and an industry association representative³³ -- we have yet to uncover any indication that emissions leakage is a risk in these sectors. However, as the interviewees noted, little work has been done along these lines (for CDM projects). Furthermore, as we have dug deeper, we have found that, for example, concerns have been raised that crediting projects for increasing the use of clinker substitutes might lead to the reduced production of low-carbon cement elsewhere in a given country/region.³⁴ While not a global competitiveness issue per se, this situation suggests there may be some incidence of actual or potential future leakage among the sectors considered.

At the same time, the CDM or other offset mechanisms could – in theory – address competitiveness concerns by reducing the EUA price and therefore compliance costs. A number of ex-ant studies have identified that potential. To date, this questions remains largely theoretical as EUAs prices are expected to remain low with the EU facing the ‘challenge’ of providing an ‘adequate’ carbon price that gives incentives to move to low-carbon technologies. The CDM or other off-set mechanisms could also be a tool to address EUA price volatility, which can negatively impact competitiveness as it reduces incentives for investment. Also this question remains hypothetical as there is no indication on the level of future price volatility.

For the long-term the situation is more complex. Low EUA prices are likely to be have negative effects on development and deployment of low-carbon technologies. However, the EUA price is but one factor or many. Others are technology support mechanisms, the rate of investment or market expectations.

To address some of the open questions and to further quantify leakage risks, further research would be required on:

- the production, use, and trade in cement substitutes (e.g. slag and fly ash) in order to characterize the potential scale of leakage risk;
- the extent of reduction in emissions intensities associated with actual CDM projects and actual production cost data (from economic models) in order to refine our assessment of relative incentives (CER revenue/production cost);
- economic assessments of leakage impacts of carbon pricing in the EU ETS (or in other developed regions), and whether we can parameterize their results to the differential economic incentive provided by the CDM; and,
- Examine the impact that the new and reformed mechanism could have on competitiveness/carbon leakage, compliance costs or price volatility.

³³ Suzanne Droege, Axel Michaelowa, and Howard Klee.

³⁴ This might be more of an issue with a new proposed standardized methodology for the cement sector (NM302) as proposed by the Cement Sustainability Institute.

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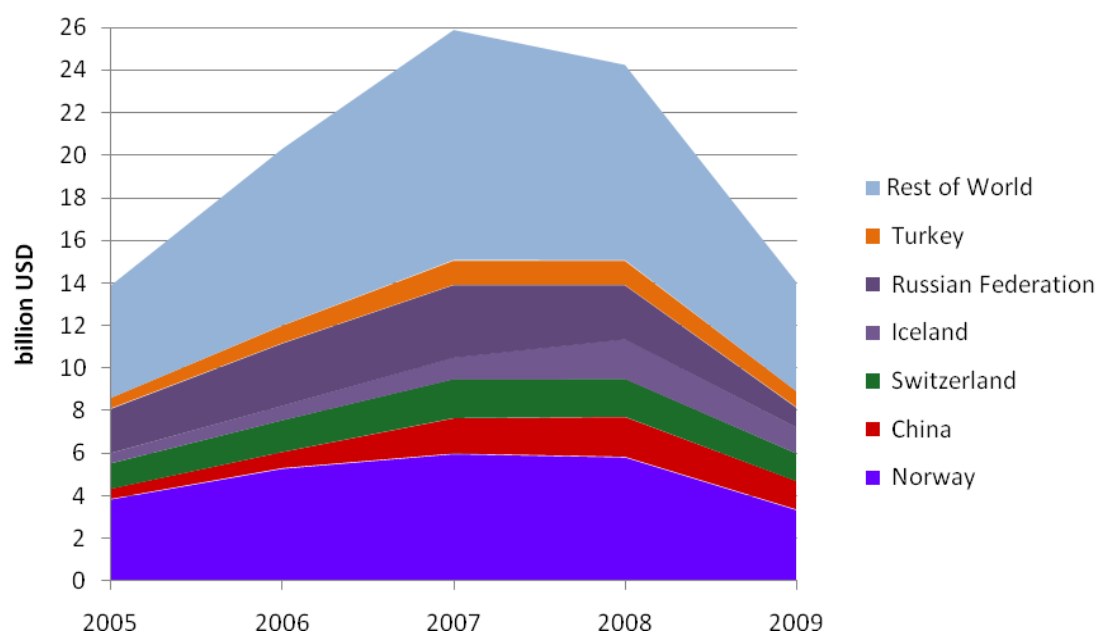
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7 Appendix – Additional Charts and Tables

Table 5. EU-27 Trade in 2009 in Aluminium, Cement, and Steel (UN Statistics Division 2011)³⁵

	Aluminium		Cement		Steel	
	Total	Scrap	Total	Clinker Only	Total	Scrap
Exports						
Value (billions USD)	\$10.6	\$1.3	\$0.9	\$0.3	\$32.3	\$5.2
Quantity (million metric tons)	2.7	1.1	11.8	4.6	42.6	15.7
Value per Quantity	\$3,930/ton	\$1,200/ton	\$75/ton	\$58/ton	\$758/ton	\$331/ton
Imports						
Value (billions USD)	\$14.0	\$0.3	\$0.8	\$0.3	\$22.6	\$1.5
Quantity (million metric tons)	5.3	0.3	9.7	4.3	28.3	3.3
Value per Quantity	\$2,650/ton	\$1,200/ton	\$82/ton	\$66/ton	\$799/ton	\$451/ton

Figure 4. Aluminium Imports to the EU-27 Since 2005



³⁵ Figures presented for scrap and clinker are also included in the totals.

Figure 5. Cement Imports to the EU-27 Since 2005

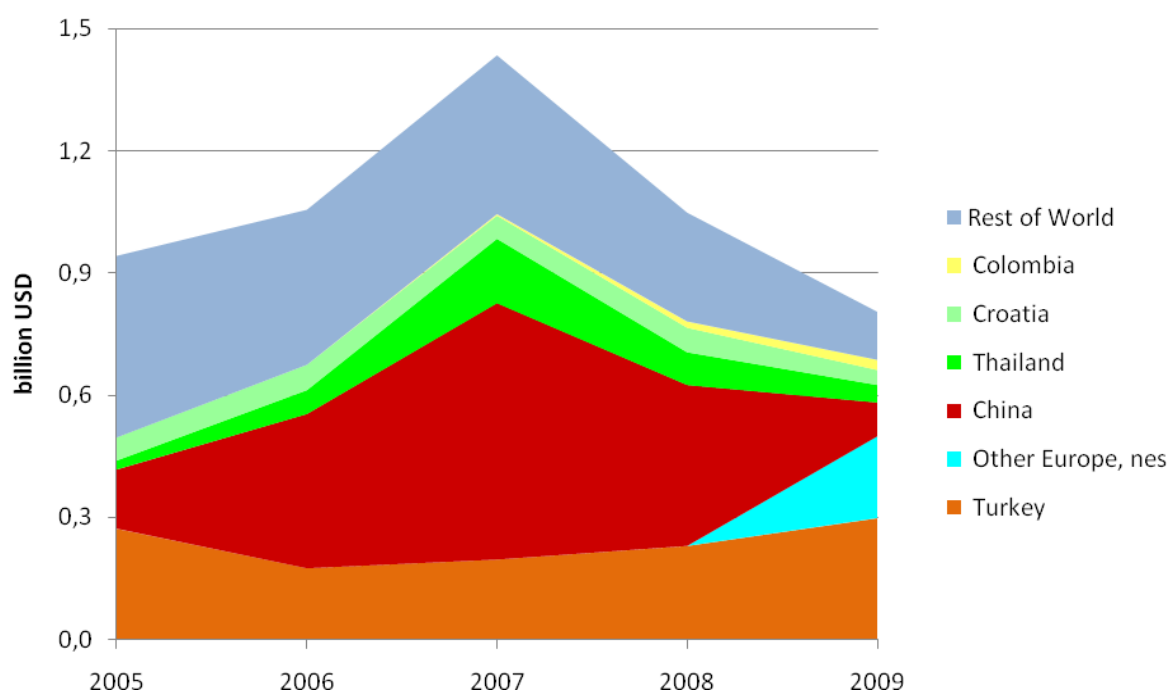
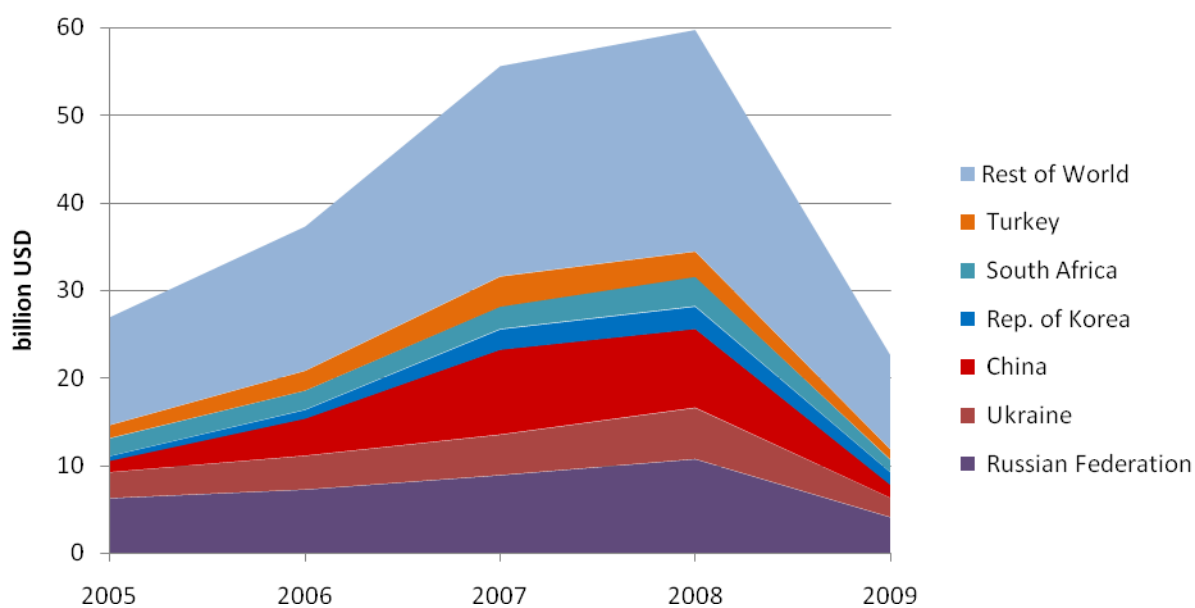


Figure 6. Iron and Steel Imports to the EU-27 Since 2005



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