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SECTORAL APPROACHES TO GREENHOUSE GAS MITIGATION

Exploring Issues for Heavy Industry

IEA Information paper

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Table of Contents

List of Figures

List of Tables

Executive Summary

Introduction and scope

This paper explores sectoral approaches as a new set of options to enhance the effectiveness of greenhouse gas reduction policies and to engage emerging economies on a lower emission path. It surveys existing literature and recent policy trends in international climate change discussions, and provides an overview of sectoral approaches in specific of trade-exposed, greenhouse-gas intensive industries (cement, iron and steel and cement). It is also based on interviews conducted by the IEA Secretariat in Australia, China, Europe, Japan, and the United States. Sectoral approaches were also discussed during workshops on technology and energy efficiency policies in industry, following the IEA's mandate under the Gleneagles Plan of Action.

At their meeting in Heiligendamm, the G8 leaders summarised the challenges ahead for climate policy: they recognise "*that the efforts of developed economies will not be sufficient and that new approaches for contributions by other countries are needed […] Action of emerging economies could take several forms, such as sustainable development policies and measures, an improved and strengthened clean development mechanism, the setting up of plans for the sectors that generate most pollution so as to reduce their greenhouse gas emissions compared with a business as usual scenario.*" Further, the communiqué stresses the need for "*policy frameworks that co-ordinate rather than compete with each other* […]" As countries embark on a new round of climate policy negotiations, they need to consider the implications of various emission goals, starting from their knowledge of potentials for greenhouse gas reductions, and their cost.[1] In parallel, we observe also country pledges on energy efficiency and international collaboration on specific sectors, including industry.

With the implementation of binding emission targets in some parts of the world (e.g. under the EU emissions trading scheme), trade-exposed and emissions-intensive activities have flagged the competitive distortions coming from the lack of similar efforts taken elsewhere.[2] The existing dichotomy between Annex I and non-Annex I Parties under the UNFCCC only reinforces such concerns[3].

We identified three broad interests underlying the possible development of sectoral approaches:

1. *To address competitiveness concerns*. To engage certain emitting activities on a more global basis in an attempt to alleviate these concerns, as well as to ensure the sustainability of sectors that are especially GHG-intensive.
2. *To start engaging countries in a global GHG reduction effort*, through sector-specific objectives and instruments.
3. *To build commitments from a bottom-up sectoral analysis*. The evaluation of mitigation potentials on a sectoral basis would be a starting point for setting future country-level greenhouse gas commitments.

Because of its emphasis on heavy industry, the present report touches primarily on the first two aspects, with some discussion of issues related to the third.

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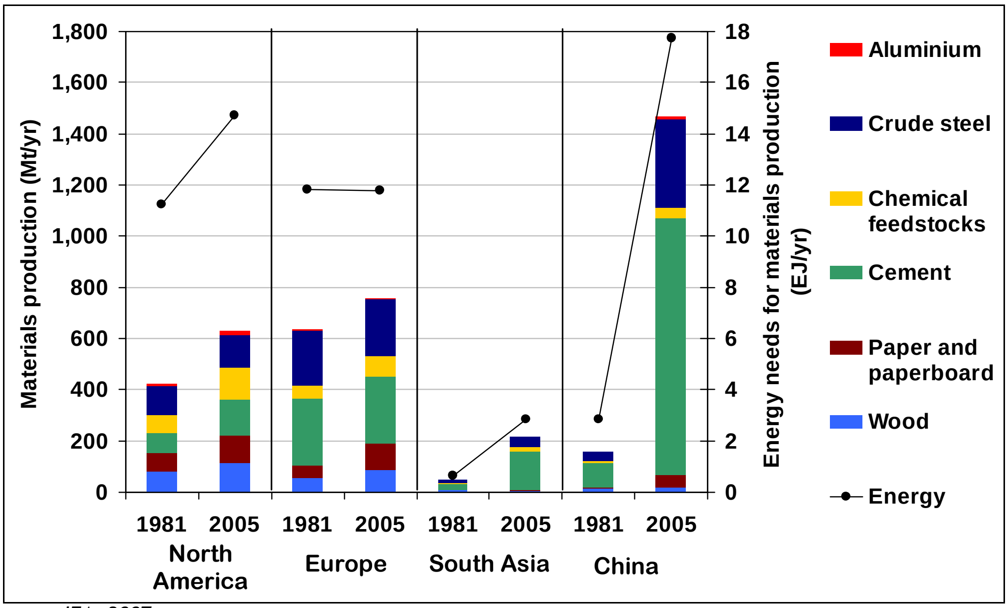
[1] The Intergovernmental Panel on Climate Change, in its survey of the literature on the mitigation of climate change, confirms that significant reductions in GHG emissions will require imposing a cost on emissions (IPCC, 2007). When, how and where such cost is implemented is of paramount importance for the effectiveness of mitigation efforts.

[2] In the conclusions of its May 2006 meeting, the *Ad hoc working group on further commitments for Annex I Parties under the Kyoto Protocol* (AWG) included "*Emission trends and mitigation potential of Annex I Parties (d) Sectoral analyses and impacts on competitiveness*" in its indicative list of topics for further work (UNFCCC, 2006).

[3] The Russian delegation has tabled a proposal for voluntary commitments by developing countries. Yet to date, no developing country has come forward with a voluntary commitment to limit emissions.

The three sectors covered in this report (aluminium, cement, and iron and steel) currently account for more than 10% of global GHG emissions and are growing rapidly, under the impetus of China, but also India and other emerging economies (Figure 1).

Figure 1: Output growth and energy use of heavy industry (selected regions, 1981-2005)



Source: IEA, 2007c.

From the standpoint of climate policy-makers, sectoral approaches (SA) could be a vehicle to enhance the effectiveness, and broaden the scope of GHG mitigation efforts. Emission trends over the last decade clearly indicate that developing countries will soon surpass industrialised countries in terms of energy-related CO_2 emissions – in spite of still fairly low emissions on a per capita basis. These countries have legitimate development priorities, but they also face growing energy and environmental problems and have started taking measures with potentially positive effects on CO_2 emissions. This may indicate an avenue for a bottom-up international collaboration. The identification of best policy practice for energy efficiency, as mandated to the IEA by the G8 leaders in Gleneagles, may provide useful input to further discussions.

Sectoral approaches and competitiveness

Part of the discussion on SA has been prompted by competitiveness concerns arising from the introduction of CO_2 policy mitigation costs in some parts of the world and not in others – with the possibility of carbon leakage as a detrimental consequence: emissions reduced in one region would be partly offset by emissions increase elsewhere. This competitiveness concern applies mostly to energy and emissions-intensive, trade-exposed industries, i.e. activities that would support a high mitigation cost and can see their product's market challenged by foreign competitors as a result. Aluminium, cement and iron and steel fit in this category, although at various degrees. At the same time, if the reality of GHG mitigation costs cannot be denied - at least for some countries - international competition and investment choices in heavy industry are driven by many factors, of which energy cost is only one. Disentangling its particular role - and the role of climate policy therein - proves analytically difficult and so does the design of policies to deal with the possible effects on competitiveness.

One caveat against sectoral approaches is the risk to create "CO_2 havens" for the sectors involved, with marginal costs of reductions that could differ from that faced by other activities. Any significant difference in marginal cost would indeed lead to a higher total cost of GHG reductions. Another risk is that of "forum-shopping" – the possibility to bring the negotiation of goals where the less stringent objective is likely to be found. In the end, if SA are to solve concerns on competitiveness, they should meet the following three criteria:

- *Environmental effectiveness*: Do SA help to introduce meaningful GHG mitigation objectives?
- *Fairness*: Without pretending to set a perfectly level playing field, does the proposed approach address existing distortions due to uneven carbon constraints?
- *Cost-effectiveness*: Do SA run the risk of setting different carbon costs applied to different activities?

Defining sectoral approaches

While the term "sectoral approach" (SA) appeared recently in international climate policy debates, some international sectoral approaches have been in place for years, and already contributed to GHG reductions. Pledges on GHG emissions and performance have been initiated by industry, including under the aegis of the International Aluminium Institute (IAI), or the World Business Council on Sustainable Development's Cement Sustainability Initiative (CSI), and are being developed further, with the hope to influence policy. The International Iron and Steel Institute issued a statement along these lines earlier this year – and has been coordinating a set of research and development programmes on low-CO_2 steel making (the CO_2 breakthrough programme). Other examples of sectoral approaches include the EU emissions trading scheme (EU ETS), although if it covers similar activities across now 27 countries, it does not prescribe –yet– a harmonised approach for each sector. Bringing together Australia, China, India, Japan, South Korea, the United States, and more recently Canada, the Asia-Pacific Partnership for Clean Development and Climate (APP), a non-binding public-private initiative seeking to help the diffusion of best practice to improve energy efficiency, energy security, local and global environment effects, across a range of activities is another example of a sectoral approach. These initiatives differ in their participants' motivations, geographical scope, their legal nature, and the cost associated with emission reductions.

With the above-mentioned scope in mind, four broad categories of SA were identified:

1. **Country-specific quantitative approach**: A country's initiative limited to a sector, recognised by the international community (e.g. UNFCCC Parties). Here, one could envision the possibility to credit greenhouse gas emission reductions on a sectoral basis, while the existing Clean Development Mechanism does so at project level only.
2. **Sustainable development policies and measures** (SD-PAMs). A country would pledge a policy that delivers both sustainable development objectives and, incidentally, lower greenhouse gas emissions. This pledge would be made to the international community (e.g. the UNFCCC conference of the Parties).
3. **Transnational quantitative sectoral approach**. The most challenging of all options, these would aim at engaging a sector on a broad international basis.
4. **Technology-oriented approaches**. These range from pooled or coordinated R&D on innovative, low-GHG technologies, to activities towards the diffusion of existing technologies.

Case studies in industry

A sound approach to sectoral GHG emissions mitigation requires a thorough understanding of today's situation on a sector-specific basis, as well as a vision of tomorrow's challenges, beyond that of climate change constraints. Energy and input prices differ, local environmental constraints are not always binding, and various local regulations and product preferences affect, positively or negatively, the local potential for CO_2 emission reductions. Growth in demand is an important driver of capacity development and of the diffusion of new, more efficient, technologies.

An essential result from case studies is that when it comes to energy/CO_2 performance, the frontier between developed and developing countries becomes blurred. While on average OECD countries' industry tends to use energy more efficiently, the most efficient plants are sometimes found in developing countries. If capacity and technology are available in these regions, the central question is how to promote their broader diffusion.

Production, market concentration and trade in aluminium, cement, iron and steel

	Aluminium (2004)		**Cement (2005)**	**Steel (2005)**
	Primary	Secondary		
Total production (Mt/year)	29.9	7.7	2,284	1,130
% traded	75%		6%	32%
Share of 10 largest firms	54%		< 25%	26.4%
Emissions				
Total emissions (MtCO2 eq.)	391		1,930	2,165
% total GHG emissions	0.9%		4.6%	5.2%

Source: IISI, 2006; Watson et al, 2005, Vieillefosse, 2006.

The above table provides basic statistics for aluminium, cement and iron and steel. The degree of market concentration may be a good indicator of a sector's ability to mobilise a critical mass to move the industry forward.

Our review of GHG mitigation policies and measures across a range of countries indicates strongly that so-called national circumstances loom large: governments in Annex I countries have taken very diverse policy measures to limit GHG emissions in the sectors covered here. In some cases, initiatives came from industry – be they voluntary actions at national level (Keidanren's voluntary action plan), or international, such as the CSI or the IAI efforts to reduce PFC emissions and energy intensity. There is little commonality in the approach of the EU emissions trading scheme and voluntary agreements established elsewhere. One implies a clear carbon cost signal – although burdens have been heterogeneous across installations – and higher electricity prices; the cost incurred by companies under voluntary agreements is less easily measured, and so is the effect of such measures on cost-competitiveness.

The very rapid output growth outside the OECD regions, in China especially, is clearly an overriding factor in industry discussion on SA. Such growth in capacity creates concerns about sectors' global contribution to GHG, but also on the evolution of international markets if Chinese demand were to slow down and trigger significant over-capacity. Such a situation, if it occurred, would be independent from climate change policy however. Interestingly, China has started removing some of the preferential energy price and export treatments for energy-intensive industry, as it considers the negative effects on domestic resources, including the environment.

Of all three materials, cement is the least traded. It is not clear, therefore, that a sectoral approach in this sector should focus on defining a level playing field – where several playing fields exist. Aluminium appears to be an exception, with a rather homogenous, widely traded product. Location choices for new smelters are more driven by the availability of cheap inputs than by local demand – with China being an exception. Experience to date shows genuine and effective efforts to reduce the emission of

PFCs – very potent GHG. The challenge for this sector lays more in emissions associated with electricity, especially in coal-based China.

As it stands, APP provides a means to diffuse best practice, and could help gather data that has been lacking on energy and environment performance in key industrial activities, mainly in China and India. For now, APP industry partners intend to collaborate on a commercial basis; the steel task force, however, has provided a first estimate a potential for CO_2 reductions based on currently used technologies. Whether APP will succeed in bringing significant improvements in energy efficiency and environment depends on a range of factors, starting with China and India's domestic policy objectives and prevailing energy prices, and potential assistance provided by Partner countries.

Both CSI and IISI have provided their vision of climate policy for their sectors, each relying on some form of GHG baseline-and-crediting approach. In European discussions, differences emerge, however: while the cement sector proposes country-specific goals, the European steel industry offers an approach that would reward higher than average performance and penalise installations below, based on a global assessment.

Turning to technology development, iron and steel seems the most advanced in efforts to develop low-CO_2 steelmaking processes, with coordination ensured by the IISI. The cement industry has also started investigating breakthrough technologies. In aluminium, companies compete to develop more efficient smelting technologies, a key competitive advantage, and have a clear disincentive to join efforts in that field.

The industry-led sectoral efforts that have been identified share features from all options under sectoral approaches – with the exception of SD-PAMs, never mentioned as such. However, some developing countries' objectives could, if such option were accepted by the UNFCCC Parties, be eligible as SD-PAMs. We also note that, while this may be driven by their participation in the EU emissions trading scheme, the iron-and-steel and cement sectors make carbon pricing an integral part of their approaches to foster higher GHG performance in their activities.

Instruments for quantitative sectoral approaches in heavy industry

Heavy industry has traditionally relied on benchmarks to identify best practice – how to produce a given volume of output with a minimum consumption of inputs. Benchmarks are useful in that they indicate actual room for efficiency improvements and barriers that stand in the way. But setting benchmarks is also a time-consuming and sometimes sensitive undertaking. The knowledge base for benchmarks is naturally in the hands of companies (that may not wish to share it with competitors), leading also to the problem of asymmetry of information between the regulated (industry) and the regulator (government). Some trust has to be established between industry and governments if benchmarks are to help guide policy-making on a sectoral basis.

Baselines – the adoption of some reference quantity of GHG per unit of industrial output (e.g. tCO_2 per tonne of steel) – could provide the basis for sector-wide crediting of GHG reductions. The evolution of the Kyoto Protocol's Clean Development Mechanism, sectoral crediting mechanisms (SCM) and the possibility for developing countries to commit to "no-lose sectoral pledges" have been researched extensively.[4] A sector (i.e. a defined set of installations) that performs better than the baseline (x tonnes of CO_2 per unit of output) would be credited GHG emission reductions, for sale on the international market, to a Party that would need such reductions to achieve compliance. The institutional requirements for the implementation of such sector-based crediting are not trivial, however.

[4] See Bosi and Ellis (2005), Ellis and Baron (2005), Baron and Ellis (2006), Schmidt et al. (2004), Schmidt et al. (2006b), Samaniego and Figueres (2002).

Sector-wide crediting raises two other issues:

- Moving to a sector-wide crediting mechanism could mean a much larger supply –eventually to be met with larger demand for the system to be effective.
- Crediting, as currently practiced under the CDM, represents a subsidy for non-Annex I installations, i.e. *potential* competitors, in the case of sectors considered here. Broadening crediting would not likely solve competitiveness concerns – unless more ambitious baselines were set in developing countries.

Whether they aim at setting objectives for improved performance at the country or transnational level, with or without the reliance on flexibility mechanisms, sectoral approaches need a measure of performance on which they can base common (or differentiated) objectives. Data collected for other IEA work reveals some important elements for industry emission baselines:[5]

- Differences in the average energy and CO_2 performance of heavy industrial activities could be interpreted *a priori* as an indication that energy/CO_2 savings are available. However, measures of performance must be based on similar boundary conditions to be valid. It is not always the case for data gathered at national level.
- Energy efficiency performance in competitive industries results naturally from prevailing energy prices. Incentives may be needed to achieve similar performance elsewhere.
- Regulatory and other barriers may hamper high energy efficiency. Governments may need to remove them in order to facilitate the uptake of less GHG-intensive practice.

More political dimensions, not studied here, would also affect how baselines may be set among various players. A baseline used as the objective for a “pledge-and-review” would probably differ from one used under a sector-based crediting system or any system with a price on CO_2 emissions. The flexibility to achieve goals at least cost through any trading mechanism may also influence stakeholders’ willingness to accept a more demanding baseline. How, and how quickly various players may be affected by the agreed policy instrument will also influence the level of the baseline, and its evolution over time. Last, the estimated marginal cost of the baseline will need to be compared with estimated costs in other sectors, as policy-makers ought to ensure that no sector is unduly penalised in comparison with others.

In summary, if baselines were designed as the basis for sectoral approaches at international level, they would need to rest on comparable data on international performance, but would eventually reflect other considerations. While recommendations can be put forward on the first aspect, the second is probably more a matter for negotiation among interested parties.

Issues for integration of sectoral approaches in future climate policy

The report also raises issues related to a possible negotiation of sector-based approaches, and how they could feed into a UNFCCC process, highlighting some of the legal aspects. These issues would play out differently under various governance systems:

- Industry could engage in a “pledge-and-review” mechanism, not requiring specific government endorsement or actual UNFCCC recognition.
- Industry-government agreements could foster mitigation across a broad set of countries and facilitate their engagement under the UNFCCC.

The question of integration in the UNFCCC hinges on what various parties expect from sectoral approaches. First and foremost, there is value in shoring up the discussion over emission objectives with

[5] IEA (2007b), Tanaka (2007).

sectoral knowledge, be it to understand how much can be done, at what cost. In the end of course, the question of how the burden is to be shared is a negotiation matter.

Whether future commitments under the UNFCCC ought to be structured around sector-by-sector objectives is also a matter for Parties. The pros and cons of such approach are not studied in the present report. In the end, the right balance ought to be struck between any level of sectoral detail that the UNFCCC negotiation needs to cover, and the practicality of doing so in a setting gathering more than 180 Parties.

One can also envision a soft link from sectoral approaches to the UNFCCC, whereby discussions held outside the UNFCCC framework – see the various pledges by governments in APEC, G8, and industry-led initiatives – could feed back into countries' decisions on country-wide objectives. An approach that would successfully address competitiveness concerns would, for instance, probably facilitate engagement under the UNFCCC. At this stage of development of sectoral approaches – e.g. efforts undertaken by heavy industry, or the public-private partnership under APP – it is too early to estimate their contribution to future commitments.

Whereto next: a pilot phase for sectoral approaches?

With a myriad of possible options tabled by Parties and think-tanks, and some still evolving industry and public-private initiatives, the picture of sectoral approaches for GHG mitigation in heavy industry remains blurred – even if challenges are clear: the rapid growth in emissions outside Annex I countries, and competitiveness issues. In particular, no straightforward solution to the competitiveness concerns emerge at this stage. At the same time, efforts underway (from data gathering to international sharing of technology and policy best practice such as APP) should enhance public and private sector stakeholders' knowledge of sector specifics, a positive contribution at a time where countries are to embark on the negotiation of future commitments.

Three challenges lay ahead for the development of sectoral approaches to international GHG mitigation:

1. *Technical*: sectors need a fair record of their starting points, from an energy emissions and technology standpoint. Efforts are underway in the three sectors studied here. This may be more difficult for emerging economies, especially China with its large number of installations – and similar development is expected in India in the medium term.
2. *Institutional*: new international instruments may need to be developed (from sectoral pledges to crediting), some of which may raise significant issues for the international climate regime. Further, developing countries' ability to implement and enforce broad-based energy and environmental policies may be limited for some time. Enhancing capacity will be crucial in that respect.
3. *Political*: the international climate negotiations to date have been characterised by a rather antagonistic North-South debate, based on the principle that Annex I Parties must "*take the lead*". There are, however, possibilities to enhance economic development, energy efficiency, local and global environment quality through international collaboration and information sharing. It remains to be seen whether emerging economies faced with these challenges will consider some form of sector-based commitment at international level to unlock these win-win potentials. Sector-specific discussions, public and private, can only help to bring these potentials forward in the UNFCCC discussion.

First and foremost, it would be useful to estimate the GHG reduction potential of these approaches, on the basis of existing technologies, production capacities, regional market dynamics, and possible policy incentives – from the diffusion of best practice to a carbon price. This would help to identify the most productive avenue for sector-based efforts, whether they are embedded in existing policy instruments, or lead to new ones.

In the run up to the Kyoto Protocol, a pilot phase for *activities implemented jointly* provided important insights for the project-based mechanisms of the Protocol. A pilot phase could also be envisioned to go beyond the theoretical and abstract discussion of SA and to face the implementation issues mentioned above. Elements to be tested could include:

- The feasibility and usefulness of a common benchmark, or a common methodology to establish meaningful country-specific sectoral objectives, reflecting national circumstances and also a country's willingness to undertake meaningful reductions.

- Countries' institutional needs to implement sectoral emission objectives, and how such institutional needs are if GHG crediting were to be involved.

- An approach for international cooperation to encourage best practice (in policy and technology). Best policy practice may not be simply "transplanted" from a developed to a developing country. The feasibility of such policy ought to be tested, possibly with plant-level pilot projects in the country. Identifying and developing case studies to illustrate such an approach would certainly prove useful.

Introduction

There is significant policy interest in climate circles on the topic of sectoral approaches. This interest is prompted by a need to broaden the scope of GHG mitigation, including in developing countries that are reluctant to take country-wide targets. It is also motivated by concerns by some parts of industry about the competitiveness effects of a carbon constraint that does not apply evenly – indeed, leaving aside a large part of the global industrial output.

Last but not least, the negotiation of future action on greenhouse gas mitigation requires that countries evaluate the actual potential for emission reductions in their portfolio of emitting activities – and at the cost making these reductions happen. Before considering sectoral approaches as an instrument in the future climate policy toolkit, sector-level expertise can contribute to a more sound discussion on future mitigation even if, in the end, other factors play a role in what burden each country/sector is willing to take. In the case of the Kyoto Protocol, emissions trading mechanisms allow for a disconnect between the principle of cost-effectiveness (no country should pay more *at the margin* to reduce its emissions than any other country) and the overall distribution of cost, determined by each country's emissions objective.

While the discussion of mitigation goals cannot be disconnected from achievable reductions in specific sectors, there has been some reluctance to engage in a piecemeal approach at international level. While this is not necessarily an indication of the present state of play, the Kyoto Protocol negotiations failed to deliver on specific, coordinated, policies and measures. In addition to the issue of agreeing to domestic policies in an intergovernmental setting, a question of practicality arises: how to address a myriad of sectors and the related technical details in a forum like the UNFCCC? Economists also haste to argue that sector-by-sector goals may result in higher costs overall, unless some inter-sectoral coordination tool exists.

The set of questions raised by sectoral approaches (SA) is wide, as the term is interpreted differently by different parties, and in different contexts. While it also includes a broad literature review on the subject, the purpose of this report is to explore SA in the context of heavy industry. This work sought to:

- Clarify the main dimensions of possible sectoral approaches and present issues that warrant further attention in any future elaboration of sectoral approaches, especially at international level.
- Illustrate some of the challenges faced by trade-exposed energy-intensive industries.
- Indicate ways forward.

Section 1 explains the possible motivations for pursuing sectoral approaches. Section 2 offers a typology and discusses instruments that could be used for the development of sectoral approaches for industry. Section 3 explores how SA could emerge and be integrated in existing policy frameworks. Section 4 offers some preliminary lessons from industry case studies looking at cement, iron and steel and aluminium. Section 5 offers areas for further work.

The report is accompanied by four appendices (available from the Secretariat on request):

- Appendix 1: A comprehensive literature review on SA.
- Appendix 2: An overview of selected legal issues.
- Appendix 3: Statistics and policy overviews for the three case study sectors.
- Appendix 4: Summary of the EC High-Level Group on Competitiveness, Energy and the Environment

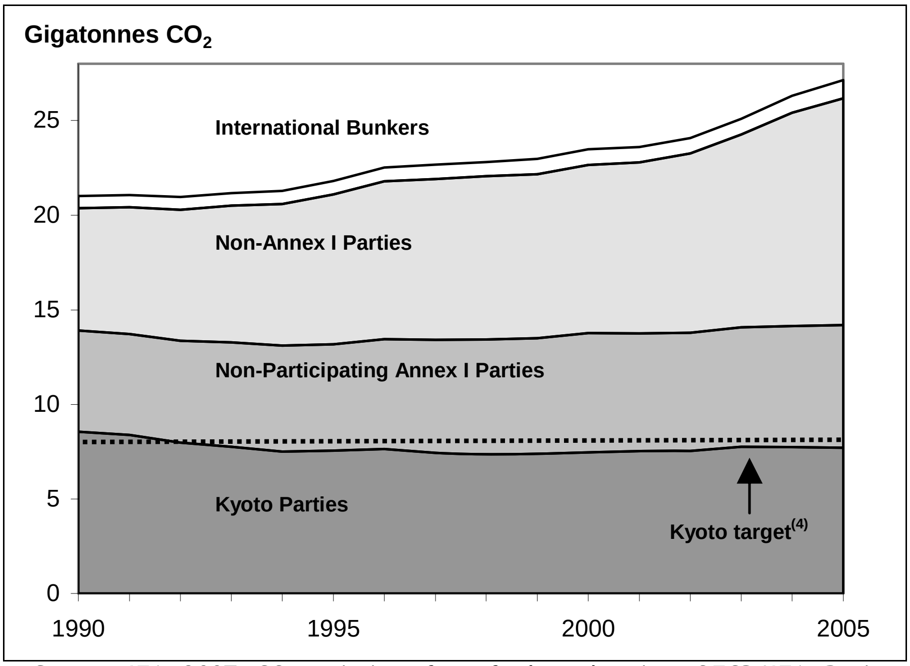
1. Sectoral Approaches for GHG Mitigation: Why?

The urgency of addressing climate change is now admitted, as stated by the G8 leaders at their Gleneagles Summit in 2005. All recognise the magnitude of the challenge of achieving drastic GHG emission reductions from current levels in the course of the coming century. IEA projections, among others, indicate an aggravating trend in CO_2 emissions from energy production and use: +55% by 2030 according to the World Energy Outlook, and +137% by 2050 in Energy Technology Perspectives (IEA 2006a, 2006b). As economies grow, so does their appetite for various energy services. This translates into liquid fuels for transport, and electricity for various end-uses, including in industry. The increasing cost of conventional resources would lead to the reliance on non-conventional resources and the transformation of coal, abundantly available, into liquid and gaseous products – with much higher level of CO_2 emissions than conventional fuels emit.

Enhancing the Scope of Greenhouse Gas Mitigation

The international policy framework to deal with climate change, the UNFCCC Kyoto Protocol as we know it today, only covers a minority of the global emissions (Figure 2). GHG projections stress that it is critical that the rest of the world take action to lower CO_2 accumulation in the atmosphere. The current energy path is simply not sustainable, as stated by IEA Ministers at their meeting in 2005.

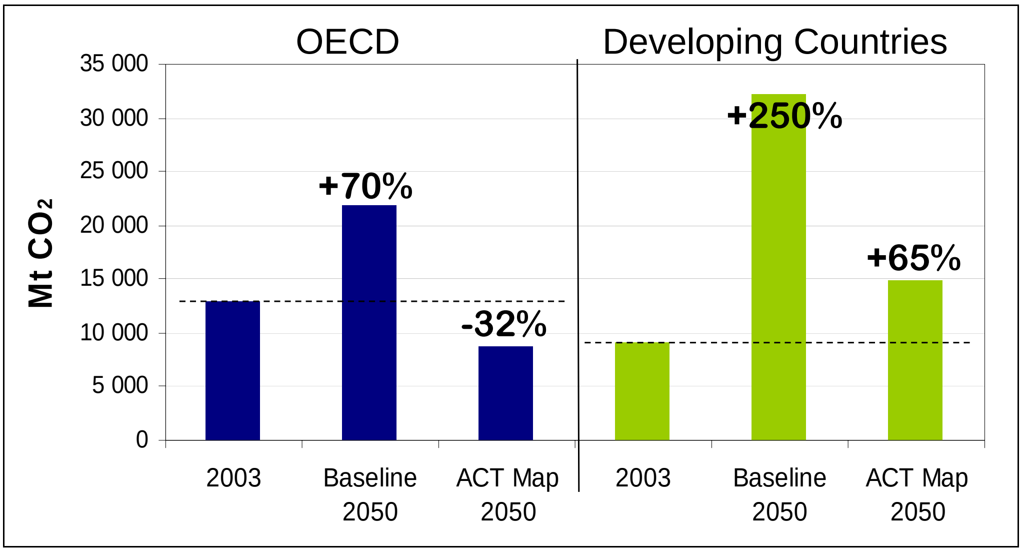
Figure 2: Global CO_2 emissions from energy, inside and outside the Kyoto Protocol



Source: IEA, 2007, CO_2 emissions from fuel combustion, OECD/IEA, Paris.

The challenge is significant: it implies a rapid transition from today's energy practice towards much higher levels of energy efficiency across all end-uses, the use of low-CO_2 energy sources, and the development of breakthrough technologies to supply growing demand for energy services with much lower or zero emissions of CO_2 in the long run. IEA has mapped such scenarios and highlighted opportunities in terms of energy cost savings, but also the need for a signal on the social cost of CO_2, if some of the most advanced technologies are to be diffused in the energy markets to the point where they achieve significant global reductions - the Accelerated Technology scenario shown in Figure 3 assumes a price signal of USD 25/tCO_2. The IEA scenarios also stress the need for all regions to take action. By 2050, returning CO_2 emissions to roughly current levels would require important reductions in emissions from business-as-usual trends in OECD and developing countries (DC) (Figure 3).

Figure 3: Regional CO_2 emissions by 2050: Baseline and Accelerated Technology development scenarios



Source: IEA, 2006a
Note: ACT stands for accelerated technology.

The new technologies brought to the market to achieve the above levels of GHG mitigation are not all costly for society as a whole: energy efficiency can help lower energy systems costs, lower local environment problems, and improve countries' energy security. However, all economic projections stress the need for an extra cost on CO_2 emissions to allow the wide penetration of technologies such as CO_2 carbon capture and storage (in power and industry), renewable and nuclear energy in power supply, and more advanced technologies to improve energy efficiency in end-uses. For some of these technologies, their wide-scale diffusion instead of more standard technologies implies a cost, justified by the need to control CO_2 and other GHG emissions. Policy-makers should thrive to achieve the identified CO_2 abatement objectives at least-cost, if these policies are to be socially acceptable and to deliver their full potential. Translated in simple economic terms: a similar *marginal cost* should be applied to all greenhouse gas emissions in order to achieve the set environmental goal at least cost. Departing radically from this principle would imply higher costs to society, or higher CO_2 accumulation and more pronounced climate change as society would find the cost of mitigation to be excessive.

The principle of equal marginal cost has driven the introduction of the so-called flexibility mechanisms in the Kyoto Protocol (see IEA 2001, 2005), and is embedded in the UNFCCC (Article 3.3). Another rationale for such choice may also have been the possibility that emissions trading offered to ensure cost-effectiveness regardless of the allocation of effort, i.e., the negotiation of country emissions objectives. This approach then left countries full sovereignty as to which sector should carry which share of the burden domestically.

At present, however, some major emitting countries and their economic activities are not facing any cost for their GHG emissions – although some activities in DC respond to the CO_2 market price through the Clean Development Mechanism, which delivers a subsidy to projects that lower CO_2 emissions. Such mechanism, however, does not significantly affect the demand for carbon-intensive goods and services. The challenge for future GHG mitigation policy is therefore twofold:

- How to broaden the scope of GHG mitigation, from the current set of countries?
- How to ensure that in the long run, mitigation objectives can be met at least cost?

The above questions are especially acute in activities that are both potentially subject to a high cost of CO_2 mitigation, and exposed to international competition from countries without constraints on their emissions at present.

Competitiveness and Greenhouse Gas Mitigation

Concerns about distortions in competition arise as soon as some regions are faced with cost increases that leave their competitors in other regions unscathed. The implementation of the Kyoto Protocol potentially creates such a situation.

Competition and climate policy

Before describing what concerns arise, it may be useful to recall two important points related first to competitiveness in general, and second to the possible implications of climate policy on international production patterns:

- Competitiveness is sometimes portrayed as a dangerous obsession, and "a meaningless word when applied to national economies" (Krugman, 1994). It is a notion best applied to companies and economic activities. Although the implications of global trade on welfare are and will continue to be debated for long (Singer, 2002; Stiglitz, 2006), countries generally benefit from the possibility to rely on each other for the production of goods and services in which each possesses so-called comparative advantages. International trade occurs because economic agents are better off acquiring a specific good from a third party than if they had no choice but to manufacture it themselves. In that sense, there is a clear benefit in trading and a country's ability to produce certain items at low cost benefits all. On the contrary, companies of course compete for market shares, and some are more successful than others. When CO_2 mitigation policy introduces a cost for some but not others in same sectors, competition among companies may be distorted. An issue arise when this distortion becomes significant. For some industrial activities, it could be, but by no means for all.

- Under a global effort to significantly reduce greenhouse gas emissions, some activities will be better off then others – some predict a higher demand for aluminium as the car industry would look for lighter materials in an attempt to improve its products' fuel economy; others see plastics, or advanced steel products, as getting the upper hand... And within activities, some companies and regions will gain, others will lose. The changes in production and consumption patterns required by the stabilisation of greenhouse gas concentrations imply radical innovation, a shift to cleaner energy use or costly abatement technologies that will affect the cost structures of certain activities. Some sectors will also become more competitive than others in similar enhanced against others'. A truly global effort to reduce emissions would shift the geography of production for especially energy-intensive activities. Today's geography of aluminium smelters is based partly on access to cheap electricity, with decisions made at a time where carbon cost was not a concern. In the future, aluminium smelters that rely on low-CO_2 electricity ought to become more competitive than those facing rising electricity prices if CO_2 emissions from electricity carry a cost. Companies and regions that can deliver the same products with less energy and CO_2 input will have the upper hand in a carbon-constrained world. There is no reason to suppose that these companies/regions are the ones that lead today and that tomorrow's trade patterns under a carbon constraint would resemble today's.

In the meantime, another form of climate policy inefficiency can occur: carbon leakage. A company that faces a high cost to meet a CO_2 target could either face increased competition from companies without such a constraint, or decide to relocate part or all of its CO_2-intensive processes where climate policy is less stringent. Emissions would not be reduced, but simply shifted to regions where they are most welcome, at the expense of economic activity in the region that decided to cut greenhouse gases. In the short run, production could be moved to regions with over-capacity and where GHG constraints do not apply. In the medium run, companies should choose to invest more in such regions, and less in GHG-constrained ones. Note that leakage would not apply to whole sectors, but mostly to their most GHG-intensive processes (primary steel production as opposed to finishing stages, for instance).

The more global the markets are, the more likely such leakage. An often overlooked factor affecting leakage is the efficiency of policy measures introduced to reduce greenhouse gases. The lower the efficiency of a policy, the higher the cost imposed on sources and the higher the distortion of competition.

As mentioned briefly, distortions of competition arising from climate policy are more likely to occur in sectors that are large energy users, subject to an emissions constraint that translates into costs, and competing on international markets. These criteria help to identify activities in which a sector-specific approach could be developed, with a focus on reducing competitiveness problems.

Illustrating competitiveness concerns

Sectors face different degrees of competition pressure according to their presence on the international market[6]. Some commodities are mainly traded on a regional scale due to difficulties in shipping them. This implies a low sensibility to competitive pressure from other actors in the same sector. The power generation in the EU is in such situation – at least until transmission lines are open to the East, where carbon constraints do not apply. While power generators inside the EU compete on roughly similar terms, with a unique price of carbon applying to all, they are not threatened by producers without a carbon constraint, as limited transmission capacity exists between Europe and the rest of the world.[7]

The more industries operate in the global (rather than regional) market, and the more their products are traded at the international level, the more are they exposed to competition. With a constraint on their CO_2 emissions, sectors that ought to be most exposed to distortion in competition are the following:

- Iron and steel,
- Cement,
- Aluminium,
- Pulp and paper.

We provide further details on the first three sectors in Appendix 3, and in the section:4. Preliminary Lessons from Case Studies.

Reinaud (2003, 2005a, 2005b), Carbon Trust (2004), Demailly and Quirion (2006) and the European Commission (EC et al., 2006) have studied the competitiveness implications of the introduction of a cap-and-trade system on the above sectors, whose reliance on fossil fuels and electricity subjects to large cost increases if CO_2 carries a cost. They focus on the situation in the EU, where the Emissions Trading Scheme sets a cap on emissions in power generation, energy and heavy industrial facilities. As

[6] The EU Emissions Trading Scheme has revealed a clear distinction between sectors that face significant international competition and those that do not: through their National Allocation Plans, governments have generally been more generous with the manufacturing sector, *de facto* taking pressure off it. Less exposed sectors such as power generation have generally been asked to reduce more.

[7] As described in the previous section, this does not imply that power generation in the EU will remain untouched by the CO_2 constraint that is now imposed to it: the cost of carbon introduced by the EU emissions trading scheme affects the economics of various generation technologies and should in the end alter the profitability of companies depending on the fossil-fuel intensity of their generation capacity.

cap-and-trade provides a useful example as it creates an observable price for CO_2, while at the same time rests on implementation features that affect both marginal cost and total cost in subtle ways, through the gratis allocation of allowances to sources. The cost imposed by other policy tools (standards, voluntary agreements or unilaterally-set emission or efficiency goals) are far more difficult to assess with current economic analytical methods.

These studies confirm the possible impact on costs (measured, e.g. as a reduction in operating margins, or a growth in production costs), while they stress the following elements:

- Policy design matters: a free allocation of emission allowances to sources represents a transfer of resources, with potentially positive effects on the profitability of activities if they can pass on the cost of carbon to consumers.
- With a modest increase in end-use prices, profit rates could be maintained, although not without a loss of market share and the possibility of carbon leakage as competitors operate outside the EU. In some cases, transportation costs would matter – cement can only be transported inland over long distances at great cost, for instance, which would reduce the scope for competition from non-EU producers. The local nature of markets also conditions producers' ability to pass cost increases on to consumers, thereby offsetting part of the cost effect of the carbon constraint.
- While the costs to industry may be low in the near-term – with the notable exception of aluminium, whose very high electricity consumption makes this activity very sensible to electricity price hikes triggered by CO_2 costs –, they can be high at the margin (Reinaud, 2005a; EC et al., 2007). These marginal costs could have a pronounced effect on decisions to increase output in the region, or import. Reinaud (2005a) finds that buying 2% of its allowances needs at EUR20/tCO_2 would add some 4% to production costs in a cement plant, acquiring allowances to cover all emissions from additional production would push costs by 38% - under the same scenario, an integrated steel plant (basic-oxygen furnace + blast furnace) would face a 15-17% cost increase (Reinaud, 2005a, EC et al., 2006). Unless the cap-and-trade system does not lead to such high CO_2 prices, or it accommodates new entrants without losing its economic efficiency, the distortion of competition could be marked.

The issue of carbon leakage has been analysed on the basis of projections of future GHG mitigation policies, as described by general equilibrium models. These global economic models generally assume full capital mobility, varying degrees of substitutability among like-products from different origins, and marginal cost pricing – i.e., a pass-through of the carbon cost onto product prices, with an immediate effect on competitiveness. It may be that such simplifications are not adequate when handling the subtle issue of carbon leakage, as it would probably apply to a fraction of industrial activities: the trade-exposed, energy-intensive (emission-intensive) sectors that do face a binding carbon constraint and corresponding costs. Put differently, carbon leakage will remain a controversial issue for some time, as it will always be difficult to track which factors may have caused what changes in industrial operations on a global basis, and to identify the exact role of a carbon policy cost.

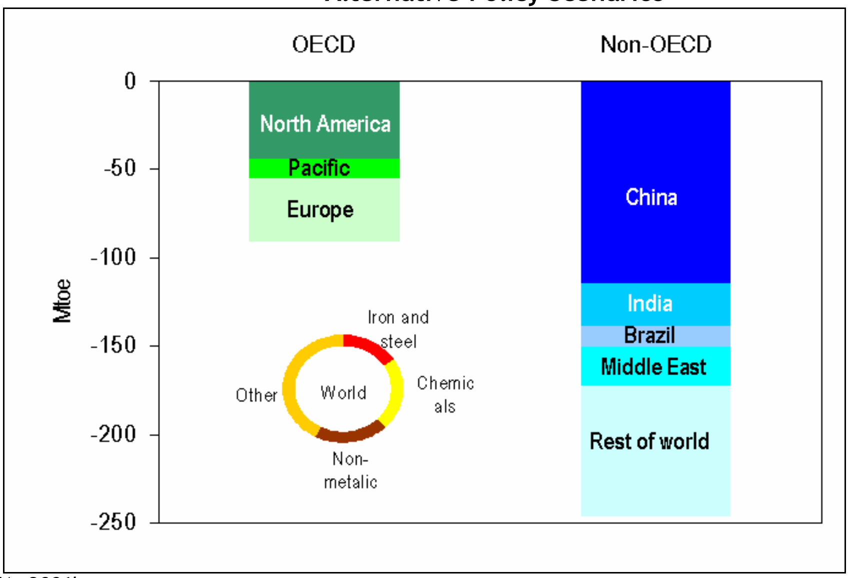
Such analyses cannot fully incorporate the broad suite of factors that define a product's competitive edge – and its exposure to international competition. In particular, certain products are defined by local regulations – certain cement qualities, refined oil products with varying sulphur contents – or by specific customers' demands, which are met exclusively by suppliers with which they have developed a working relationship over the years.

Further, there is a myriad of factors affecting production and investment decisions, import and export flows, or plant closures. These include other production costs (natural resources, labour, capital), access to skilled labour and good transport and communication infrastructure, political stability, and regional market dynamics. Considering today's industrial evolutions through the only prism of carbon costs could oversimplify the picture – indeed, nobody would attribute the growth in China's cement and steel sectors to the carbon cost borne by these activities in Europe; domestic Chinese demand is of course driving this growth, not the absence of a carbon constraint in China. Further, there is an argument to be made about national circumstances that surround these industrial activities, other than climate policy: energy costs, labour costs, infrastructure, access to technology, and broad economic contexts can differ widely from one country to the next. Industrial energy prices may be much higher in Japan than in China or in the United States – resulting in the adoption of higher efficiency processes that such high prices justify there, not here. In that sense, the playing field has not been level, and various companies/regions have developed market segments that make best use of their resources and cost constraints.

Yet the cost of GHG mitigation policy cannot be ignored. As countries embark on a negotiation of more ambitious targets, it is likely to grow and, with it, concerns about distortion of competition and carbon leakage in energy-intensive industry. This has definitely been one motivation for some industries' interest in international sectoral approaches. The European Commission has brought together a high-level group to address this issue, in the broader context of energy policy (see Appendix 4). We should haste to stress that the possible distortion of international competition is by no means the only argument in favour of establishing international sectoral approaches: the rapid growth in emissions in DC may be an even more fundamental driver of such efforts. DC may find sectoral targets more acceptable than country-wide targets that probably require more government resources to implement and monitor, and are perceived to affect the whole economy. On the positive side, sectoral targets could induce technology transfer, increasing efficiency and growth possibilities.

We will see that sectoral approaches (SA) will probably not take the same form if their primary target is the non-level playing field of trade-exposed energy-intensive industries, or if it is to assist DC in curbing the growth in their emissions. The *World Energy Outlook* (IEA, 2006b) sheds an interesting light on this latter point: the potential for energy efficiency improvements in industry are shown to be significantly larger in DC than in OECD countries between now and 2030 (Figure 4). The main question is how to engage these regions and activities in measures that improve energy efficiency, in a way that is at least in their interest, if not in all countries' mutual interest.

Figure 4: Savings in industrial energy demand by region and sector, between the Reference and Alternative Policy Scenarios



Source: IEA, 2006b.
Note: the pie chart shows the breakdown of energy savings across major industries.

Box 1: Trade measures and climate policy

The issue of competitive distortions from the one-sided implementation of greenhouse gas constraints has triggered research and analyses of trade measures to mitigate any negative impacts. OECD (2003) considers multiple carbon tax scenarios in the iron and steel industry, including the effect of border-tax adjustments – export subsidies and import taxes. This work clearly shows the effectiveness of such measures to reduce so-called CO_2 leakage and negative impacts on production levels. It remains unclear whether such instruments would hold WTO scrutiny, however. Further, no carbon taxes are applied, to date, to heavy industry. Border adjustments would need to be of a different nature.

Godard and Avner (2007) propose border adjustments in the case where the EU would act unilaterally beyond 2012. The logic would be to avoid that other countries "free-ride" on the EU climate policy. The border adjustment would be based on the sectoral level of effort inside the EU (e.g. a rate of reduction from current emissions) and on the industry's best available technology (BAT). Importers would be "taxed", or obliged to acquire allowances, only for emissions corresponding to the BAT times the level of effort – a preferential treatment, as on average, they are likely to emit more than the BAT. Exporters would receive a subsidy, or allowances, also based on the BAT and the effort level. According to these authors, Article XX(g) of the WTO rules, related to the conservation of exhaustible natural resources, would allow such treatment.

Houdashelt et al. (2007) discuss the possibility to use trade incentives to encourage a developing country's participation in a sectoral approach: the country would benefit from lower tariffs on goods produced within the sector at stake, when they are imported by a developed country – this assumes that tariffs on such goods exist in the first place, one of the preliminary questions flagged by these authors. This would also require a set of bilateral agreements, less likely to be challenged under the WTO. Importing countries would also need to adjust their customs procedures to recognise which products "comply" with the sectoral agreement from those that do not. Houdashelt et al. (2007) also point out other trade issues (in agriculture especially) that may hold more promises for developing countries, and that these could play a role if developed countries were to put these on the climate negotiation table – whether the pooling of multiple negotiations is likely and would be productive remains to be seen, however.

In closing, we note that China is reluctant to export basic energy and CO_2 intensive materials like cement and that it removed an export tax credit, as well as an import tax on such products. Egypt has also started to tax cement and clinker – cement's primary input – in an attempt to halt domestic price hikes, and not to avoid negative environmental impacts (Neuhoff and Droege, 2007).

For a recent overview of Kyoto Protocol and World Trade Organisation issues, see Cosbey and Tarasofsky (2007) and van Hasselt and Biermann (2007) on WTO and the EU ETS.

Sectoral Approaches: Caveats and Challenges

While sectoral approaches (SA) have not been defined so far, some obvious hurdles and disadvantages should be borne in mind throughout our analysis. Some of these caveats could help policy-makers and sectoral stakeholders think more pragmatically about sectoral approaches. For this discussion, we focus on the perspective of government authorities and climate negotiators, assuming they are searching for a most efficient approach to global greenhouse gas mitigation. The following questions arise, when thinking about sectoral approaches in the broad set of activities discussed above:

- **The cost of changing course?** Wherever policy instruments are already in place, are SA an improvement in terms of environmental outcome (both domestically and internationally), and in terms of cost-effectiveness? Changing the course of policies has a cost, which must be put in the balance with the expected benefits of a new approach. If SA manage to lower competitiveness concerns in a way that increases the potential for mitigation at home, it would represent a significant gain from the status quo. However, as Kyoto Parties' starting points on GHG mitigation policy in industry differ, their willingness to adapt to a new scheme will vary. In public interventions for instance, the EC has shown no interest in replacing the EU ETS with a sectoral approach, in spite of various industry proposals (e.g. iron and steel) – but the EC is open to having a sectoral discussion feed into its review of the trading scheme. The possibility to rely on benchmarks to guide future allocation was also mentioned repeatedly (Zapfel, 2007).

- **Increased complexity?** Very few sector-specific discussions have taken place in the international climate policy arena, with the notable exception of land-use, land-use change and forestry, handled specifically in the Kyoto Protocol. UNFCCC negotiators may worry that sectoral details would exhaust their expertise and negotiation capacity. The complexity of sector-specific discussions may be better handled elsewhere.

- **Information asymmetry?** Governments often have limited knowledge of the technical details of heavy industrial activities. First, recent IEA work on energy efficiency potentials in industry, and efforts under way under the Asia-Pacific Partnership on Clean Development and Climate, or the Cement Sustainability Initiative, all show a lack of sound data at the level of individual sectors on an international basis. Second, among others, the allocation process under the EU ETS has revealed, in a number of cases, the inability to properly project output levels in the near term, and corresponding emission levels. As industry has the full knowledge over technology, economic and market potentials of various processes and practices, its input to the debate is critical, but ought to (will?) be treated with care by governments. One can only hope that a broader sectoral discussion can enhance the acceptability of mitigation costs for industry, and not lead to gaming, resulting in less ambitious outcomes, or less-than-efficient policy designs.

- **How to avoid creating "sectoral havens"?** As stated above, an important principle of sound mitigation strategies ought to be to avoid imposing higher costs on some emitting activities than on others. Is there a risk that sectoral approaches would end up protecting certain activities from mitigation costs? This critique is frequently voiced (Bradley, 2007). Some policy instruments (emissions trading in particular) make it possible to separate the discussion of the distribution of cost and economic efficiency. In other words, sectoral targets could be based on a sound analysis of mitigation potentials, but also be linked to other sector's mitigation activities via a market, to avoid the efficiency losses resulting from different marginal costs of mitigation among activities. Then again, the choice of policy instrument will be conditioned by the possible distortions of competition that it helps removing.

On Economic Efficiency and Sector-by-Sector GHG Mitigation Policies

From a climate policy perspective, sectoral approaches should aim at broadening the scope of international greenhouse gas activities. For heavy industry activities that are exposed to international competition, SA could represent a means to engage the rest of the world and alleviate concerns about a competitive edge granted to unconstrained sources – and the risk of leakage. In the end, removing these concerns should facilitate more ambitious reduction goals in the sectors at stake here.

Reducing a tonne of greenhouse gas emissions has the same environmental effect irrespective of where, and in which sector action is taken. The most economically-efficient climate regime would therefore allow reductions to take place where they are less costly. This is the logic of economic instruments, carbon taxes or emissions trading, and the Kyoto Protocol so-called flexibility mechanisms. An approach that targets certain sectors only, or introduces different signals across activities, can lead to higher costs of abatement. Sectoral approaches should therefore be considered carefully, if they eventually lead to such cost distortions among various GHG sources.

On the other hand, the current global climate mitigation regime is far from the economist's ideal of a common signal given to all GHG sources, and neither is it likely to be so before some time: even country-level commitments do not necessarily imply an identical price of carbon across activities within an individual country. Governments rely on various policy tools, with cost implications that eventually depend on how implementation proceeds (cap-and-trade here, voluntary agreements there, exemptions on certain sectors exposed to international competition). Other countries currently without commitments under the Kyoto Protocol also lack the institutional framework to implement a common carbon cost across sources. Some international sector-specific approaches could assist these countries in developing meaningful GHG mitigation policies.

Another oft-mentioned flaw in international climate policy is the lack of a long term signal. Accordingly, another possible contribution of sectoral approaches could be in engaging specific sectors in efforts to develop breakthrough technologies that will be needed to achieve major reductions from current levels.

To sum up, sector-wide GHG mitigation approaches for activities contemplated in this report should be assessed against three criteria:

- Effectiveness: the capacity to introduce meaningful, sector-based, GHG mitigation policies, in the absence of – and while we wait for – a truly global climate mitigation regime. Such policy objectives could include R&D towards breakthrough technologies.

- Fair competition, in light of leakage concerns: the capacity to address distortions arising from uneven carbon constraints.

- Cost-effectiveness: the risk of creating a policy framework that would, in the future, result in different carbon costs applied to different activities. This risk points to an important, yet difficult, element of the discussion of SA: their possible integration in existing frameworks – including the existing Kyoto mechanisms and countries' policies and measures.

2. What could Sectoral Approaches Include? Typology and instruments

A Typology of Sectoral Approaches

Sectoral approaches, on paper, could take many different forms – we will mention in the next section what existing policies and initiatives fit in this broad category. The present section defines broad features to help think about the role of SA, based on the existing literature on climate policy.[8] We identify several dimensions that allow distinguishing between different concepts. Sectoral approaches could notably vary in terms of:

- Their goal:
    - o Quantitative approaches address emissions directly: their metrics is the quantity of emissions, either in absolute or relative terms, such as in cap-and-trade systems, rate-based trading (which applies to emission vis-à-vis some defined standard, e.g. emissions per unit of output) or project-based crediting (which applies to emission reductions below defined baseline) – including sectoral crediting mechanisms. So-called "Sustainable-Development policies and measures" could also fit in this category.
    - o Other approaches address emissions indirectly, via changes in elements that drive emissions levels. These can include alternative choices of technology, fuels, infrastructures, policies to influence behaviour, etc. Energy efficiency pledges, as they do not mandate a specific level of emission, would fit in this category. We note that APEC leaders, as part of their effort to reduce greenhouse gases, have taken steps in this direction, albeit at country level, at their meeting in 2007.[9]
- Their geographical scope (national or international);
- Their mode of governance (unilateral industry action, or with endorsement by governments).

The second difference is all the more important for approaches directly addressing emissions. At this point, we will thus distinguish 4 main categories. They are the following:

1) Country-specific quantitative approach

2) Sustainable development policies and measures

3) Transnational quantitative sectoral approaches

4) Technology-oriented approaches

We characterise briefly these four categories in turn, and introduce further distinction as appropriate, before giving a short review of the relevant literature.

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[8] Appendix 1, available on request, offers detailed descriptions of academic and other literature on the subject.

[9] " … we have decided to highlight the importance of improving energy efficeinty by working towards achieving an APEC-wide regional aspirational goal of a reduction in energy intensity of at least 25 per cent by 2030 (with 2005 as the base year) […]"

Country-specific quantitative approach

Description

This approach would commit a country to achieve an emissions goal limited to a sector. This commitment to the international community would presumably open the possibility for emission trading, if the sector goes beyond the set objectives.

Further differentiation

Sectoral approaches would be limited to one or several sectors – although conceivably several sectoral approaches could cover most, or even all, greenhouse gas emissions from a given country. These could be industrial sectors or – to the opposite – household or transportation sector. In the former case, the approach would aim at reducing emissions from large industrial sectors while alleviating the concerns about unfair competition from unregulated areas and possible associated carbon leakage. In the latter case, the industry sectors would be considered sufficiently concentrated to allow for profitable CDM projects and the sectoral approach would focus on sectors whose wide dispersion of emission sources would make hardly suitable for CDM projects if transactions are to remain low.

Quantitative emission sectoral approaches can be further distinguished by their *modus operandi*. They could be based on a cap-and-trade system, or on some project-based mechanism – like the clean development mechanism, especially under its so-called "programmatic" form. In the first case, they would be simply called sectoral targets, in the latter sectoral crediting mechanisms. Sectoral targets themselves can be fixed or indexed (i.e. output based), binding or non-binding. In the latter case, companies involved in the said sector and in a given country would be able to sell allowances but would not have to acquire allowances if their emissions are above their targets. Rate-based trading is also a possibility – but could also be considered a form of technology-oriented approaches as considered below.

Hence we can define several types of country-specific quantitative sectoral approaches, as follows:

- Targets in countries *with* emission goals:
  - Fixed (binding/non-binding)
  - Output based (binding/non-binding)
- Sectoral-crediting mechanisms.

Short literature review

Philibert and Pershing (2001) suggested various possibilities for sectoral approaches, including non-industry emissions. Samaniego and Figueres (2002) introduced the concept of broadening the Clean Development Mechanisms to whole sectors. Schmidt (2004) and Schmidt and Helme (2005) identified the industry sectors with large emissions (e.g. electricity, cement, steel, oil refining, pulp/paper, metals) and further developed the concept of non-binding ("no lose") output-based ("intensity") targets. Ellis and Baron (2005) showed that the electricity sector would be best addressed with country-specific sector-crediting mechanisms while the aluminium industry me be more amenable to a transnational approach.

Bosi and Ellis (2005) distinguished three main options for "sectoral crediting mechanisms" (SCM):
1) *Policy-based crediting,* where credits would be generated by adopting and implementing GHG-friendly policies in particular sectors; 2) *Rate-based (indexed) crediting,* where GHG emissions below a certain intensity level (e.g. per product output or per value of output) would generate emission credits;

and 3) *Fixed sectoral emission limits*, where emissions "credits" could be generated if a sector or company emits at a lower level than an agreed, fixed, limit.

Baron and Ellis (2006) investigate institutional and operational issues of sector crediting mechanisms. Schmidt et al. (2006a) consider the implications of opening the Clean Development Mechanism to "program of activities", as decided by the UNFCCC at Montreal. Schmidt et al. (2006b) advocate country-specific, output-based, non-binding targets. The role of SCM is discussed in more depth later in this section.

Sustainable development policies and measures

Description

SD-PAMs, as put forward by South Africa in the UNFCCC, are a pledge-based approach to developing country participation in global GHG reductions. SD-PAMs start with the development objectives and needs of developing countries. Policies and measures for sustainable development leading to reductions or, to the opposite, increases in greenhouse gas emissions need first to be identified and these effects quantified. SD-PAMS with GHG reduction potential should receive climate-change related funding.

Further differentiation

The initial description of this concept suggested that SD-PAMs may be funded, amongst other climate-related financing mechanisms (the GEF, the Marrakech Funds, etc.), from the Clean Development Mechanism (see Winkler et al., 2002), more likely today with its "programmatic" form (Schmidt et al., 2006a). For other stakeholders, SD-PAMs should be separated from crediting mechanisms and seek other forms of funding and international recognition for efforts undertaken by developing countries to combine their development goals with less GHG-intensive choices.

There is a great variety of conceivable SD-PAMs in all emitting sectors. It must be noted, however, that the original concept was for a country to submit to the international community a range of SD-PAMs potentially covering all sectors, as this would be the only way to consider their net effect on emissions. Considering various PAMs independently from each other in a given country, as often suggested in the literature, deviates from the original concept.

Short literature review

Winkler et al. (2002) laid the foundation of the concept, which Bradley and Baumert (2005) further developed and illustrated with case studies on biofuels in Brazil, motorisation in China, rural electrification in India and carbon dioxide capture and storage in South Africa. Ellis et al. (2007) provide a full discussion on how SD-PAMs could be developed under the UNFCCC.

Transnational quantitative sectoral approaches

Description

Transnational quantitative sectoral approaches would be concerted efforts to reduce the GHG emissions of a given sector at a international level – if not global – by setting some kind of targets for its greenhouse gas emissions.

Transnational sectoral approaches would best fit the possibilities of highly-concentrated sectors, such as the aluminium industry. This industry has indeed provided the widely-quoted example of a range of voluntary objectives as expressed by the International Aluminium Institute, regarding PFC emissions, smelting energy usage and overall GHG emissions per tonne of alumina.

Further differentiation

Transnational quantitative approaches can be voluntary i.e. resulting from the exclusive initiative of an industry, or negotiated and mandatory, which would involve in the case of GHG some kind of agreement between the industry and some governments – there are, at present, hurdles to any legally binding commitment between an industry and an intergovernmental body like the UNFCCC. They can also be legally binding or non-binding.

Further, they could be designed to address the emissions of sectors currently not regulated through national commitments, such as the international aviation and marine bunker fuels. They can also be designed for sectors whose emissions are, in some countries, also covered by country-wide quantitative targets. A third possibility is that transnational sectoral approaches lead to "carve out" the emissions from that industry from the national targets (Baumert, 2006). Whether or not an industry would want to rely on some international flexibility in meeting its target would need to be considered in the broader context of countries commitments.

Transnational quantitative approaches can lead to fixed targets or indexed targets – an option which heavy industry usually prefers. These approaches could hence lead to the adoption of emission standards or benchmarks. Approaches setting emission or energy consumption standards for industry products are often not considered for integration in emissions trading schemes but this possibility has been considered for example by the IEA (2005).

Short literature review

Watson et al. (2005) considered what forms transnational sectoral approaches could take and investigated five industry sectors – four with respect to their process emissions (aluminium, cement, steel and coal-fired electricity), one with respect to its products emissions (light duty vehicles). The IEA (2005) has examined how CO_2 emission standards for light duty vehicle could be turned into emission allowances for inclusion in broader emissions trading systems. Kulovesi and Keinänen (2006) investigate some of the legal issues relative to transnational agreements. Baron (2006) examines how transnational quantitative approaches could be integrated in the current global climate regime. Bodansky (2007) discusses international sectoral agreements in a post-2012 climate framework that a useful contribution would consist of defusing competitiveness concerns that otherwise hamper progress.

Technology-oriented approaches

Description

Technology-oriented approaches focus directly on the promotion of the development and dissemination of more energy efficient and cleaner technologies. These objectives, however, may be somewhat conflicting. Indeed the instruments for the dissemination of existing efficient technologies, if prescriptive in terms of technology, could freeze the development of more efficient ones.

There is a great variety of technology-oriented approaches in the literature – and in the policy mix of many countries or at other levels. Some focus on the direct and/or emissions due to the manufacturing process. Others target the energy consumption of the products, e.g. appliances or vehicles, from the said sector. Indeed, the latter would aim at indirectly reducing the emissions of other sectors, namely the household (for appliances) or transport (for cars) sectors.

Further differentiation

Technology-oriented approaches can be distinguished depending on their geographical scope.

- Country-wide approaches:

Some are essentially country-wide or undertaken at a State or Province level; they can result from governmental or other public authorities decisions, such as the renewable energy portfolio standards or feed-in tariffs, and standards and labels of energy consumption (in most industrialised and a growing number of developing countries). They can also result from initiatives undertaken by some gathering of the large companies in a given sector. One such example is the Sustainable Forestry Initiative launched in 1994 by the American Forest and Paper Association.

Initiatives from an industry sector can be “recognised” by the government in what is often named “voluntary agreements”. An important example is the voluntary agreements of the European, Japanese and Korean carmaker associations to reduce the CO_2 emissions per kilometer of the car marketed in Europe, which has been recognised by the European Commission.

- Transnational approaches:

Transnational sectoral non-quantitative approaches might be based on knowledge sharing and coordination, and extend to the sharing of R&D efforts. The IEA Implementing Agreements offer a series of examples of such international cooperative agreements (Philibert, 2004) but there are others, such as the Generation IV Nuclear Partnership, the International Partnership for the Hydrogen Economy, the Carbon Sequestration Leadership Forum. The Asia Pacific Partnership hosts a series of technology-oriented discussions, though they focus on the deployment of current technologies, not on R&D. On the private sector front, the International Iron and Steel Institute has introduced a CO_2 breakthrough programme, which explores radical innovations to allow steel making with much lower levels of CO_2 emissions.

Other, more ambitious approaches have been suggested, such as an obligation for new coal-fired power plants and oil refineries to be zero emissions by 2010 for industrialised countries, and by 2020 for developing countries. More generally, a sector could agree to targets and timetables for the diffusion of a given technology seen as more climate friendly than current practice.

Technology cooperation-based approaches could also consist of softer measures from improving maintenance and operation in existing installations to formation of workforce to using cleaner technologies being transferred in a given country.

Short literature review

Philibert (2004) examined how improved international technology cooperation can help mitigating climate change. Sugiyama and Sinton (2005) suggested that climate change mitigation may result from a multiplicity of approaches including sectoral technology-oriented agreements. Philibert (2005) showed the difficulties of comparing and integrating quantitative and non-quantitative technology approaches. The IEA (2005) showed how emission standards for vehicles could be linked to emissions trading systems.

De Coninck et al. (2006) consider how international technology-oriented agreements to address climate change may look like, examining 13 existing such agreements. Most are of the “knowledge sharing and coordination” or “research, development and demonstration” types, two about technology transfers (the Multilateral Fund under the Montreal Protocol, and the Global Environment Facility), two relative to “technology mandates and incentives” (MARPOL and the EU Renewable Directive). Three prospective technology-oriented agreements, more directly related to climate change, are also considered: the suggested carbon capture and storage technology mandate, the zero-emission technology treaty proposal and a proposal for combined technology R&D and standards.

A combination of approaches?

As the notion of a sectoral approach to greenhouse gas mitigation is by no means fixed, the above four categories may not tell the full scope of possible contributions from sectoral approaches to a future GHG mitigation – and to the climate policy regime more broadly. In theory, combinations and cross-fertilisation of the above can easily be envisioned:

- A transnational, industry-led effort could nurture a discussion what GHG emission reductions could be credited, if sector-based crediting is envisioned.
- It could also bring information for the design of SD-PAMs, or help towards their implementation.
- Some industry-led efforts may combine emissions objectives with a joint effort to develop breakthrough technologies (a technology-oriented approach).

Before we turn to the question of how such approaches could be integrated in international climate policy, we first explore some of the instruments that could be used by sectoral approaches.

Instruments for Sectoral Approaches

Many of the broad categories discussed above need a quantitative basis to measure and compare performance, establish current best practice across various processes, and help determine a sector's limits to energy efficiency improvements and CO_2 reductions – from market, economic and technological perspectives. In what follows, we assume that a sector is committed to a quantitative objective, either universal, or translated in various domestic goals according to circumstances – an intensity objective (tCO_2 per tonne of output) or an absolute goal, such as the allowances granted to an installation under the EU ETS.

There are certainly limits to the use of such assessments, especially when it comes to long-term policy objectives such as those imposed by climate change mitigation strategies. For instance, technological breakthroughs could significantly increase the reduction potentials from our current knowledge. Further, the introduction of a carbon price signal, necessary to achieve the stabilisation of greenhouse gases in the atmosphere (IPCC, 2007b[10]) could reveal technical solutions of limited interest to industry and equipment providers up to now.

In any case, recent policy experience and official interventions in the UNFCCC context point to the need for an objective assessment of mitigation potentials and costs across emitting sectors. However they are estimated, mitigation costs are likely to play an important role in defining country mitigation objectives. The availability of mitigation potentials in developing countries, and the policy options to bring them into the fold of the climate mitigation regime, will also contribute to this debate.

One essential contribution of sectoral approaches – in their finite form, if any, or via the analytical processes that they generate – is probably to shed light on mitigation potentials and on the means to exploit them at least cost. This section starts by explaining the role of industry benchmarks, a common practice that could be used in designing sectoral approaches. We later turn to the role of various crediting mechanism, as tools to engage participation on a broader sectoral basis. Last, we touch on the important role of government policies and measures and on the potential for improvements through policy cooperation.

Industry benchmarks: what are they, how can they be used?

"Benchmark" is frequently used in industry circles, less so in the context of GHG mitigation policy. As explained by Worrell (2006), benchmarking allows industry actors to compare their performance against agreed values for technologies. As such, it can guide industry to best practice, i.e., how to reach maximum levels of energy efficiency for a given process or set of processes in a given sector. Benchmarking is not based on broad indicators such as energy or CO_2 intensity for a sector's total output. Rather, it takes into account the specific product and input mixes, typically determined at

[10] Table SPM.2, in the IPCC Fourth Assessment Report, Working Group III summary for policy-markers, indicates CO_2 cost ranges for the year 2030, derived from various stabilisation scenarios, between USD20 to USD100/tCO_2.

plant level, and draws comparison on that basis. This, then, allows plant operators that share similar processes, input and output mixes to compare performance. Of course, other plants may produce similar output based on other processes with less energy and associated CO_2 emissions – e.g. electric arc furnace (EAF) steel, using scrap metal, uses far less energy than the blast furnace route (BF), but the comparison is of little value for a BF plant operator seeking to improve its performance.

As defined, benchmarks can help to evaluate margins of improvements for existing plants, based on international comparison. They can also establish the "best in the category" and allocate efforts to reduce GHG emissions accordingly. There will of course be cases where economics work against the implementation of best practice, and these should be reflected in setting objectives, unless the government also envisions to affect economic conditions through other policies – pricing or else.

The concept of benchmarking can also deviate from the above definition, and be used on a more aggregate basis, for a sector in a whole country, a group of plants, a company – at which point, analysts point to the problem of mixing "apples and oranges". At that level of aggregation, insights on specific processes, and how to best run them, are lost in the data. On the other hand, such aggregate indicators may be interesting for companies that compare overall production strategies, a point of lesser importance in this particular work. They may also indicate what the best choices are for companies that envision their next investment.

Because it is based on micro-level analysis, benchmarking is a rather data-intensive activity, but one that is deemed necessary by industry as it inquires about its global performance and possible improvements. The main advantage of benchmarking in its plant-by-plant comparison version is also a weakness from a climate change policy perspective: it is a good indication of the performance "here and now" and how to improve it, but not of what could be done under different constraints. For instance, it is possible that certain production routes ought to be abandoned and remaining ones be adapted to other inputs, to be applied more broadly. This requires some innovation, maybe some radical one, the outcome of which is never certain.

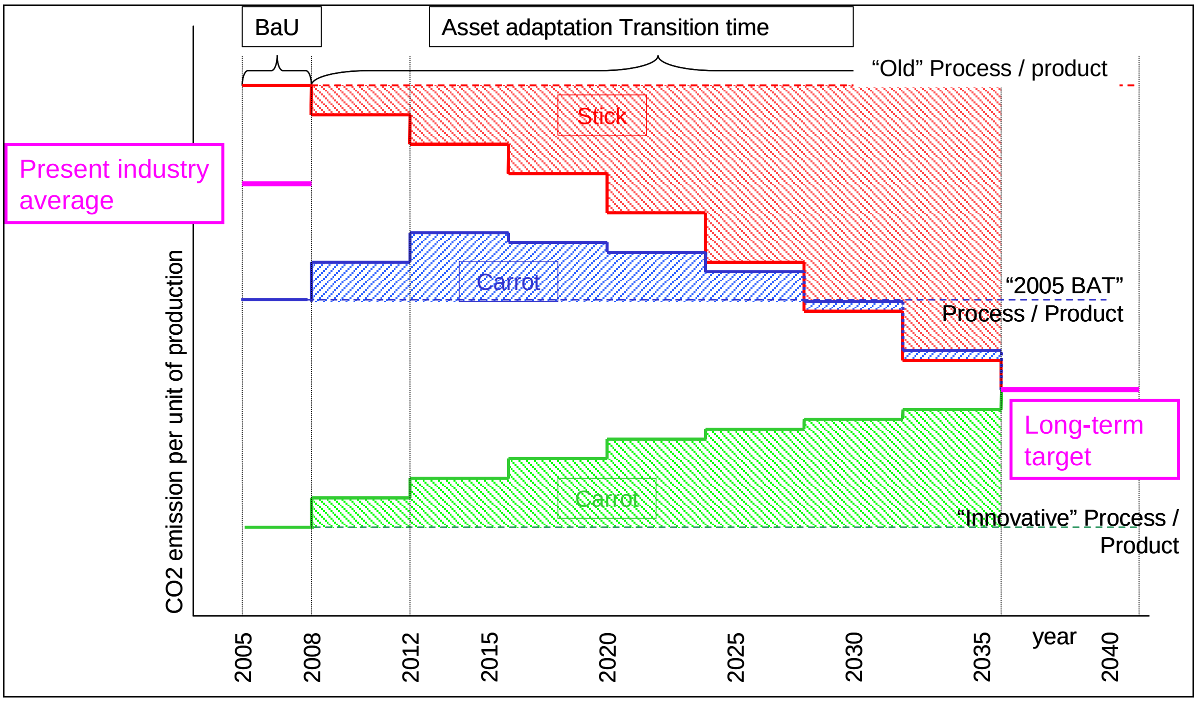
How can benchmarks be used in sectoral approaches?

- At micro level, it is a tool to identify best practice and help target technical assistance to improve performance. This said, there may be barriers to such improvements such as low energy prices that may not justify investing in reaching best practice with a given technology. Such considerations will be particularly important as one draws comparisons across regions/continents.

- In a GHG crediting mechanism, it can help set intensity targets (CO_2 per unit of output), using best performance as an end goal, and some margins for less performing plants to be rewarded as they move towards it. Figure 5 provides an illustration of how benchmarks could be used dynamically to encourage movement towards best practice. In this case, old, less performing processes would quickly be penalised. One way to encourage entities to move towards the benchmark would be to establish a virtual baseline, above the target benchmark (Baron, 2006) – or, more simply, the country's own average emission level per unit of output. Care should be given, however, to the possibly large quantity of credits triggered by such a baseline.

- In a cap-and-trade system, it can assist to allocate allowances that better reflect past performance, a departure from a grandfathering allocation mode that treats all installations similarly. Benchmarking can also be used to define conditions for entry of new installations, if a reserve of allowances exists for new entrants. Best available technology and best practice could be used for that purpose.

Figure 5: Differentiated benchmarking: illustration of incentives and evolution



Source: Vanderborght, 2006.
Note: Numbers are indicative only. The initial point in time - no carrots or sticks - takes into account the present stage of performance across the industries. Installations operating above present industry average would start being gradually penalised in 2008. Those performing below would be rewarded ("carrot"), a form of crediting for being "early" performers, with a higher reward for most innovative processes, growing with time, hence encouraging others to move towards such innovative processes. The incentive schedule would need to be adjusted to attract developing country participants whose performance may be much above average and would have no incentive to enter this system. Alternatively, the benchmarks could be used for CDM, attracting good performance only.

Benchmarks help industry and policy-makers obtain a better grasp of how large a potential for improvement exists, and what can be expected from best practice for the next generation of installations. It does present some drawbacks:

- Benchmarking is a time-consuming, data-intensive activity, all the more so as various conditions may need to be accounted for in an international approach. There is a risk of an inflation of the number of benchmarks, as operators will argue special circumstances that all require special treatment.

- In some cases, benchmarking may require disclosing data that companies judge proprietary or of strategic importance. This may be handled through a careful choice of performance indicators used in the benchmark.

- It is a useful tool to describe an industry status "here and now" but as it is based on today's technologies and practice, it provides little guidance on what level mitigation can be achieved in the future – as in some cases, technology is yet to be invented. Can a benchmark then be used as a forward looking method?

- The use of an average industry benchmark as a reference to allocate effort will immediately define "winners" and "losers" – i.e. installations that perform better or worse than the chosen benchmark target. While the effect on their cost would be a fair reflection of the cost associated with CO_2 emissions, it may be difficult to agree to, unless the benchmark is set as a future target, as illustrated in Figure 5.

- There is an asymmetry of information between any industry and a government when it comes to assessing the ability to adjust processes and to invest in new technologies to reduce greenhouse gas emissions. It is not, *a priori*, in an industrial actor's interest to reveal the full extent of its mitigation potential and its real cost.

All quantitative sectoral approaches defined above could nonetheless use the insights and data provided from benchmarks, if they exist. Various industry initiatives, including under the aegis of APP, are focusing their efforts on data gathering to assess the current status of their industry with respect to energy efficiency, CO_2, and other indicators.

How to apply GHG crediting at sector level?

We mentioned above the possibility of introducing Sustainable Development Policies and Measures (SD-PAMs) as a means to engage developing countries in international efforts on GHG mitigation, while tending to their domestic needs and achieving development priorities. As a number of energy sector analyses point to the potential for significant energy efficiency improvements in OECD and DC countries alike, SD-PAMs could be a vehicle to help countries access these potentials. The industry case studies, as well as Appendix 3, show the tremendous challenges of rapid industrialisation from an energy and environment perspective. China in particular as recognised energy efficiency as a priority for its current five-year plan, and expressed interest in obtaining international assistance towards these goals. SD-PAMs, which have yet to be formally introduced in the UNFCCC process, could provide a vehicle for such assistance.

So far, however, analyses have focused on the extension of the current international framework, the Kyoto Protocol and its mechanisms, as a means to engage developing countries more broadly. At the Heiligendamm G8 Summit, the developing country partners have expressed their support for a well-functioning carbon market to encourage the take-up of more efficient and less GHG-intensive technologies.

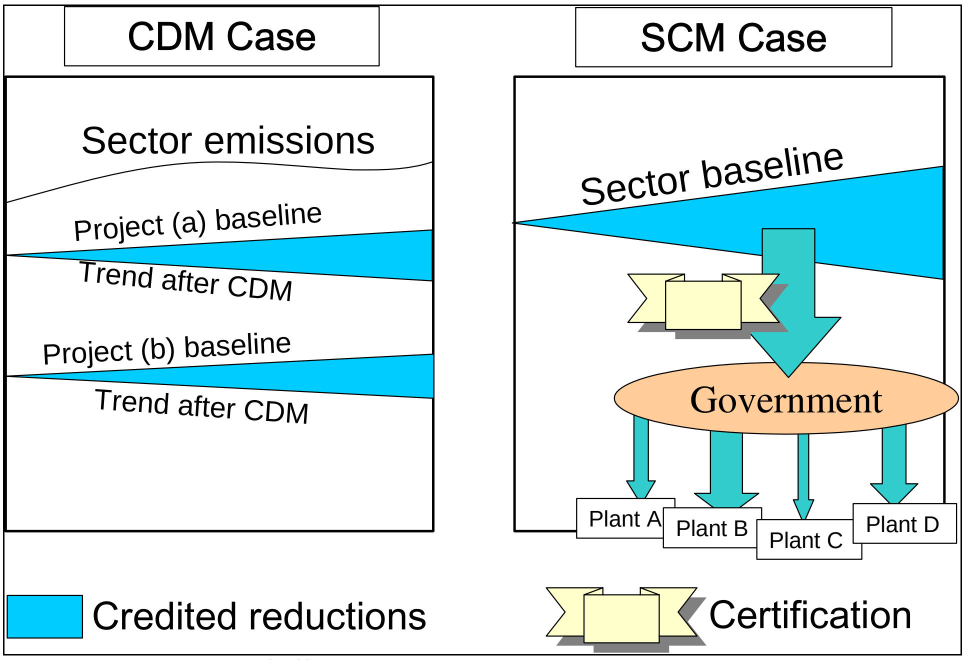
We remain, here, in the field of quantitative sectoral approaches, whether they are country-specific or transnational. We summarise below the main findings of work on so-called sectoral crediting mechanisms, which encompasses, among others, ideas developed by CCAP (see Schmidt and Helme, 2005; Schmidt, Helme and Houdashelt, 2006), Bosi and Ellis (2005), Ellis and Baron (2005), and Baron and Ellis (2006).

From CDM to sectoral crediting mechanism: definition

SCM has been envisaged as a step up from the existing, project-based clean development mechanism. It would represent an opportunity for a country to engage in GHG mitigation activities, with the prospect of receiving GHG credits for achieved reductions. Crediting could be based on sectoral baselines, probably country-specific, or on pre-agreed policies and a quantification of their contribution to GHG abatement, over and above a business-as-usual trend. In contrast with CDM, where only plants that are likely to deserve GHG credits go through the process, sector-wide crediting assumes that all plants included in the sector's perimeter would define its performance, and the quantity of credits allocated to it (Figure 6). Installations that perform above the baseline would diminish the total quantity of credits granted to the sector as a whole.

As CDM experience shows, establishing a proper metric to assess genuine reduction efforts can be a technically tedious but also a contentious matter. Among critical questions is the following: are the achieved reductions part of a sector's business as usual evolution and should they, in such cases, be rewarded with credits at all? Because of the probable diversity of situations across installations covered by such an approach and the complexity that arises from it, sector-wide crediting will require a political "deal" to set the level of effort based on which credits would accrue.

Figure 6: Clean Development Mechanism vs. Sectoral Crediting Mechanism



Source: Baron and Ellis (2006).

Illustration: SCM for the electricity and aluminium sectors[11]

Encouraging a shift to lower-carbon fuels, to more efficient combustion technologies, larger plant sizes, improved maintenance, better quality coals and/or better coal preparation, and end-use efficiency improvements could help reduce electricity-related CO2 emissions. Since national variations in fuel mix and availability are significant, one is lead to assume that any SCM developed for the electricity sector will be done at a national, rather than international, level. This would allow for a variation in the "baseline" and thus allow countries with both lower and higher electricity intensities to generate credits by improving their performance.

Other design features are more specific to each SCM design:

- A policy-based option would require an *ex-post* assessment of achieved reductions, as divergences from baselines may stem from various factors other than the targeted policy.

- A rate-based (emissions intensity) approach requires clear eligibility criteria for crediting: crediting may be attributed on a plant-by-plant basis, or based on the sum of all plants. Decisions will also be needed on whether the rate should be a single one for a whole country or grid, or whether it should be specified on a technology basis. One downside of a rate-based approach is that its focus on generation deprives the sector from one of its most cost-effective

[11] This section is based Ellis and Baron, 2005.

mitigation potential: improvements on the end-use side (IEA, 2006a, 2006b). Indeed these should have a limited impact on the generation's carbon intensity. A rate based approach would therefore be less economical from a CO_2 mitigation perspective; it would also make credit generation from renewable electricity systems difficult. On the other hand, it may be suited as it recognises various starting points, and the fact that, when endowed with large fossil fuel resources, developing countries are unlikely to stop using them in the near future.

- A fixed target applied to power generation emissions could encourage generators to take up a broader range of mitigation options, including end-use efficiency, neglected by a rate-based approach. As in standard cap-and-trade systems, a crediting mechanism based on a fixed limit would credit all reductions, whether or not linked to mitigation measures. This highlights the importance of business-as-usual projections in this option. A fixed target could also require some allocation of emissions within a sector and country, which can in itself be a resource-intensive process. Last, the political acceptability of a fixed cap on emissions in a developing country may be quite low at present.

Unlike the electricity sector, an international approach to crediting may be more appropriate for the aluminium sector. This is because new primary production plants (smelters) are not wedded to particular regions: they are usually located near cheap sources of electricity, an important cost element for this industry. Further, the aluminium industry has already adopted a number of voluntary initiatives to reduce their GHG emissions through a range of measures targeting both their direct emissions and electricity consumption, a large source of greenhouse gas emissions for some aluminium installations.

Technology utilised in smelting, the most GHG-intensive part of aluminium production, is widely shared around the world, with new plants adopting generally the most energy-efficient and low PFC-emitting technology. However, many older, less efficient and higher PFC-emitting smelters are still in operation, particularly in China and Russia. Further, plant management has a marked impact on process-related emissions of PFCs, with reported emissions from this technology type varying from 0.018 to 3.71 tCO2eq/t Al at different plants in 2003 (IAI 2005).

The inclusion of indirect emissions, related to power generation, has a very significant impact on aluminium's overall GHG-intensity, as some electricity sources are carbon-free while others rely on fossil fuels[12]. Establishing a single baseline level for GHG emissions per ton of aluminium that includes power generation emissions would have a strong impact on future production choices (including location, as producers would look for the least CO_2-intensive electricity resources). It may not be practical if it applies to current plant operations, as there is limited scope to reduce electricity-related emissions from existing generation capacity.

A potential impediment of a sectoral-crediting approach in such a competitive sector is the possibility that it could reward laggards, in fact subsidising their GHG improvements while others have taken such measures without financial incentives. Crediting may thus distort the playing field and appear unfair to entities that have moved more promptly to reduce their emissions (Ellis and Baron, 2005).

Sectoral crediting: new solution, new problems?

While it is difficult to conclude from case studies, sectoral crediting in its basic form appears to run against at least one primary motivation for pursuing sectoral approaches. If effective, SCM would help a large number of industrial facilities in enhancing their energy efficiency or lowering their overall GHG emissions, thanks to financial help provided by the international carbon market. This would only help

[12] Note that under a broad-based emissions trading system such as the EU ETS, the incentive to reduce indirect emissions is given by the pass-through of CO_2 allowance prices in electricity consumed by industry. This section does not address such a situation, but a typical non-Annex I country situation, where electricity emissions are not constrained, by a trading system or else.

these activities' competitive edge vis-à-vis the rest of the world, where a carbon constraint applies. If any distortion of competition existed prior to sectoral crediting, such mechanism would not redress the situation.

When given a choice for their next investment, companies would prefer to install a best practice plant in a country that could receive GHG credits for its performance than to do so in a country where a climate policy imposes an additional cost. Hence, unless it is carefully thought through, SCM could worsen, not improve, the competitiveness distortions introduced by international climate policies. One option to reduce this effect would be to discount credits, or to establish baselines that go beyond reductions available at no net cost (the so-called "no-regret" potential that could stem from a host of barriers) – as is the case under CCAP's proposal. Both options must eventually resort to a political decision: the former requires an agreement on the rate of discount that applies to sector-wide credits. The latter requires an agreement on the baseline, and an evaluation of what represents a no-regret potential in the sector at play.[13] We now turn briefly to the issue of baselines to measure performance.

Other fundamental issues should be borne in mind when considering sectoral crediting:

- Administrative capacity requirements. Monitoring emissions, industrial output, or energy performance and reporting on these components at national level may require government interventions beyond the existing capacity in developing countries. Turning such measurements into actual incentives for improvements at the plant level would require policy tools that most developing countries have not experienced to date – beyond the piecemeal, project-by-project approach of the CDM which mostly rewards good performance, and does not penalise bad one.

- While this is highly dependent on the ambition set by a sectoral baseline, engaging many installations within a sector into a crediting mechanism could trigger a large supply of credits – provided there is an equally large demand, and a price to sustain it.

Setting baselines: is there a silver bullet?

Whether they aim at setting objectives for improved performance at the country or transnational level, with or without the reliance on flexibility mechanisms, sectoral approaches need a measure of performance on which they can base common or differentiated objectives.

The IEA has provided an important contribution to this discussion through its publication *Tracking Industrial energy Efficiency and CO_2 Emissions* (IEA, 2007b). This work also highlighted a number of important elements for the discussion on emission baselines for industry:

- Existing data indicate important differences in the average energy and CO_2 performance of heavy industrial activities across major countries. This can be interpreted as an indication that both energy and CO_2 savings are available, provided countries catch up with the "first in class".

- However, to be technically – if not economically – relevant, measures of energy efficiency performance must be based on similar boundary conditions (Tanaka, 2007). There seems to be, up to now, limited homogeneity on this front in the publicly available data.

[13] Further, it also implies some assistance to implement such no-regret potential, as some barriers must have stood in its way so far and must be removed. In some cases, information sharing and training may suffice; in other cases, some financial assistance may be required, e.g. if technology is not readily available on the domestic market.

- Improved energy efficiency performance does not necessarily imply better CO_2 performance overall. The availability of more or less CO_2 intensive fuels, of alternative materials, and the possibility to use them in the country of operation are important factors.

- Energy efficiency performance in competitive industries results naturally from prevailing energy prices – companies and installations that have enjoyed low energy prices have invested less in energy saving technology, as such investment was not justified economically. Imposing choices made in a given price environment to plants operating in a different price environment may lead to energy and CO_2 savings, but maybe not at least cost.

- Regulatory and other barriers may hamper high energy efficiency. Governments may need to intervene – or alter their current intervention – to facilitate the uptake of more efficient, less GHG-intensive practice.

The above indicate the methodological hurdles that must be overcome if common baselines are to be set at international level. Beyond these important questions, more political dimensions of a baseline-setting exercise come into play, starting with the basic question: how will be baseline be used?

- Is it part of a pledge by the sector to improve performance at country level? At international level?

- At what level is the baseline to be used? Is performance measured at plant level, company level, or sectoral level for a whole country? In the latter case, how is the baseline translated into incentives for individual plants?

- Is the baseline the basis on which a sector/country may be credited for improvements, or penalised otherwise? Some industry proposals set the baseline at the industry's mean performance level so as to immediately reward good performance and penalise bad performance. This is obviously a different tool from a baseline that sets a performance benchmark for industry to meet sometime in the future.

- Is the goal set for the near, medium and/or long-term? Capital stock turnover and innovation with time, and a credible policy signal, should result in higher performance. play an important role in enabling higher performance. A baseline that sets efforts for the coming five years cannot be the same as one established to trigger changes over two decades or more. How the baseline is to be adjusted over time is to be driven by the level of effort expected from the sector.

- Is the baseline to be adjusted to reflect the country's overall commitment to greenhouse gas mitigation, and the principle established by the UNFCCC of "common but differentiated responsibilities and respective capabilities"?

- Last, what is the marginal cost of CO_2 abatement corresponding to the achievement of the baseline? How does it compare with marginal cost in other activities? A policy instrument that does not allow for some flexibility in seeking least cost reductions, including outside the sector perimeter, may not demand the same level of effort.

In summary, there is no one-size-fits-all method to establish a sectoral baseline; the exercise hinges almost entirely on the policy context in which it will be used. A medium-term target under a multisectoral cap-and-trade system with a price on CO_2 cannot rely on the same benchmark objective as that of a pledge-and-review objective under a SD-PAM in an emerging economy.[14]

The key question for policy-makers interested in sectoral approaches is the extent to which they should go into the sectors' specificities when setting medium to long-term goals. This question should also be viewed in the broader climate policy context: energy systems transformation require that all materials and activities compete eventually under a greenhouse gas constraint. Figuring out the precise contributions of single activities over the medium to long-term is probably an illusory objective for policy-makers.

Summary: Instruments and Objectives

We covered briefly a range of options for SA, not all of which could apply to both developed and developing countries. SD-PAMs and crediting options are more suited for developing countries. We pointed out the fact that sector-wide crediting should be handled with care for sectors in which distortions of competition introduced by climate policies loom large. However, industry, among others, has voiced concerns about the complexity and cost of the current CDM process, an indication of its interest in pursuing more projects, including in the heavy industry activities covered here. CDM-related finance in these sectors is not likely to trigger cost advantages leading to major changes in the international trade of cement, steel or aluminium. Much broader crediting at sectoral level, however, seems to run against the competitiveness argument.

As we will mention later, industry (unilaterally, or with government support, e.g. under the Asia-Pacific Partnership on Clean Development and Climate) has undertaken efforts to gather reliable data on their energy and environment performance (including greenhouse gases). Whether or not they facilitate the establishment of a crediting mechanism, form the basis of international pledges, or help policy-makers in setting domestic goals, benchmarks could prove helpful for policy-makers as they seek to improve the effectiveness of mitigation measures. The burden is on the industry to gather and organise the data for such activity, and to build a credible story on how to achieve meaningful GHG mitigation. One should not minimise the other elements that will come into play when agreeing to objectives for individual activities. What policy instruments are used at domestic and international level, the nature of countries' commitments under the UNFCCC and their capacity, all are likely to come into play when agreeing to actual sectoral objectives.

Although we only touched briefly on technology-oriented approaches and SD-PAMs, there is value in considering these approaches further in the context of heavy industry sectors:

- First, existing policies and measures, whether or not they introduce a visible CO_2 price signal, do not provide a clear long-term signal for R&D, necessary if radical changes in energy use and CO_2 emissions are to be achieved by heavy industry. Technology-oriented approaches could also set objectives in terms of technology diffusion based on a selection of technologies, a discussion best informed by benchmarks. An important point should be made on technology development and industry: in the cement and iron and steel sectors, producers do not own nor develop the technology, which belongs to a few equipment suppliers. A different set of players,

[14] An example is provided by a recent decision taken by the CDM Executive Board to credit clean-coal technologies in power generation in China. Credits would be attributed as the difference of performance between the proposed new plant and the "top 15 performing power plants […] that have been constructed in the previous 5 years". While this encourages the adoption of clean coal in China, we note that an identical, new power plant would be at a competitive disadvantage against other less GHG-intensive technologies under New Zealand's proposed emissions trading framework, as it would need to acquire all allowances from the market in order to operate (New Zealand Government, 2007). While the marginal economic cost may be similar, assuming a well-functioning international carbon market, the baselines and respective burdens would differ radically.

with different strategies than those of technology users, should be brought at the negotiation table to allow any significant progress on that front.

- Second, developing country governments have identified policy objectives that would deliver positive outcomes on several fronts, from lowering the pressure on domestic resources, to water and air quality, economic welfare, and energy security. Such SD-PAMs should be encouraged. While we focused on industry's role in providing benchmarks, governments, too have a role to play in this field. Various policies already apply to these sectors, which may facilitate or hamper the diffusion of best practice. Governments ought to share experience on effective policies to encourage higher energy efficiency – this is, among others, a task that the IEA has been asked to perform in support of the G8 Gleneagles Plan of Action. Transnational sectoral approaches could be developed with such principle in mind.

If, as pointed out by Bodansky (2007), international sectoral agreements are to defuse competitiveness concerns, a delicate political balance will need to be struck between efforts requested from, and incentives provided to sectors in countries that have not actively engaged in GHG mitigation so far. While there are analytical tools and indicators to shed light on sectors' potentials, some political dimensions (burden sharing, cost) cannot be ignored.

3. How Could Sectoral Approaches Emerge?

On paper, many options exist to engage sectors more broadly in efforts to reduce GHG emissions. We identified four broad categories: country-specific quantitative approaches, sustainable development policies and measures (**SD-PAMs**), transnational quantitative sectoral approaches, potentially spanning Annex I and non-Annex I countries, technology-oriented approaches, and.

On closer inspection, examples of international sectoral approaches abound, be they multilateral or bilateral, ranging from broad policy coordination (a common approach in the EU) to initiatives taken by industry associations to establish the sustainability of their activity. To name a few:

- The European Commission voluntary agreement with car manufacturing associations (ACEA-JAMA-KAMA), with targets on CO_2 emissions per kilometer for new cars.

- The EU Emissions Trading Scheme, an international policy approach to common sectors across countries – although without harmonisation of the treatment of same activities from country to country, another source of complaints by industry.

- The sectoral task forces of the Asia-Pacific Partnership on Clean Development and Climate.

- The voluntary targets of the aluminium industry members of the International Aluminium Institute.

- The commitments of the members of the WBCSD Cement Sustainability Initiative.

- The CO_2 Breakthrough Project of the International Iron and Steel Institute, and the regional contributions thereto.

- Various R&D forums, mentioned above (see *Technology-oriented approaches* Technology-oriented approaches).

- And also the existing consolidated methodologies for Clean Development Mechanism projects, as they can be the common basis for implementation of projects in like-activities across non-Annex I countries.

This section deals with the broader implementation issues related to sectoral approaches, namely:

- Governance options: who participates, what form of government participation can be envisioned?

- Negotiation forums.

- Integration in existing policy frameworks.

Governance Options

Three options for the negotiation and governance of sectoral approaches can be envisioned (Baron, 2006):

- A global **action** (GAn), i.e. a unilateral move by industry to foster GHG improvements.
- A global **agreement** (GAt) between industry and Parties to the UNFCCC.
- A series of national policies targeting a sector (NPIC), with some **intergovernmental coordination**.

In what follows, the term “global” does not imply that any action or agreement other than truly global would not be appropriate. Obviously, a number of countries or companies could gather a critical mass that would influence a whole industry, without requiring engaging all countries/companies – the multitude of cement, steel and aluminium companies in China, for instance, would make such option impractical.

Global action (GAn): “pledge and review” in industry

A global action (hereafter GAn) would be an industry-led pledge-and-review mechanism that would not be subject to government oversight or compliance measures. Under a GAn, sectors could adopt greenhouse gas (GHG) goals, or agree on principles to move towards lower GHG emissions. For instance, a sector could propose to achieve a certain benchmark level for its activities by a given date, and possibly seek recognition from national governments (Parties) for such effort. Or its participating companies may agree to set individual GHG emission objectives, either fixed or intensity-based, by a given date. The GAn would offer a coordination forum for companies’ mitigation efforts.

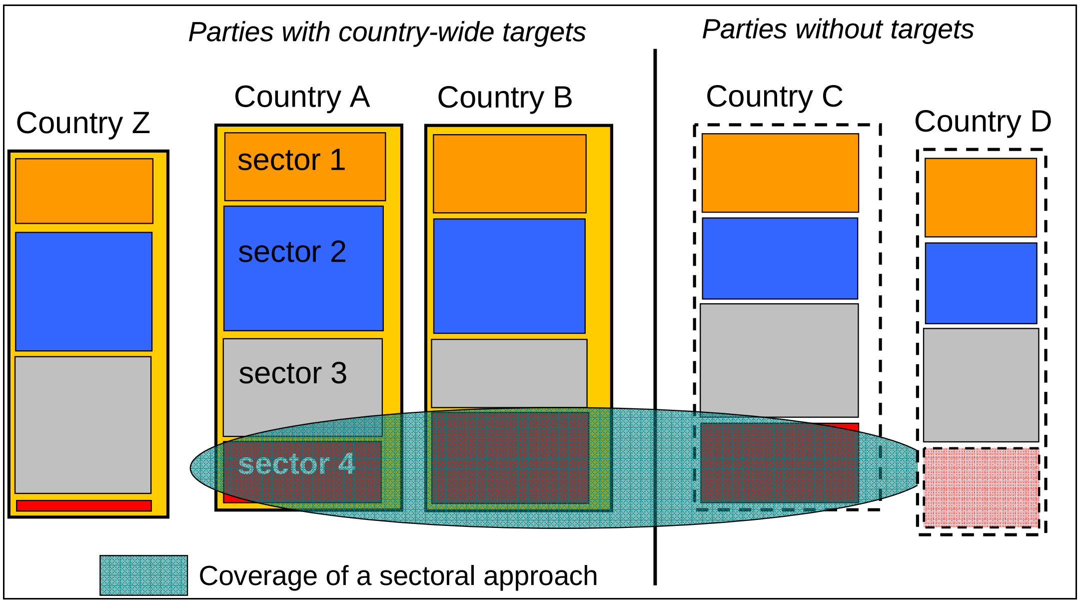
Depending on the diversity of the sector, this global sector-based action could consist of a number of benchmarks: the iron and steel sector could distinguish between the integrated steel plants and arc furnaces (the latter have notably different energy and CO_2 requirements)[15]. The automobile industry could distinguish between personal vehicle, light-duty, trucks, or between fuels (gasoline versus diesel). Such design choices are not neutral when it comes to the agreement’s environmental performance, an issue that is beyond the scope of this analysis however.

The GAn would need to set precise boundaries for both its products/outputs and related GHG emissions, so as to be able to credibly report on its achievements. The industry could report its achievements on a regional or global scale. It may rely on its own means to ensure that the set benchmark is actually met. Alternatively, it could report on a country-by-country basis and rely on domestic policy frameworks to ensure monitoring, verification and review of GHG. While monitoring alone cannot guarantee that objectives are met, it would be an essential tool of communication between the private sector and governments, all the more so as countries are likely to demand increasing reductions from all sources and industry has a strong interest to demonstrate good practice[16].

[15] The longer the timeframe for which objectives are set, the less distinction there can be on processes, as this risks favouring the status quo. Rather, long-term goals should foster efforts to develop radical technology innovation.

[16] Whether governments would accept such action as sufficient in light of the global emission goals and efforts demanded in other activities is of course another question.

Figure 7: Transnational sectoral agreements need not be global.



Source: Baron, Buchner and Ellis, 2007
Note: Country Z would not take part in the negotiation as its weight in the sector makes it unlikely to change the global picture. Country D may not be institutionally equipped to engage in such negotiation.

Examples of such initiatives already exist, although they are not global in their coverage. The International Aluminium Institute (IAI) has developed a range of voluntary objectives, some of which pertain to climate change mitigation (IAI, 2006):

- An 80% reduction in perfluorocarbon (PFC) greenhouse gas emissions for the Industry as a whole per tonne of aluminium produced by 2010 versus 1990.
- A 10% reduction in smelting energy usage for the industry as a whole per tonne of aluminium produced by 2010 versus 1990.
- The industry will monitors aluminium used in transport, to track aluminium's contribution, through light-weighting, to a reduction in greenhouse gas (GHG).
- A reduction of GHG emissions from the production of alumina per tonne of alumina produced.

The Cement Sustainability Initiative of the World Business Council on Sustainable Development is another example. Individual companies taking part in the initiative have agreed to (WBCSD, 2002):

- Use a CO_2 protocol to define and make public their baseline, and report CO_2 emissions.
- Develop a climate change mitigation strategy, and publish targets and progress by 2006.

The International Iron and Steel Institute “CO2 Breakthrough Programme” is an effort to coordinate research on innovative steel-making technologies to lower GHG emissions. An example of a technology-oriented approach initiated by industry, it is also supported, in Europe, by the European Commission, in the framework of the ULCOS project. The latter envisions to test the technical and economic viability of various options. Similar efforts are underway in North America, South America, Korea and Japan.

As such, these "pledge-and-review" initiatives are not subject to government oversight. In the terminology employed here, such actions qualify as voluntary actions – as opposed to voluntary agreements, which assume some negotiation between a national authority and private entities.

Global agreement (GAt): from negotiated agreements to public-private efforts

Moving towards firmer commitments, an industry could meet internationally and negotiate a Global Agreement (GAt) with Parties to achieve certain greenhouse gas objectives. These could be expressed as emissions per unit of output, total emissions, the diffusion of certain low-GHG emitting technologies, etc. The voluntary agreement between the European Commission on one side and the European, Japanese and Korean car manufacturers on a CO_2/km target for new vehicles belongs to this category – note that it has not lead to the introduction of country-by-country policies to translate the goal into a set of domestic targets (see NPIC below).

The main difference with the preceding approach would be that the Global Agreement would require formal recognition of industry's efforts by governments/Parties. For Parties where GHG policy is in place in these sectors, this could involve substituting the Agreement goals to domestic policy; for other Parties (e.g. non-Annex I countries), the GAt would be a way to engage their industry towards lower emissions.

Parties may also develop some enforcement mechanism to ensure that all companies and governments work towards the agreed outcome. For instance, it may be important for companies that each government put appropriate emissions (and other) monitoring mechanisms in place, so as to avoid certain companies free-riding on the agreement.

Presumably, industry would be interested in this approach as an alternative to, say, a more dispersed set of policies implemented at domestic level, or policies perceived to have a more negative impact on the sector as a whole – the threat of harsher policy instruments has been a traditional motivation of voluntary agreements (Morgenstern and Pizer, 2007). While it may be illusory to envision an Agreement that would cancel and replace all existing domestic policies, an industry-driven ambitious emission goal could feed into these policies and homogenise the industry's energy and GHG practice on an international basis.

One ongoing initiative that *could* (but does not have as its mandate to) lead to global voluntary actions or agreements is the industry-focused work under the APP. The Task Forces combine activities from data gathering towards the establishment of sectoral benchmarks, information sharing on technologies, and implementation of projects to enhance energy efficiency and environmental effects including "greenhouse gas intensities" (APP). Partner governments also participate in the task forces to share experience on regulatory issues. As such, APP task forces should lead to energy and CO_2 savings, but have not established specific goals, nor policy instruments – participation by industry is voluntary. Achievements rest therefore on the financial viability of projects identified by the various task forces, without specific incentives for GHG reductions. As it stands at present, goals that could be brought forward by APP would fall under the "pledge-and-review" category, with the distinctive feature of a public-private partnership – nearer a negotiated agreement than a unilateral industry action.

Box 2: Objectives of the APP steel task force

The Action Plan of the steel task force proposes the following objectives:
- "Develop sector-relevant benchmark and performance indicators.
- Facilitate the development and transfer of best practice steel technologies.
- Increase collaboration between government agencies, research bodies and industry institutions between relevant Partner countries.
- Develop processes to reduce energy usage, air pollution and CO_2 emission from steel production.
- Increase recycling across the Partnership."

The Action Plan mentions funding for the implementation of identified projects and encourages Partner countries to mobilise more funding from both public and private sources "to bring about full implementation of the practical projects identified in the Action Plans […]" (p.3)

The steel task force is reported to have identified a potential for the reduction of some 127 $MtCO_2$ annually in the sector across the six original Partners, based on ten readily available, proven technologies.[17]

Source: APP (2006), Steel Task Force - Action Plan.

National policies with intergovernmental coordination (NPIC)

Moving from the global to the regional or national dimension, a sector could negotiate an agreement on GHG mitigation objectives with its government, based on some international coordination to handle competitiveness problems (we refer to this option as a set of national policies with intergovernmental coordination, or NPIC).

The EU Emissions Trading Scheme is an illustration of this option. On a broader geographical basis, the World Trade Organisation negotiations on agriculture, services and other activity-specific items, provide another example of how an intergovernmental negotiation could target specific activities and their great complexity, and lead to implementation at domestic level based on the reached agreement.

Another obvious example is the Montreal Protocol on Substances that Deplete the Ozone Layer.[18] An obvious difference between the Montreal Protocol and international climate change policy is in the number of stakeholders (industry or else) in the latter. It has often been said that the success of the Montreal Protocol lies in the agreement among major manufacturers on the technological solution to the identified problem. At this stage, such technological fixes to the emissions of GHG are not readily available in the sectors covered here – maybe with the exception of aluminium, where very substantial reductions in PFCs can be achieved with currently available technology and adequate plant management. However, such technology does not address direct CO_2 emissions and indirect emissions in power generation.

Negotiation Forums

For the sake of simplicity, it is useful to distinguish the issue of how sectoral approaches can be formalised through negotiation, from the next step, i.e. their integration in existing policy frameworks. In many cases, these dimensions are intertwined: a discussion on methodologies for sector-based crediting is probably only valid if it stands a chance to be recognised by UNFCCC Parties.

[17] Okamoto, comments at 7th IEA-IETA-EPRI Annual Emissions Trading Workshop, Paris, 9 October 2007.
[18] http://ozone.unep.org

Similarly, a country seeking recognition or funding for pursuing sustainable development policies needs to have such mechanism included the UNFCCC toolkit (see BASIC, 2006, for a framework including SD-PAMs, crediting and various commitment types in the negotiation of a post-2012 framework).

How international sectoral approaches can be negotiated hinges partly on the industry's structure (market concentration) and existing international bodies to host technical discussions. In searching for effectiveness in industry negotiations, one must first consider the number of players, companies or countries that represent a critical mass in the industry (or in the supply of equipment to this industry). In light of the competitiveness questions, a preference would be for those most engaged in international trade. From this standpoint, aluminium appears to be more concentrated than cement and steel making, when looking at the market share of the 10 or 20 leaders in the sector (see *4. Preliminary Lessons from Case Studies)*. Aluminium however amounts to a much smaller share of global GHG emissions.

If the negotiation is envisioned as an intergovernmental, not an industry-led process, a critical mass can be gathered with few countries – largely because China, in most industrial sectors, represents the lion's share of global output. The issue then becomes one of national coordination via national industry federations (see *Legal aspects of sectoral approaches: role of industry associations,* below). More specifically, how would international decisions over a sector be then implemented and enforced at domestic level?

The technical complexity of industrial activities is beyond the field of expertise of UNFCCC delegations as we know them today.[19] Further, engaging all Parties would probably bring diminishing returns to the negotiation over a specific sector. An approach based on an ad hoc forum, and a critical mass of either countries or companies, may be preferable.

International and national industry federations have a role to play, e.g. in gathering and organising data for benchmarking purposes. There are, however, limits to their active role in a negotiation and to the matters that they may discuss as a group, in light of the risk of anti-competitive. These issues are reviewed in more detail below.

Legal aspects of sectoral approaches: role of industry associations

The process of negotiating and implementing any climate change regime necessarily involves input from industry, but a shift in focus from aggregate national emissions levels and policies to industry-specific approaches suggests the possibility of new and greater roles for industry. Accordingly, many of the sector-based proposals include rather prominent roles for industry associations—roles that depend on the sectoral approach chosen (and that consequently raise important legal questions. This section identifies some of the key legal issues (and provides a framework for further analysis). Appendix 2[20] provides a fuller development on some legal aspects of international sectoral approaches.

International legal status of international industry associations and implications

The legal status of the parties to any agreement dictates to a great extent the range of possible agreement. It is therefore important to consider the legal status of industry associations when evaluating options for sector-based approaches. Without going too much into detail, one conclusion is fairly straightforward: current legal regimes do not allow for the imposition of global climate change obligations directly on private entities; any agreement of global scope would thus need to either be

[19] The various issues surrounding the measurement of energy efficiency performance in industry (Tanaka, 2007), the technological aspects of heavy industry, as shown in IEA, 2007d, the many national circumstances that have affected and continue to affect industrial choices across countries, all these elements concur to paint a highly technical picture of industry issues, when it comes to assessing and comparing CO_2 and other GHG emissions.
[20] Available on demand.

based on state-to-state negotiation or coordination or be essentially non-binding. Further, the status of industry federations does not seem to allow them to legally bind their members.

It is hard to see how a sector (through industry associations or otherwise) could conclude enforceable global/international agreements given two main reasons:

- **Legal personality**. International industry associations operate in the realm of municipal (i.e., national) law, as opposed to international public law (Cf. Kulovesi and Keinänen, 2006). Given the fact that industry associations lack legal personality under international law and thus cannot enter into treaties, any agreement involving an industry association would thus have to be concluded under municipal law.

- **The jurisdictional limits of national agreements**. Given the legal personality of private entities, the question is whether a binding agreement of international scope could be entered into under national law. The design of a binding transnational sector-based system would require either (1) some kind of formal or informal agreement between states (Kulovesi and Keinänen, 2006; Sussman, 2004) or (2) the creation of a new legal system, i.e., an international treaty with obligations applied directly to "individuals, private entities or sub-national entities such as cities" (Bodansky, 2003). The first approach would create nothing more than a framework for establishing a series of legally-binding country-based agreements, and any regulation of, or binding commitment on, sectors would thus likely have to be based on national law, necessarily requiring a country-based approach (Philibert, 2005; Kulovesi and Keinänen, 2006; Schmidt et al., 2006). As regards the second approach, there are precedents for establishing international legal obligations on individuals—namely in the context of international criminal law prohibitions on genocide and torture. However, there is currently no legal basis for applying international climate change commitments directly to private entities (see Bodansky, 2003).

Any agreement of global scope entered into by an international industry association would thus have to be essentially voluntary, or translated into a set of national policy instruments, an option we refer to as *national policies with international coordination* (NPIC).

Competition and antitrust law

Given that sector-based proposals mostly represent some form of sector-wide coordinated activity, antitrust law issues are likely to arise. Industry associations have to be aware of antitrust law in pursuing many of their traditional activities, but their potentially expanded roles within sectoral approaches are likely to put more pressure on their legal compliance efforts, both because they may well be moving closer to the line between acceptable and unacceptable activities and also because they will be treading less familiar ground. As a consequence, there are a number of potential intersections between competition law and industry association activity related to sector-based climate change policies and initiatives.[21]

- **General principles of competition law**. Antitrust laws serve a number of goals. General aims include protecting the interests of consumers, ensuring that all competitors in a market have a fair chance to compete and dispersing accumulated economic power to serve the interests of economic equity. In the EU, competition law also plays a significant role in achieving single market integration. Certain activities are unequivocally prohibited under antitrust law; e.g. agreements between competitors to fix prices or output, rig bids, or share or divide markets

[21] In addition note that antitrust law and competition law are national legal regimes with rules that vary from jurisdiction to jurisdiction. "Antitrust" is the term typically used in the United States, whereas "Competition Law" is used in Europe. The terms are used interchangeably here unless specified.

are per se violations of US antitrust law resulting in criminal prosecution and are similarly prohibited by EC law. Other kinds of agreements between competitors, such as those that do not impact on the relevant parameters of competition, are generally allowed. Many of the activities contemplated (or implied) by the various sectoral approaches to climate change mitigation fall somewhere between these two extremes, and the analysis of any particular activity will be extremely fact specific.

- **Industry associations and competition law within sectoral approaches**. Most of the roles that industry associations would perform in the context of sector-based climate change policy would be substantially similar to roles they already play in their traditional activities. Sector associations already participate in data collection efforts, assist in research and development pooling arrangements, and work with governments in standard-setting processes in a manner that is (presumably) consistent with competition laws. The key question, then, is whether there are any features necessary to sector-based approaches to climate change mitigation that fundamentally alter the antitrust calculus. In this regard, two issues in particular warrant further discussion:
  (1) the significance of market share, and (2) the data gathering process.

  As regards the first issue, the effects of a sector agreement on competition will generally be less significant where the parties to an agreement represent a small share of the market. Scrutiny is bound to be heightened in the case of any broad-based sectoral agreement, as scrutiny generally increases with an increase in the competitiveness effects of an agreement, and since competitiveness effects tend to be more significant where agreeing parties represent a significant market share[22].

  As regards the second issue, associations must be very careful to comply with antitrust law in data collection and statistical reporting activities as there is an inherent risk that sensitive information could be revealed giving rise to charges of anti-competitive cooperation. Antitrust compliance is an important consideration in an industry association's data gathering activities. The question, then, is whether the information gathering required by sector-based climate change programs is somehow different, i.e., whether they require fundamentally different data to be collected or whether the use of that data in a negotiation process makes any difference in the antitrust calculus. The answer depends not only on the nature of the agreement, but also on the nature of the industry. In general, the greater the possibilities for differentiation within a given sector, the more complicated (and data-intensive) become the negotiations on those sectoral approaches (Bosi and Ellis, 2005). It is thus difficult to say whether the information gathering necessary to a specific global sectoral agreement could be carried out consistently with antitrust laws.

- **The deterrent effect of antitrust law**. Industry associations often advise their members to avoid even mere discussion of matters upon which they could not agree. Uncertainty about the status of environmental agreements is thus a strong hindrance to unilateral agreements in this area as firms will not want to test the boundaries of the law unless they have something significant to gain. Pre-empting stricter regulation may well be significant enough if there is a credible threat of firmer measures being put into effect.

There may be limits on the role that industry associations can play in gathering information for, discussing and finalising the details of transnational sectoral approaches. If industry seeks government

[22] In the EU context, some commentators have suggested that antitrust exemptions will be difficult to obtain where parties to an agreement control more than 60 percent of the market (see Bailey, 2000: citing Khalastchi and Ward, 1998). However, there are examples of agreements between parties representing over 90 percent of a market getting approval for their environmental agreements (see Bailey, 2000). Despite these examples, it is fair to say that in both the US and the EU, scrutiny likely will be heightened for any sectoral agreement of environmentally significant scope.

endorsement of their activity, or even the substitution of SA to existing policy measures, SA may well boil down to implementation, monitoring and review of achievements on a domestic basis, where governments can enforce compliance on private entities, which is beyond the reach of international industry federations.

Sectoral Approaches under the UNFCCC

It is worthwhile to note in introduction to this question that although a number of multilateral efforts are underway with an aim to contribute to solving the climate change problem (G8 Gleneagles Plan of Action, Heiligendamm Process, APP, APEC, the Major Economies Meeting on Energy Security and Climate Change), country participants general reaffirm their commitments to the UNFCCC. There is still considerable uncertainty on the shape of a post-2012 climate mitigation regime, and the question of how sectoral approaches may be integrated into this regime – or simply supplement it – will remain unanswered for some time.

Before going into the details of various SA and what they imply for the progress on mitigation under the UNFCCC, it may be useful to recall a key principle for the acceptability of SA: their contribution to global GHG mitigation. If they succeed, as such, their integration in the UNFCCC will at least be through Parties' ability to engage in meaningful mitigation commitments, and to start taking action, for those countries that have no targets to date. The question in this section is whether SA would need to be formalised under the UNFCCC.

Transnational quantitative approaches: trading or "pledge-and-review"?

Of all mentioned sectoral approaches, none have been the object of a negotiation under the UNFCCC. On the other hand, certain regional policies have based their structure on mechanisms provided by the Convention – e.g. the EU ETS and the possibility to trade emission allowances across Annex I countries that have ratified the Kyoto Protocol. A transnational quantitative approach that would seek to use the flexibility provided by Protocol's trading instruments would require endorsement, but also monitoring and enforcement by Parties whose installations participate in the approach (Baron, 2006).

Transnational quantitative approaches need not, however, rely on trading mechanisms.[23] Sectors may pledge emission objectives to be achieved by all of the industry, and report on achievements over some pre-announced timeframe. This is the model followed by the IAI so far. These efforts, if effective, would be felt at country level, and contribute to a country's achievement of any nation-wide objective. For some countries, installations covered by the approach may already be subject to domestic policy instruments. Those policy instruments may be designed or adjusted, based on the information provided by the industry's international objective.

Technology-oriented agreements

Technology-oriented approaches (TA) could be cast in the current debate opposing Annex I and non-Annex I countries on the question of technology transfer. At present, however, efforts to develop so-called breakthrough technologies in heavy industry have been led by either associations (IISI's CO_2 Breakthrough Programme) or private companies (e.g. in the aluminium sector).

Under APP, the diffusion of best practice technology is not formally linked to the UNFCCC process; arguably, such diffusion could rest on CDM projects. Interestingly however, the acquisition of

[23] We note that recent industry proposals for sectoral approaches (Cement Sustainability Initiative, and ArcelorMittal, reflecting the European iron and steel industry) rely on some form of trading and a carbon price as incentives to improve performance (Buttiens, 2007; Mages, 2007).

technology is not necessarily North-South – the APP discussions have already led to the acquisition of Chinese cement technology by an Australian party.

Building commitments from the bottom-up

One last option towards the integration of sectoral approaches in the UNFCCC is to rebuild country commitments entirely on a sectoral basis, via an informed negotiation on which activities can deliver what reductions. This option opens up a set of opportunities and challenges.

- As illustrated by the approach under APP, a sector-level discussion can help bring identify win-win GHG mitigation potentials. This may facilitate the engagement of countries that have been reluctant to commit to mitigation, perceived as a constraint to economic development. Highlighting co-benefits in terms of energy security, economic performance and local environment could only encourage emerging economies to engage in mitigation.

- Industrial sectors could bring a different interpretation of "common but differentiated responsibilities and respective capacities": new plants in emerging economies often match, or are above the performance of OECD counterparts. As companies may compete on the international market, with the same access to modern equipment, exposing them to similar level of GHG mitigation efforts seem more acceptable than when comparing standards of living – and energy use – of typical OECD and Chinese or Indian households.

- Some Parties, in the past, have been reluctant to discuss, let alone negotiate, domestic policies with other Parties. Any discussion on reduction potential will necessarily lead to a debate on appropriate policy tools, best practice, and arguments on how much more – or less – could be done with one instrument versus another.

- How could the cost-effectiveness of an approach based on sector-by-sector objectives be assured? Ideally, this would require a detailed cost assessment for all sectors, in an attempt to equalise marginal costs across sectors and countries. Furthermore, achievable emission objectives are a function of the cost of CO_2. A bottom-up, sector-by-sector negotiation would therefore need to start by a negotiation about cost.

- What would be the measure of effort used to compare Parties' individual contribution to GHG emission reductions? If incurred mitigation costs were chosen (either per capita, as a percentage of GDP, or else), debates inside the IPCC Working Group III over more than a decade have shown the wide differences in estimates based on various assessment methods.

In the end, the call by Parties to provide thorough evaluations of mitigation potentials is a sound one, and sector-level analyses cannot but usefully shed light on how far, and how fast, countries can go to reduce GHG emissions in various activities. A positive way forward may be to identify those sectors for which some international coordination may overcome barriers to progress – competitiveness concerns may be a good pointer for such sectors[24].

[24] Competitiveness issues is one of three elements identified by Bodansky (2007) as indicators that a sector may benefit from an international sectoral agreement. The other two are: critical technology and finance issues, and the possibility of "potential tipping effects […] to leverage agreement among a few parties into a broader, perhaps global, technological transformation" (p.19).

From SA to Domestic Policy Frameworks

The most contentious element in a discussion of transnational sectoral approaches is likely to be the policy approach under which various sectors already operate in Annex I countries – where one assumes that action is being taken to reduce GHG emissions. Discussions with industry stakeholders have shown that sectoral approaches were seen as either a response or a complement, or a substitute to the current domestic policy.

From this basis, it is difficult to imagine a single framework that would meet the demands of companies subject to different constraints, while satisfying the expectations of governments who have already taken –different– steps to curb GHG emissions in these activities.

Policy measures implemented, or under development, include:

- Mandatory closure of less efficient plants (in China).
- CO_2 cap-and-trade (in Europe, Australia, and New Zealand) or intensity-based trading (Canada).
- Voluntary agreements and unilateral industry actions on fixed emission goals, CO_2 intensity, or energy efficiency objectives.
- Information sharing on best practice.

This diversity suggests that sectoral approaches could contribute differently in different settings, even if they stem from a single effort, i.e. the gathering of performance data, the development of industry benchmarks, or the actual setting of emission goals.

Key Issues for Integration

This section has offered a tentative overview of issues that would need to be revised, if and when SA emerge as policy options. Two broad questions arise.

- Which stakeholders would be engaged (governments, companies) and under which governance framework (government-industry? Intergovernmental? Industry-industry?) Should a critical mass (participating countries or companies) be sought to facilitate discussions? What are the legal implications of these various configurations? We indicated concerns about anti-competitive behaviour, although industry is now fairly accustomed to discuss trade matters

- What negotiation forums would be most suited for SA, and what would be the possible roles, and constraints, of industry associations in such negotiation? Transnational quantitative approaches may be best tackled through a negotiation among key countries, with support information from industry (not unlike World Trade Organisation's negotiations). The Asia-Pacific Partnership has established a public-private space for such discussions, but is not mandated to negotiate emission objectives.

The question of integration in the UNFCCC very much hinges on what various parties expect from sectoral approaches. But first and foremost, one should recognise the shoring up the discussion over emission objectives with sectoral knowledge, even if the question of how the burden is eventually shared among Parties and what cost is borne by countries/sources will be critical and hinge on negotiation considerations beyond the scope of our analysis.[25] Whether the actual negotiation ought to

[25] What tools for international cooperation exist in the framework (flexibility mechanisms, other forms of assistance, international R&D efforts) would also influence the setting of objectives.

be structured around sector-by-sector objectives is also a matter for Parties – this would represent a radical departure from the negotiation process to date.

One can envision a soft link from sectoral approaches to the UNFCCC, whereby discussions held outside the UNFCCC framework – see the various pledges by governments in APEC, G8, etc. – would facilitate an outcome under the UNFCCC. We should note the call from the G8 Heiligendamm Summit Communiqué in this respect: "*Action of emerging economies could take several forms, such as sustainable development policies and measures, an improved and strengthened clean development mechanism, the setting up of plans for the sectors that generate most pollution so as to reduce their greenhouse gas emissions compared with a business as usual scenario*" (emphasis added).

In the end, the right balance ought to be struck between any level of sectoral detail that the UNFCCC negotiation needs to cover, and the practicality of doing so, in light of the various expertises needed to have a fruitful exchange on sectoral aspects.

4. Preliminary Lessons from Case Studies

This section offers some insights from three sectors seen as pivotal in the discussion of SA, as they have voiced concerns on competition distortions and witness extraordinarily rapid growth in output – and emissions – outside the OECD region. These sectors are cement, iron and steel, and aluminium.

In spite of some core concerns, the three sectors that have provided material for these case studies display some striking differences – among sectors, but also within sectors with respect to the challenges that they face and to the climate policies and measures that apply to them. Obviously, these differences occur mostly across the division line of Annex I and non-Annex I countries, due to their respective commitments under the United Nations Framework Convention on Climate Change. Further, countries that have ratified the Kyoto Protocol present a different picture from that of Annex I countries currently outside the Protocol. Having said that, most policies have been in place for a few years only, and overall effects on emissions and costs remain difficult to assess. Extrapolations are even more daunting, in the current state of uncertainty on future climate policy.

Appendix 3, available on demand, gives a current picture of the cement, iron and steel, and aluminium industries for countries and regions that have been surveyed during this study, and other regions and statistical information, when available. [Note that data and information in Appendix 3 will be updated based on industry and member countries' feedback.]

Table 1 provides important summary statistics for these three industries. In particular, the ratio of traded volume over total output indicates of how significant, or not, competitiveness concerns may be. The situation may of course change if and when cost disparities become significant. Nevertheless, the relatively low price of a tonne of cement makes its transport costly and limits international trade. This is less true for steel and aluminium.

In what follows, we present an overview of the challenges faced by these sectors as one considers the many facets of a sectoral approach for greenhouse gas mitigation. It is based on a number of interviews with industry stakeholders, policy-makers and observers in China, Europe, Japan, the United States.

The purpose of these sections is to summarise:

- The sector's market structure.
- Major global and regional trends.
- Efforts underway on GHG mitigation (and energy efficiency, when appropriate).
- Initiatives that can be characterised as "sectoral approaches", or efforts towards that goal.

Table 1: Production, market concentration and trade in aluminium, cement, iron and steel

	Aluminium		**Cement**	**Steel**
Production	**Mt/y**		**Mt/y**	**Mt/y**
	Primary	Secondary		
Total production	33.2 (in 2006)	14.3	2 284 (in 2005)	1 130 (in 2005)
% traded	75%		6%	32% (in 2005)
Share of 10 largest firms	54%		<25%*	26.4% (in 2005)
Emissions	**$MtCO_2$ eq.**		**$MtCO_2$ eq.**	**$MtCO_2$ eq.**
Total emissions	360		1930	2165
% total GHG emissions	0.9%		4.6%	5.2%

**The output of the 16 largest cement producers amounts to less than 25% of the global output.*
Source: IISI, 2006; Watson et al, 2005; IAI, 2007.
Note: Indirect emissions from electricity in the aluminium sector and in the iron and steel sector are included

It should be stressed at the outset that none of these sectors have finalized views on sectoral approaches as next steps towards GHG mitigation, even if some have taken measures as a group, e.g. within industry federations, to improve the near- or long-term environmental impact of their activity.

A Regional Policy Overview

To avoid repetition in our sectoral discussion, we first recall the major, broad policy instruments that are currently implemented in regions discussed in this report.

- In the European Union, industrial installations including iron and steel, electricity generation and cement are subject to the Emissions Trading Scheme, which introduces emission caps on installations' CO_2 emissions, including process emissions. The stringency of the cap partly defines the mitigation burden of an installation. Installations must also bear the cost of more expensive inputs to their processes, e.g. higher electricity prices as they reflect the price of CO_2 allowances as an opportunity cost (see Reinaud, 2007). Allocations to installations have been defined by each government of EU 25 (now 27) countries for 2005-2007 and 2008-2012.
- In Japan, industry's efforts have been driven by the Employers' association Keidanren, with its Voluntary Action Plan, which defines various goals for industrial activities, accounting for 44% of Japan's CO_2 emissions as of 1990 (roughly 500 MtCO2 at present).
- In the United States, a number of voluntary programmes are in operation, lead by US EPA, US DOE, and the White House. These include the Climate Wise Program, Climate Vision, Climate Leaders, and the Greenhouse Gas Reporting Program – known as 1605(b). They either engage individual companies or industries as a whole, through their associations.
- In Australia, the Energy Efficiency Opportunities program is a mandatory regulatory program under which companies consuming more than 0,5 Petajoules on a company level (e.g., including emissions from transport) must publicly report their consumption levels, and devise energy efficient investment opportunities.
- At international level, the Asia Pacific Partnership on Clean Development and Climate (APP) brings together Australia, China, India, Japan, South Korea, the USA and, more recently, Canada. The Partnership was initiated in January 2006 as a complement to the UNFCCC Kyoto Protocol. It comprises task forces including three industry-specific on aluminium, cement and iron and steel. The APP aims are to:
    - "Create a voluntary, non-legally binding framework for international cooperation to facilitate the development, diffusion, deployment, and transfer of existing, emerging and longer term cost-effective, cleaner, more efficient technologies and practices among the Partners through concrete and substantial cooperation so as to achieve practical results.
    - Promote and create enabling environments to assist in such efforts.
    - Facilitate attainment of our respective national pollution reduction, energy security and climate change objectives.
    - Provide a forum for exploring the Partners' respective policy approaches relevant to addressing interlinked development, energy, environment, and climate change issues within the context of clean development goals, and for sharing experiences in developing and implementing respective national development and energy strategies" (APP, 2007).

Cement Summary

The cement industry produces a relatively homogenous product, based on a limited set of processes. Fuels and raw materials inputs have an effect on the sector's overall CO_2 emissions although an important share of these is related to process, i.e., independent from energy inputs. Thus, although it is an energy-intensive activity, it can also be characterised as emission-intensive – not unlike aluminium.

Market structure

- *Concentration level*

The cement industry is characterised by a relatively low concentration, with the sixteen largest companies accounting for less than 25% of global output (Vieillefosse, 2006).

- *Industry associations*

The main cement industry grouping with a focus on climate change and an international scope is the World Business Council for Sustainable Development *Cement Sustainability Initiative* (CSI). This initiative gathers some 18 major cement producers which collectively account for more than 50% of the world's cement production, excluding China – 25% if we include Chinese cement production.

- *Technology ownership*

In the cement sector, technology is owned by equipment suppliers, distinct from cement companies. Pending financial resources, any producer can buy clinker production equipment or grinding facilities. The competitive edge between cement companies is achieved by efficiency of production. However, what is becoming more and more proprietary of the cement producers is the downstream knowledge of final cement mix products. Indeed, several additives can be mixed with clinker to make cement. Cement production is owned and sold by contractors.

- *Geographical distribution of production*

The global production of cement is dominated by the Chinese market, as illustrated below. Recent statistics indicate that China's production totaled 1.2 billion tonnes in 2006. Demand for cement in Europe and North American has been growing over the last few years – one primary concern of the US industry is to be able to match demand growth with domestic supply. Japan's demand has been cyclical and declining since the late 1990s, with growing exports as a result.

Table 2: Cement production, 2005

	Production [Mt/yr]	Share [%]	Cumulative [%]
China	1064	46.6	46.6
India	130	5.7	52.3
United States	99	4.3	56.6
Japan	74	2.9	59.5
Korea	50	2.2	61.7
Spain	48	2.1	63.8
Russia	45	2.0	65.8
Thailand	40	1.8	67.5
Brazil	39	1.7	69.2
Italy	38	1.7	70.9
Turkey	38	1.7	72.6
Indonesia	37	1.6	74.2
Mexico	36	1.6	75.7
Germany	32	1.4	77.1
Iran	32	1.4	78.6
Egypt	27	1.2	79.7
Vietnam	27	1.2	80.9
Saudi Arabia	24	1.1	82.0
France	20	0.9	82.8
Other	392	17.2	100.0
World	2284	100.0	

Source: USGS, 2006, Japan Cement Association

International trade and investment decisions

International competition is less of an issue for cement than for other energy-intensive higher value products, aluminium and steel that are easier to transport long distances. *Cement* is not traded significantly across regions of the world, due to high transportation costs when compared to cement prices. This global picture may however hide regional differences, e.g. the proximity of Southern European and Northern African markets, the Mexican and US markets, etc. *Clinker* can be transported more easily and opens up the possibility to increase cement production without having to add clinker production capacity. This is an important factor as clinker production is where most of CO_2 is emitted in the cement manufacturing process.

Main challenges

In Europe, the energy efficiency and GHG picture is dominated by the EU ETS and the issue of rising electricity prices. Issues remain on the incentives provided by the EU ETS to introduce practices that lead to an overall reduction in GHG emissions. Further, cement producers point to striking differences in levels of allocation for plants that share similar efficiency characteristics (Vanderborght, 2006). While data lack to confirm this, such differences are probably related to installations' country of operations and to this country's level of effort under the EU burden-sharing agreement. This state of play nevertheless encourages the industry to look at a more harmonised allocation of effort.

In Australia, currently, there is a tight balance in capacity with a shortage of both clinker and grinding capacity. A tenth of the demand is met by imports, mostly from Asian countries, instead of by an increase in domestic capacity. Since energy costs are still relatively low, more efficient technologies cannot always be justified. Investments in efficient technologies are only made where commercially viable. Increase in Australian cement production has been mostly met by increased use of supplementary cementitious material.

In Japan, efforts in cement manufacturing have recently focused on the use of alternative fuels and raw materials (various waste), after two decades of efforts to lower the energy intensity of cement.

In the USA, a market that is largely supplied by European and Mexican companies with American operations, the Portland Cement Association (PCA) has entered a voluntary agreement to reduce the CO_2 emissions per tonne of cementitious product produced or sold by 10% from 1990 levels in 2020. PCA also works with the US EPA to reduce barriers to the use of alternative fuels and materials in cement manufacturing.

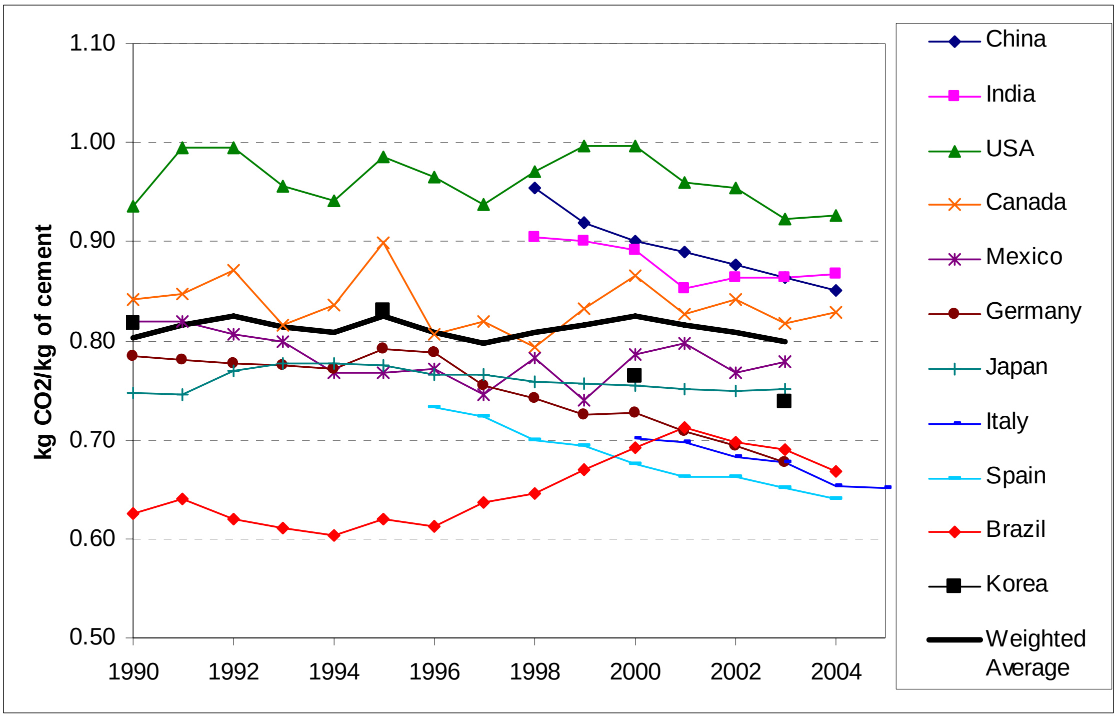
China presents a different picture, with a disparate structure of cement production. The sector is highly diffuse, with some 5,000 plants and an average of 200,000 tonnes of capacity, an industrial structure which Western observers find unreasonable from an economic perspective. The central government has introduced mandatory measured aimed at forbidding the use of outdated, energy-intensive processes. How effective such measures will be is still uncertain. The government has set a goal of replacing some 400 Mt of capacity currently based on low-efficiency vertical shaft kilns with dry kilns – a goal that is viewed as overly ambitious in light of the needed investment, but, most of all, of the social and income implications in regions where such processes are more commonly used[26]. Cement manufacturing in China has local environment impacts, with pollution control equipment often installed to comply with regulations, but not operated for cost reasons. From an energy efficiency perspective, new, large-scale equipment produced by Chinese suppliers reaches performance levels matching OECD countries'. It's been reported that actual performance may be lower as some operators invest only limited resources in maintenance.

Differences in performance

Generally speaking, the trend in CO_2 emissions per tonne of cement, including process emissions, follows that of energy-related emissions, because trends in the clinker ratio impact on the emissions from the energy needed for clinker production. China, Germany, Italy, Korea and Spain have achieved significant improvements in the CO_2 intensity of cement production including CO_2 emissions from energy consumption and process emissions (see Figure 8). Total CO_2 emissions per tonne of cement from energy and calcination in 2003-2004 range from around 0.65 kg CO_2/kg of cement in Spain, Brazil and Italy to around 0.93 kg CO_2/kg of cement in the United States (IEA, 2007). The main explanations are: a higher rate of wet processes and a lower efficiency rate of clinker kilns.

[26] NDRC issued a region-by-region schedule for the closure of so-called obsolete capacity, with capacities of 136 Mt to be closed in 2007-2008 and 148 Mt in 2009-2010.

Figure 8: Process and energy CO_2 emissions per tonne of cement by country (1990-2005)



Source: IEA, 2007b.
Note: Numbers show CO_2 emissions per kilogramme of cement, including thermal energy, upstream electricity emissions and process emissions. Note that a lower clinker-to-cement ratio - i.e. more use of additives - implies lower CO_2 emissions per tonne of cement. The above data does not reflect the energy efficiency performance of clinker, but rather the CO_2 performance of the whole energy chain leading to cement manufacturing.

Sector-wide greenhouse gas initiatives

The WBCSD Cement Sustainability Initiative has initiated work on a sectoral approach for the cement sector, starting with a data gathering exercise – "Getting the numbers right".[27] The Asia-Pacific Partnership task force on cement is also collecting energy and CO_2 data in Partner countries. Both exercises rely on the WBCSD Cement CO_2 protocol.

The CSI has also moved forward on policy proposals (Mages, 2007). The intent is to establish country baselines, negotiated with governments, to form the basis of intensity-based objectives (tCO2 per tonne of product) and a baseline-and-crediting system. Developing country participants would come into the system on the basis of a so-called "no-lose" target. The system would seek full integration in existing trading systems.

The discussion of benchmarks, and in particular the accounting of CO_2 emissions from alternative fuels, sheds interesting light: co-processing of such fuels in the cement sector potentially displaces emissions from fossil fuels. The accounting of such avoided emissions is developed under the WBCSD Cement CO_2 Protocol, which states that the use of alternative fuel and raw materials (AFR) can "*partly, fully or more than fully offset the direct CO_2 emissions from waste combustion at the cement plant*". The protocol argues for a simple treatment of the indirect effect on CO_2 emissions, for the sake of simplicity. It should be noted, however that these are not accounted for under the EU ETS – or at least,

[27] CSI set out its structure and quality assurance process of data collection, with Price-Waterhouse-Coopers undertaking aggregation and ensuring confidentiality to meet anti-trust requirements. Participating companies will need to provide data for all their plants, for years 1990, 2000, 2005, as a start. Data ought to be released by the end of 2007.

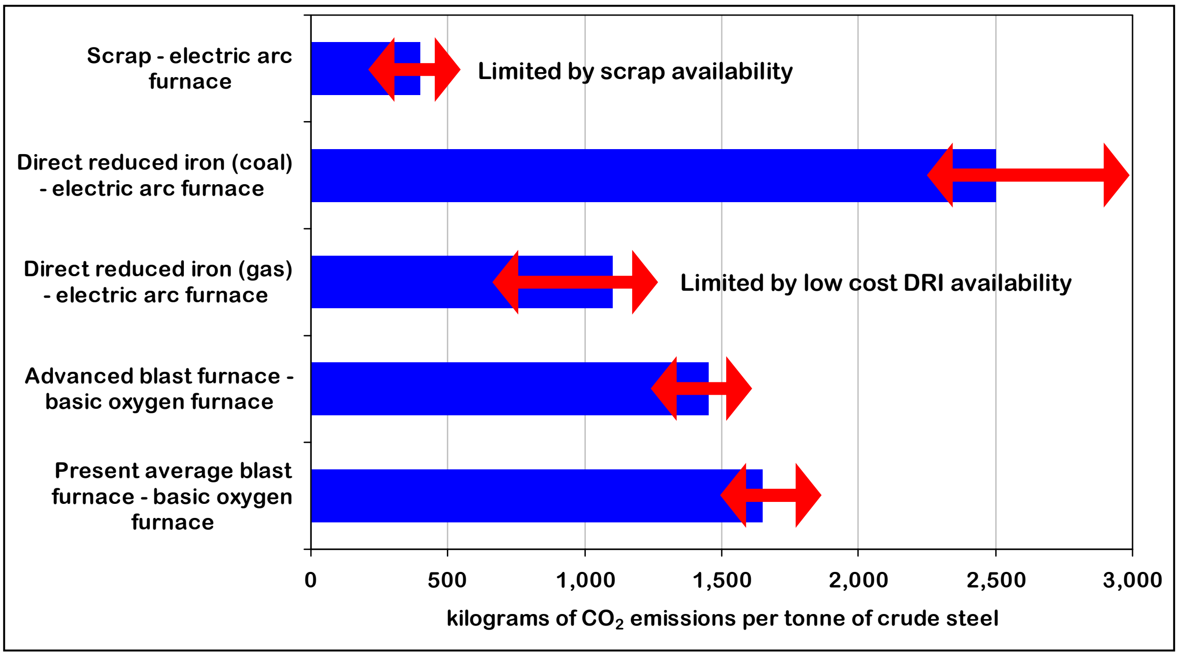
that cement plants cannot claim allowances for the use of AFR. This gives an indication of changes needed in the approach if such benchmarking procedures were applied to the allocation process in the EU, for instance.

Technology-oriented approaches can also be envisioned,[28] from cooperation on best technology practice and projects (e.g., APP), to a possible agreement on targets for the diffusion of an identified technology – albeit with the well-known risk of "picking winners" and freezing innovation as a result. The diffusion of best practice would certainly improve the energy performance of Chinese cement manufacturers. It is perceived, however, as a possible threat to the competitiveness of other producers in the region, in light of the overriding importance of energy costs in cement manufacturing. This may become a challenge for progress under APP's cement task force.

Iron and Steel Summary

While iron and semi-finished steel products are considered as homogeneous products, finished steel products differ in their quality level and their use. The sector's production routes are also quite diverse. On the production side, we distinguish the more energy-intensive basic oxygen furnace (BOF) from the electric-arc furnace (EAF), entirely based on recycled steel products (scrap). Figure 9 shows the different levels of CO_2 emissions per tonne of crude steel for various technologies, based on country averages. While EAF shows significantly lower levels of emissions, its growth is limited by the availability of recycled steel.

Figure 9: CO_2 emissions per tonne of crude steel



Source: IEA, 2007b
Note: The high and low-end ranges indicate CO_2 free and coal-based electricity and account for country average differences based on IEA statistics. The range is even wider for plant-based data. The product is crude steel, which excludes rolling and finishing.

[28] The cement industry has not engaged, as a group, in R&D towards breakthrough technologies to reduce CO_2 emissions, although some exploratory work on carbon capture and storage for cement was mentioned – it is included in CO_2 reduction technologies that could be applied by 2050 in IEA (2006b). It was noted that cement manufacturers do not develop technologies, but rather buy them from equipment suppliers, that would need to be engaged if research on breakthrough technology is launched.

Market structure

- *Concentration level*

Despite recent consolidation, the steel industry is less concentrated than aluminium, but more than cement. In 2005, the top 10 producers represented 26.4% of the total world production and the next largest ten accounted for an additional 8%; mergers that have occurred since then have not significantly increased the industry's concentration. Further, in some countries steel is dominated by a small number of large producers such as Australia and Korea. In others, such as China, it is characterised by a large number of small producers with rather low levels of energy efficiency, although a number of very large efficient plants have emerged in recent years. There are 800 to 900 steel-makers in China, the first 200 of which account for 95% of total capacity.

- *Industry associations*

The main industry association in the iron and steel sector is the International Iron and Steel Institute (IISI). IISI gathers over 190 steel producers (including the world's 20 largest steel companies), national and regional steel industry associations, and steel research institutes. IISI members produce around 60% of the world's steel.

- *Technology ownership*

The primary technology is in the hands of equipment suppliers. However, through the IISI CO_2 breakthrough programme, steel manufacturing companies have begun investing in fundamental upstream R&D, together with equipment suppliers.

- *Geographical distribution of production*

Total steel output totalled 1.2 billion tonnes in 2006 (IISI), resulting in more than 2 billion tonnes of CO_2. In the last five years global crude steel production has increased 34%, driven by strong demand in China. In 2006 alone, China and India steel production grew by 19 and 13% respectively, adding some 73 million tonnes to global output. China is now the world's largest steel producer and consumer, accounting for 31% of world production as illustrated in Table 3. Equivalent figures for Western Europe are 19%, for Japan 10%, and for the USA, 9%. Since 2003, Asia has accounted for 82% of the global output growth. China has moved from the first importer of steel in 2003 to the first exporter in 2006 (with 34 Mt of crude steel equivalent, IISI figures), a situation that is not welcome by the Chinese authorities, as steel draws heavily on natural resources and energy, and is a major source of pollution in regions.[29]

International trade and investment decisions

Trade plays a growing role in the steel market. Global steel trade grew from 100 Mt to more than 300 Mt between 1975 and 2006, i.e. 25% of global output. The share of trade in *finished* steel has been constantly increasing, from 23% of total world production in 1975 to over 42% in 2004.

Today, according to industry experts, there is an increasing trend towards the unbundling of vertically integrated facilities or companies within the same country. Indeed, the specialisation in semi-finished slab production has been led mostly by Brazil, but also Mexico, Russia and Ukraine. This trend is driven by cost differentials across regions, but has been going on before any CO_2 cost started appearing on companies' accounts. At the same time, the economically-rational migration of slab-making has been hindered by political concerns and management inertia. Certain countries such as Brazil and Ukraine may increase steelmaking in order to respond to the demands of the most industrialised countries (as well as their own needs).

[29]Although the Chinese Federal government is aiming to limit the country's exports, at the States' level, there is a strong push for increasing investments and production.

Table 3: Steel production, 2006

	Production	Share	Cumulative share	BOF steel	Electric	Open hearth
	Mt	%	%	%	%	%
China	422.7	34%	34%	87	13	-
Japan	116.2	9%	43%	74	26	-
United States	98.6	8%	51%	43.1	56.9	-
Russia	70.8	6%	57%	61.6	18.4	20
South Korea	48.5	4%	61%	54.3	45.7	-
Germany	47.2	4%	65%	68.9	31.1	-
India	44	4%	68%	47.3	50.5	2.3
Ukraine	40.9	3%	72%	56.4	9.8	33.8
Italy	31.6	3%	74%	37.4	62.6	-
Brazil	30.9	2%	77%	73.9	24.4	-
Turkey	23.3	2%	78%	29.2	70.8	-
Taiwan	20.2	2%	80%	53	47	-
France	19.9	2%	82%	61.7	38.3	-
Spain	18.4	1%	83%	19.6	80.4	-
Mexico	16.3	1%	85%	25.7	74.3	-
Canada	15.4	1%	86%	58.6	41.4	-
United Kingdom	13.9	1%	87%	80.8	19.2	-
Belgium	11.6	1%	88%	70.3	29.7	-
Poland	10	1%	89%	57.6	42.4	-
Iran	9.8	1%	89%	22.5	77.5	-
South Africa	9.7	1%	90%	53.2	46.8	-
Other	121.9	10%	100%			
World	1241.7	100%	100%	65.5	32	2.4

Source: IISI, 2007, World Steel in Figures
Note: BOF: basic oxygen furnace, EAF: electric arc furnace; OHF: open hearth furnace.

Main challenges

The overriding factor in the world steel picture has been the extra-ordinary demand – and production – growth in China, and the implications this has had on materials cost but also prices, and profitability, worldwide. This trend has encouraged more steel-making and with it higher emissions, a challenge for policy-makers that intend to introduce binding constraints on CO_2.

The main challenge for the iron and steel industry at present is company consolidation and internationalization. In particular, Europe, Japan and the United States face higher production costs for bulk steelmaking than other regions, which could eventually drive companies to look at other locations as investment in new capacity is envisioned. Identifying the role of any CO_2 cost in this expected trend will prove difficult.

In the long term, the sector is also concerned with overcapacity issues. Although global demand is projected to increase strongly[30], especially in China and India, any slowdown in these countries' domestic demand would entail excess supply worldwide. In China, as is the case for cement, the central

[30] IISI projects global demand at 1.6 billion tonnes by 2015.

government has instructed regions to close a large share of the low efficiency and dirty steel capacity: 55 Mt of basic oxygen furnace and 100 Mt of blast furnace over the next 5 years. Experts do not however project a shortfall in domestic supply as large, state of the art, capacities are being built. Whether such substitution will result in significant impacts on CO_2 emissions is unknown. CISA, the Chinese Iron and Steel Association (formerly a ministry), does not report CO_2 emissions from steel making. Although China has not been a producer of high-end steel products, the growing Chinese automotive industry demands such products; the importance of "just in time" delivery has prompted some joint ventures in China, to supply such high-quality products. Recently, the government announced measures that seek to discourage exports, namely the cancellation of steel exports tax rebates, and to facilitate imports of semi-finished products, and re-export of finished products. The move is intended to contain the growth of energy and pollution-intensive products. Whether such a measure will affect domestic production remains to be seen.

Another concern is the availability of scrap for electric arc furnaces. Although there are substitutes for scrap via the direct reduction route, it requires sufficient supply of gas and coal at competitive price levels. While gas-based DRI results in lower CO_2 emissions than BOF, coal-based DRI is more CO_2 intensive (Figure 9).

The Australian steel industry mentioned the price and availability of raw materials as their main concern in the short term, while over the longer period, they fear additional competition from the Chinese market. Other challenges mentioned by steel producers in other areas, include complying with the climate change policies implemented in several countries or regions across the world. In the near term, Japanese steel companies mentioned that their focus was on complying with the Keidanren voluntary agreement target.

In Europe, current high electricity prices are driving most Europe producers to relocate their upstream production (i.e., steel slabs) in countries such as Brazil where there is easy access to raw materials and where long term electricity contracts can be concluded with state-owned generators. Overall, this may lead to loss in energy efficiency and increased CO_2 emissions – in addition to freight-related emissions[31], imported steel slabs sometimes require energy to be re-heated before they can be turned into final products.

Differences in performance

Energy performance changes a great deal from one installation to another and depends on which production processes, raw materials quality, reducing agents are used in steel plants, and on the mix of finished products. Likewise, what processes are included – or not – in an iron and steel plant may change from one country to another, making systematic comparisons of performance difficult (Tanaka, 2007).

Across countries, differences in technologies and in efficiency – and CO_2 emissions – stem from a range of factors. One key factor is the energy cost: more efficient technologies are sometimes not taken up (e.g. in the US) as the result of low coal and electricity prices. The foreseen energy savings would simply not justify the expenditure. The result is that information sharing on best practice, based on benchmarks, may fall short of triggering technology adoption, in spite of the technical potential for energy efficiency improvements. One way to bridge the economic gap may be to generate credits under the CDM, although there is no certainty that these would add significantly to the cash-flow of the investment.

[31] Note however, that in the alternative, heavy materials would have to travel to the manufacturing sites; when the exporter has access to such materials (iron ore, coking coal), the on-site transformation results in lower emissions from the freight of these materials. The net CO_2 balance for freight is therefore not clear-cut…

The diversity of production efficiencies between countries and companies is also related to the age of the plant. New and more efficient facilities are now found in non-Annex I countries. If leakage were to occur as a result of uneven CO_2 constraints, this indicates that the leakage rate[32] may be less than 100%: any displaced production could be offset by somewhat cleaner production in more modern plants outside Annex I.

Sector-wide greenhouse gas initiatives

While the sector is trade-exposed and open to international competition, the product differentiation and the different stages of technology development and use across regions open up the possibility for some international cooperation. Some companies and countries (e.g. US, Japan, Western Europe) specialise in high-value added products, e.g. to meet the specific demand of sectors like automobile; others produce lower grade products for more generic use in construction and other infrastructure. Cooperation on the basic, energy-intensive parts of steel making could be envisioned with less of a risk of disclosing trade secrets to competitors.

Under the APP (see Box 2 for a general presentation), and with bilateral supports to China in particular, steel companies have launched a data gathering exercise to establish indicators for the two main production routes (BOF and EAF). The participation of governments in the Partnership has been described as helping trigger collaboration on data gathering, a task that had been notably difficult over the past decade, according to IISI.

The APP industry participants are also working on a State of the Art Clean Technology handbook listing technologies for environmental protection and energy efficiency, expected to be delivered in December 2007. All such technologies are available on a commercial basis from equipment suppliers – it was noted that this is the case of energy efficiency equipment in general, whereas technology and know-how closer to the final products, where higher value added is usually generated, is the propriety of producers. The latter is, however, of much lesser –if any– importance for the reduction of steel's CO_2 emissions. The issue of intellectual property right protection is mentioned in APP's task force action plan as a barrier to the diffusion of clean technologies in the sector.

According to some members of the steel task force, APP's main benefits are:

- Benchmarking: showing potential CO_2 emission reductions from all 6 participating countries if there were a possibility for all companies to adopt best available technologies. The APP's steel task force has been reported to have estimated the Partner's CO_2 saving potential, at some 127 $MtCO_2$.
- Production growth forecasts. These illustrate vividly how future increases in steel making will surpass the emission reduction potential identified above.

The International Iron and Steel Institute has launched a task force to develop a global sector-specific approach for CO_2 reductions in the post-2012 period. In a new policy statement on CO_2 and climate change, members of the board of IISI called on governments to replace cap and trade emission regimes with new policies that allow efficient companies to grow and the least efficient to decline. IISI is asking governments to work with the industry to develop and adopt a sector-specific framework that involves all of the major steel-producing countries in the world. The framework encourages the phase-out of obsolete technologies.

Recently, ArcelorMittal, a leading iron and steel company, has presented an approach to address the sector's CO_2 emissions, recalling the broad principles laid out by IISI. The proposed sectoral approach would rely on a sectoral baseline (tCO2 per tonne of finished product) derived from baselines for input to the iron and steel processes – from fuels to material inputs and electricity – in the latter case, the CO_2 content would be a global average, i.e. not determined from the region's fuel mix. Those producers with emissions above the industry average, per unit of output, would compensate those with emissions

[32] The leakage rate is the ratio of increased emissions outside the constrained region over the emission reductions in that region.

lower than average. The price would be set by the carbon market, although the steel baseline system would not buy from nor sell into the carbon market. The proposed approach departs from current systems, both from a CO_2 accounting perspective – steel would be accountable for upstream emissions, but these would be computed from a global average, not from actual, local upstream emissions – and from the existing emissions trading systems, whereby a sector can always rely on another sector's excess allowances to achieve compliance. With such accounting, the sector would need to be "carved out" of the current compliance system, as individual countries would not be accountable for emissions within their borders alone.[33] In this proposal, supply would automatically equal demand, as the baseline would be set at the average of the sector's performance.[34]

On the technology side, IISI has launched a "CO_2 Breakthrough Programme", which has led to several regional initiatives to advance the sector's technological capacity to achieve significant reductions in CO_2 emissions in the coming decades. It is one example of an international technology-oriented approach that usefully complements other GHG mitigation policies that focus on near term CO_2 emission reductions or energy efficiency improvements.[35]

The iron and steel sector has been the topic of intergovernmental negotiations, under the auspices of the OECD Steel Committee, with a mandate to address issues related to overcapacity and trade frictions. It does not hold a mandate to open negotiations on the environment, but it recently engaged its members on the climate change policy issue. It held a special session on sectoral approaches for greenhouse gas mitigation in November 2006, in collaboration with IEA and IISI. The meeting revealed the wide disparity of starting points and motivations among the industry, and identified the low concentration of the sector and anti-trust issues as potential hurdles to reach a transnational agreement within the industry – i.e. a global, industry-led, action, to use our earlier typology. Dealing with the question of incentives for participation and the level playing field, it was mentioned that CDM and Joint Implementation could be used as a carrot to encourage developing country producers to take obligations under a SA (OECD, 2006). This point brings us back to the ambiguous role of crediting in the competitiveness discussion although in this case, it is used as a carrot towards a binding, i.e., not voluntary commitment by developing country participants.

Challenges for an international sectoral approach in the steel sector, beyond efforts underway under the auspices of IISI and APP, are the following:

- The sector may not be concentrated enough to gather a critical mass of global supply inside a workable industry group. IISI may provide a forum for discussion, with the limitations indicated above on the role of industry federations in SA.
- It is highly competitive, with rapid growth in capacity outside Annex I countries. Those producers enjoying growth now may not welcome commitments leading to the introduction of more costly processes.

On the other hand, Chinese authorities have set very ambitious energy efficiency goals for the industry, for which international cooperation may be useful. This would certainly help to lower the global CO_2 emissions from the sector. In light of the high impact of the sector on natural resources and air quality, efforts to improve steel making in China may fit well under the label of SD-PAMs – if such an instrument were eventually endorsed by UNFCCC Parties. We note in that respect China's efforts to curb the rapidly growing steel exports, and to remove subsidies on new energy-intensive industries in general.[36]

[33] A hydro-based electric arc furnace would be accountable for CO_2 emissions from power generation based on the global CO_2 content of power delivered to steel makers, likely to be above its current zero emissions.

[34] For the system to be balanced, transactions would occur only after performance has been measured across the sector, and the average baseline computed accordingly.

[35] Note that the Australian IISI platform has equipment manufacturers cooperating on the research of breakthrough technologies.

[36] "Restraints on energy intensive industry to increase after rapid Q1 growth – NDRC" – Interfax-China, Shanghai April 30, 2007.

Aluminium Summary

Aluminium ingots (semi-finished products) are considered as relatively homogeneous products, although alumina content may vary. Aluminium final output and production routes differ, as is the case in the iron and steel sector. There are two main types of aluminium smelting technology - Søderberg and pre-bake. The principal difference between the two is the type of anode used. The first uses a continuous anode, while the latter uses multiple anodes. Primary aliminium smelting is extremely electricity-intensive. The pre-bake process, which accounts for more than 70% of global output, is generally more efficient than the Søderberg process – 13-16.5 MWh per tonne vs. 15-18 MWh per tonne (IEA, 2007b). Secondary aluminium, using recycled metal, is however much less electricity-intensive and is therefore a priority for the industry's effort to reduce its electricity-related CO_2 emissions. Naturally, growth in secondary aluminium production is capped by scrap availability.

In addition to indirect emissions through the use of electricity (when it is based on fossil fuel generation), aluminium smelting can emit an important quantity of greenhouse gases: CO_2 from the carbon anode and perfluorocarbons (PFCs) through the so-called anode effects ().[37]

Market structure

- *Concentration level*

There is a strong concentration level in the industry. The primary aluminium industry has undergone significant consolidation in recent years and is now relatively compact with five companies representing 41% of world production in 2004. The top ten account for 54% (Watson et al, 2005). Significant economies of scale mean that small primary production plants are not economically viable.

- *Industry associations*

The main industry association in the aluminium sector is the International Aluminium Institute (IAI). In 2007, IAI had 26 Member companies representing every region of the world including Russia and China. End 2006, the membership was responsible for around 80% of world primary aluminium production and a significant proportion of the world's secondary production.

- *Technology ownership*

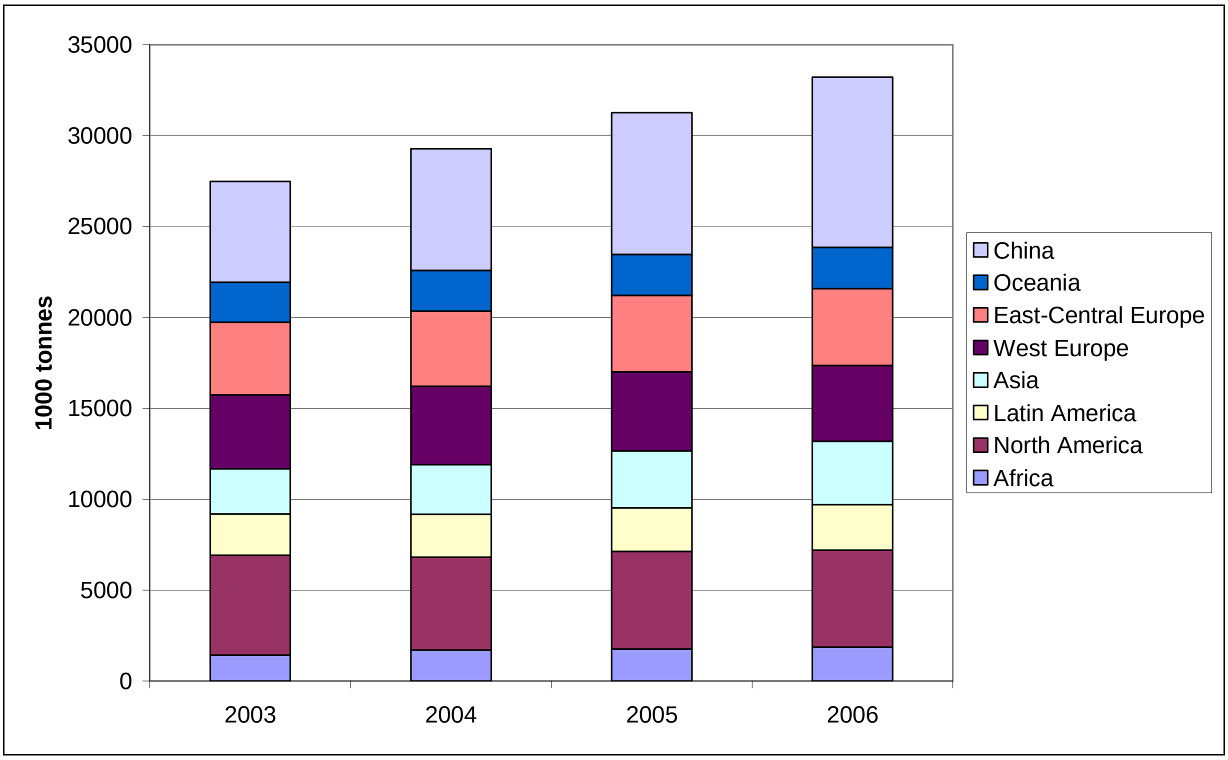
The technology for aluminium smelting has been in the hands of the industry –Péchiney, now Alcan, developed the most commonly used smelting technology – unlike cement or iron and steel for which suppliers provide equipment to the industry. Aluminium companies are competing to develop the next smelting technology, with an aim to reduce the electricity input. Collaboration on this front is therefore unlikely. However, collaboration on the reduction of PFC emissions exists, via the IAI.

- *Geographical distribution of production*

Not unlike iron and steel and cement, the global growth of output has been driven by China, with a reported growth of 42% between 2004 and 2006. In 2007, China is reported to account for close to 40% of global production - Russia is ranking second, with some 12% of production capacity as of 2004.

[37] See the aluminium case study in*How* to apply GHG crediting at sector level.

Figure 10: Primary aluminium production, 2003-2006



Source: International Aluminium Institute, 2007
Note: The data exclude primary aluminium production in Azerbaijan, Iran and North Korea) and in Bosnia-Herzegovina, Poland and Romania. The omitted production is approximately 2% of the world total.

International trade and location choices

Aluminium is heavily traded, reflecting the fact that capacity investment is driven by electricity costs, but also that, as a material with rather high value per tonne (USD 2500 per tonne in early 2007), transport costs weigh little in the final price. As a result, proximity to markets is not the overriding factor that it is for materials like cement. At present, more than three-quarters of global output is traded internationally.

Main challenges

Over the long term, industry in OECD countries is feeling the pressure from both the growing Chinese output, but also from the additional capacity established in the Middle East, which benefits from lower energy costs, based on fossil fuels, and without a constraint on CO_2 emissions.

Probably because it is global, the aluminium industry is not concerned about GHG credits *per se* and their impacts on Southern competitors. The view is that it is more important that DC producers be engaged in GHG reductions, including with the help of revenues from CDM credits.

Nonetheless, while cement and steel manufacturing consumes electricity, aluminium's electricity intensity is by far the highest, rising concern about the sector's indirect GHG emissions whenever power is generated from fossil fuels. The issue has been most visible in Europe, through the significant rise in electricity prices partly driven by the introduction of CO_2 prices in traded prices. Whether or not CO_2 has been the main driver for rising electricity prices, some smelters have allegedly been closed as the result of higher electricity costs. The aluminium industry has been actively pursuing new forms of power contracts in order to access electricity supply at prices below spot prices (see Reinaud, 2007).

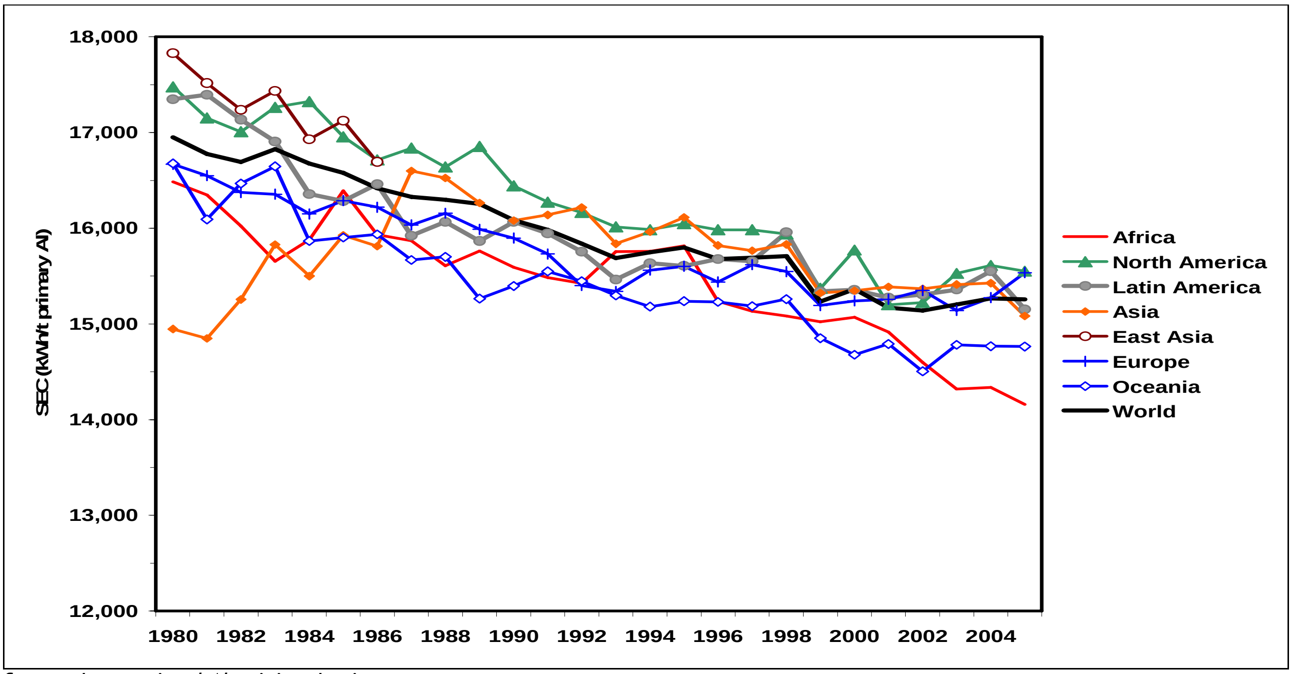
Differences in performance

National averages for energy intensity of aluminium smelting reveal important differences (Figure 11). We note that Africa, where the most recent smelting plant has been established, ranks first in electricity performance (see Figure 11).

Sector-wide greenhouse gas initiatives

We already described the International Aluminium Institute's objectives and performance to date, especially on the reduction of PFC, a very potent greenhouse gas. Data collected by IAI still indicates a wide dispersion of PFC emission for like processes, suggesting further room for improvement in the industry. To some extent, the IAI's efforts to date resemble most a transnational quantitative approach at sectoral level, in this case led by industry, without any government endorsement. However, IAI members have sometimes engaged in domestic GHG mitigation policies, often on a voluntary basis.

Figure 11: Specific power consumption in aluminium smelting in world regions



Source: International Aluminium Institute.

Like iron and steel and cement, the aluminium industry is engaged in APP, on similar terms, starting with an agreement on a PFC emission reporting format, the establishment of benchmarks, and exchanging information on best practice and technologies to reduce PFC emissions. Seven projects are underway, focusing mainly on benchmarking and reporting of energy consumption and emissions – including China, who had not reported PFC emissions through IAI to date. None of these projects involve intellectual property issues, as they deal mostly with the management and operations. APP builds on the existing measurement protocol developed by IAI. Recycling of secondary aluminium is another element of the aluminium task force action plan.

On the policy side, the aluminium industry is working with the European Commission to remain outside the EU ETS, on the basis of the diffusion of best practice and the use of best available technologies for greenfield projects. If it were successful, it would be a first example of so-called global agreement (GAt), combining a quantitative target (based on emissions intensity) and technology elements (the adoption of BAT for new projects). This will provide a good test case for the policy-makers' willingness to engage in an agreement with an industry at international level. We note however that aluminium is a rather small contributor to overall GHG emissions – especially when upstream emissions are already covered by other policy instruments, as is the case under the EU ETS.

In the United States, the aluminium industry has engaged with the U.S. Environmental Protection Agency to reduce its PFC emissions. The CO_2 equivalent emissions per tonne of aluminium have been halved between 1990 and 2002. The goal is to reduce total GHG emissions by 53% between 1990 and 2010. The industry is perceived as pro-emissions trading. Alcoa, the US largest aluminium producer, supports the US CAP initiative, promoting an ambitious climate policy for the US.

The above summary provides a rather optimistic view of the aluminium industry's ability to generate international GHG reduction activities on a unilateral basis. The industry may lend itself to such initiatives, with a very high level of CO_2 equivalent emissions, and some well-developed practice to control them, both through well-known technologies and best practice in plan management. The challenge ahead lies in the management of indirect emissions – which vary widely, from installations based on virtually zero-emission (hydro or nuclear plants) to those relying on long-term contracts with coal-based generators. While it is difficult to identify the exact role of the EU ETS on increased electricity prices faced by the industry, electricity costs will remain a determining factor for the choice of the next location for a new smelter – a choice on which *international* climate policy may have little impact for some time. Domestic policy choices, however, loom large in this field, as illustrated by the EU ETS effect on electricity prices.

Challenges and Possible Ways Forward

A sound approach to sectoral GHG emissions mitigation requires a thorough understanding of today's situation on a sector-specific basis, as well as a vision of tomorrow's challenges, beyond that of climate change constraints. Energy and input prices differ, local environmental constraints are not always binding, and various local regulations affect, positively or negatively, the achievable potential for CO_2 emission reductions. These starting points cannot be ignored; further, they may indicate avenues for international cooperation, if not coordination.

In the field of GHG mitigation, our review of policies and measures across a range of countries indicates strongly that so-called national circumstances loom large: governments in Annex I countries have taken very diverse policy measures to address the rise in GHG emissions of the sectors covered in our case studies (see Appendix 3 for further details). In some cases, initiatives came from industry – be they voluntary actions at national level (Keidanren's voluntary action plan), or international, such as the WBCSD Cement Sustainability Initiative or the International Aluminium Institute's efforts to reduce PFC emissions in smelting. It is fair to say that there is little commonality in the approach of the EU emissions trading scheme and voluntary agreements established elsewhere.

In the former case, carbon costs are felt directly, even if caps have varied a lot in stringency from one installation to the next, across countries – which triggered complaints about the system's fairness among its participants. As electricity consumers, heavy industry companies have been subject to the increase in electricity prices via the pass-through of CO_2 allowance prices onto the electricity markets. While industry in other continents may also face rising energy costs, they may not be so directly driven by climate policy.

The possibility that the US and Australia would introduce emissions trading schemes is likely to trigger discussions on their impact on industry's international competitiveness. For now, measures in these countries are voluntary – with varying coverage. Japan's negotiated agreements under the auspices of Keidanren are probably more comprehensive. The effect of such actions on the industry's cost and competitiveness are difficult to assess, however.

Companies have adapted to various national circumstances and established their competitive positions based on their national capacity and constraints. National differences in energy prices, labour cost, environmental and other regulations are obviously important factors in industry's overall competitiveness, but so is product quality, and ability to supply products to high-end segments with specific needs. This point was highlighted several times in the steel sector discussions. This may be less true in cement manufacturing. On the other hand, cement is much less traded than steel, which raises the question whether the search of a level playing field should be the priority of a sectoral approach, when cement markets seem to be so compartmentalised. Aluminium appears to be an exception, with a rather homogenous product that is widely traded, as location choices are more driven by the availability of cheap inputs than by local demand.

As it is, APP provides a means to diffuse best practice, and could help gather data that has been lacking on energy and environment performance in key industrial activities, mainly in China and India. Whether it will succeed in diffusing best practice and more efficient technology on commercial basis will depend on a range of factors, starting with China and India's domestic policy objectives and prevailing energy prices. At present, it is not envisioned that activities would seek CDM credits under the Kyoto Protocol, be it to supplement the financing if the technology were not economical.

An overwhelming factor in these discussions remains the growth in the sectors covered here outside the OECD regions, namely in China – India's growth is also rapid, but starts from a lower base. Such growth does create competitiveness concerns but one should haste to add that these are not linked primarily to climate change policy. Rather, the possibility of a slight slowdown of Chinese demand for industrial products worries the rest of the world about a possible outflow of industrial products on the world's markets. The industrial growth in coastal areas also facilitates exports. The fact that China moved from the first steel importer to the first steel exporter on worldwide markets between 2003 and 2006 is a striking illustration. While this concern is legitimate from the viewpoint of the industry in the rest of the world, a sectoral approach to *GHG mitigation* is unlikely to alleviate it in any significant way.

To be successful in developing countries, any sectoral approach should align its objectives with domestic policy priorities of "host" countries – when they are consistent with the goal of lowering GHG emissions. China's ambitious energy efficiency goals, its desire to rationalise industrial structure, combined with the pressure on local environment and coal resources, all elements offer a venue for international cooperation – as was expressed publicly by Gao Guangsheng, from NDRC, during the UNFCCC Dialogue at COP-MOP2 in Nairobi. The magnitude of the challenge is daunting (thousands of plants in all three sectors covered here, not to mention power generation), but the rapid rise of the country's industry-related CO_2 emissions requires action, action that need not be against China's interest. The same remark probably applies to other developing countries.

Different vehicles can be brought forward to assist developing countries in achieving domestic policy objectives while assisting in GHG mitigation:

- CDM or an extension thereof (policy-based CDM, SCM, no-lose sectoral targets), with the caveats discussed earlier. For countries nearer the income and capacity level of Annex I Parties, crediting (beyond CDM) could become an incentive to take binding targets at sectoral level.

- The possibility to engage in Sustainable Development Policies and Measures. This concept, promoted by South Africa, has not been fully developed in the UNFCCC, but could fit the policy objectives of developing countries.

In this field, the interviews conducted with industry have also revealed the role of best policy practice, an area where all parties could gain – and one in which the IEA is engaged, under its G8 mandate, in the field of energy efficiency. The adoption of best policy practice, e.g. to allow the use of additives in cement production – lowering the clinker-content of cement –, could help improve industry's performance while reducing overall CO_2 emissions.

In the near term, the priority lies in data gathering to better understand the industry's overall performance and its potential for improvements. All three industries have developed various GHG and energy measurement protocols, sometimes with differences in boundaries that may make international comparison difficult. In general however, industrialised countries are more advanced in this field than their developing country counterparts. Efforts underway for the countries gathered under APP, facilitated by the intergovernmental setting, should be helpful even if transparency issues were raised several times. The IEA is also developing energy performance indicators for a range of energy end-uses, including heavy industry, a task that has proven arduous.

A useful way to structure future work on sectoral approaches may be to distinguish those that would primarily address developing countries, and those that also seek to enhance GHG policy in developed countries. For the latter, the prospect of an industry-led initiative leading to a substitution of existing policy tools seems remote. However, a structured sectoral expertise could bring valuable information for next steps:

- First, governments can usefully engage in technical discussions on best practice, as possible guidance for their policy design.

- Second, the near term allocation of effort can be based on indicators of performance across the industry.

The issue of asymmetry of information (companies hold the key to technical knowledge within their industry, not governments) is probably a barrier in these government-industry discussion. It can best be removed by ambitious GHG mitigation proposals put forward by industry.

5. Possible Next Steps

We have tried to identify all possible options for sectoral approaches, recognising that implementation in a specific sector requires in depth analysis, for each specific configuration. Namely, a SA geared to facilitating improvements in developing countries will mobilise a different expertise from that required to establish sound performance indicators and benchmarks for industry in Annex I Parties.

Sectoral crediting mechanisms, also known as "no-lose sectoral pledges" have been well researched by IEA and other organisations (CCAP, see Schmidt *et al.*, 2005, 2006, 2006a, 2006b). This option offers a valid point of entry for some developing countries that may seek to enter GHG mitigation commitments through a sector, rather than a country-wide, approach. One area for future work may be the broad international climate policy aspect of such options, namely:

- How problematic is sector-wide crediting for trade-exposed, GHG-intensive industries?
- Implications for Annex I Parties, in a framework based on international emissions trading (i.e. Kyoto flexibility mechanisms).
- Nature, duration and scope of GHG crediting, in light of required levels of global reductions.

Sustainable development policies and measures (SD-PAMs) are another area worth exploring to engage developing countries in international policy cooperation, including for sectors covered in the present study. SD-PAMs are not yet officially recognised by the UNFCCC but are increasingly present in developing country submissions. The IEA puts great emphasis on energy efficiency as a main vector for lowering greenhouse gas emissions, and stresses the sustainability advantages of such an approach (e.g., if we consider this through the prism of the three Es: economy, through a more economical use of energy resources, environment, through lower local and global impacts, and energy security, as illustrated in IEA, 2007a).

Further, the IEA has engaged into in-depth analysis of energy efficiency best policy practice: reaching out to so-called +5 countries could deliver significant gains in terms of more sustainable energy practice and lower GHG emissions. Such expertise could be used as to help design SD-PAMs, as an instrument that aligns DC domestic policy objectives with the need to start reducing GHG emissions.

Industry performance indicators. It is clear, after many industry interviews and presentations on issues such as boundary conditions, energy and GHG accounting at the plant level, or country-specific regulatory approaches to industrial activities, that a benchmarking activity can only be initiated by industry groups, ahead of the curve of most organisations like the IEA. On the other hand, the use of such information, once collected, opens up a range of policy questions that could be researched by IEA (over and above ongoing IEA activities for the G8, under the Gleneagles Plan of Action). These include:

- How to use benchmarks in policy design? In particular, what is the role of benchmarks in light of the need to reach, as much as possible, a least-cost outcome for GHG mitigation activities?
- Benchmarks: from current observations to a dynamic approach to efficiency and GHG improvements.

Beyond industry. Power generation and use, as well as transport, are the fastest growing sources of GHG emissions in the developing world. These activities (power generation, electricity end-use, automotive industry, transport policies) do not raise similar competitiveness concerns as those illustrated in this work. Is there an avenue for sectoral approaches in these sectors? The IEA has started exploring this question for power generation. Further work could be envisioned, especially from the angle of sectoral crediting – with the above caveats still applying.

A pilot phase for sectoral approaches. In the run up to the Kyoto Protocol, a pilot phase for activities implemented jointly provided important insights for the project-based mechanisms of the Protocol. A pilot phase could also be envisioned to go beyond the theoretical and abstract discussion of SA and face the implementation issues mentioned above. Among elements to be tested are the following:

- The feasibility and usefulness of a common benchmark, or a common methodology to establish meaningful country-specific sectoral objectives, reflecting national circumstances and also a country's willingness to undertake meaningful reductions.
- Countries' institutional needs to implement sectoral emission objectives, and how such institutional needs are if GHG crediting were to be involved.
- A method for international cooperation to encourage best practice (in policy and technology). Best policy practice may not be simply "transplanted" from one developed to a developing country. The feasibility of such policy ought to be tested, possibly with pilot projects in the country. Identifying and developing case studies to illustrate such method would be a useful first step.

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List of Acronyms

APP:	Asia-Pacific Partnership for Clean Development and Climate
CDM:	Clean Development Mechanism
CSL:	A country's commitment at sectoral level, with some quantified element
CSI:	Cement Sustainability Initiative, hosted by the World Business Council on Sustainable Development
DC:	Developing countries
EU:	European Union
EU ETS:	European Union emissions trading scheme.
GHG:	Greenhouse gases
IAI:	International Aluminium Institute
IISI:	International Iron and Steel Institute
NDRC:	China's government National Development and Reform Commission
SA:	Sectoral approaches
SCM:	Sectoral crediting mechanism
SD-PAMs:	Sustainable development policies and measures