# Sectoral approach and development

## Input paper for the workshop: Where development meets climate - development related mitigation options for a global climate change agreement

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# Summary

This report provides background information on sectoral approaches and development in the context of the international negotiations on climate change. Within this paper, we provide an introduction of three of the prominently discussed sectors - electricity, cement and iron and steel. We then examine some of the concepts that are discussed under the term "sectoral approach" and summarize the current discussions on the categorization of approaches. Finally we describe three relevant approaches in more detail – a bottom-up negotiated sectoral target, a "Best Available Technology" (BAT)-based approach and sectoral sustainable development policies and measures.

The agreement on the Bali Road Map in December 2007 accelerated the pace of the international climate negotiations. This decision set the framework to come to a comprehensive international agreement on climate change by the end of 2009. This includes the assignment of new emission reduction targets for countries covered by the Kyoto Protocol, mitigation commitments or actions by all developed countries (including the USA) and mitigation actions by developing countries by the end of 2009.

To broaden the efforts, sectoral approaches have come into focus. Sectoral approaches can be supplemental but are for most no alternative to emission reduction targets for developed countries. But they could be attractive to developing countries. While the contribution of developing countries to global GHG emissions is increasing rapidly, per capita emissions are still low and developmental challenges remain significant. Future efforts with a sectoral focus however could offer the possibility of creating new opportunities in developing countries, especially through technology transfer and capacity building, which can contribute to sustainable development.

**Sectors**

Electricity and heat account for about 13 $GtCO_2$-eq representing 26 percent of global GHG emissions, making it the largest sector. This makes it the most obvious candidate for a sectoral approach. Additional elements that make this sector interesting are the usually high degree of concentration within the sector and the only limited competitiveness concerns.

The cement industry emits about 5% of the global $CO_2$ emissions. The cement industry is relatively fragmented, at least on a global scale, with the ten largest international firms accounting for about one third of global production and with a large number of small producers, especially in China. It is essentially a local product with a market restricted to 200-300km around the plant. Long-distance trade is limited due to the weight and resulting high cost for transportation compared to the low price per tonne of the product. World trade has typically accounted for approximately 6-7% in aggregate terms. This lowers competitiveness concerns. Nevertheless, imports of cement to the USA, the EU and other coastal areas have increased.

The iron and steel sector emits about 1500-1600 $MtCO_2$-eq (IPCC, 2007), equivalent to roughly 3% of global GHG emissions. The sector is slightly more concentrated than the cement sector, with the 20 largest companies accounting for almost 40% and the largest 80 companies for 70% of world production. Unlike cement, trade is quite substantial in the sector. Finished steel as well as crude steel and iron products are traded with shares of up to 40% of total production.

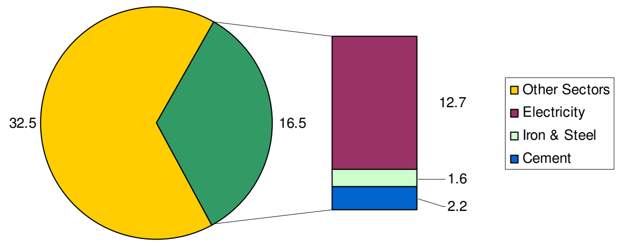



Illustration A: Total GHG emissions by sector in Gt $CO_2$-equivalent (approximate values for 2004 to 2006).

## Overview of sectoral approaches

A variety of possible options for sectoral approaches is currently discussed. The following Table A describes a few of them. Even small variations in one element can have large effect on the impact of an approach, like environmental effectiveness, distributional effects or simplicity of negotiation.

Table A. Overview of sectoral proposals

| | Policy-based | Technology-based | | Emissions-based | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | | F | | G |
| | SD-PAMs | Technology cooperation | Technology standards sector-based | Transnational / emission global targets | CDM | | Sectoral Targets | | Binding national targets |
| | | | | | Classic | Sectoral | Sector no lose targets | Binding sectoral targets | |
| **Legal status** | Binding / non-binding | Non-binding | Binding / non-binding | Non-binding | Non-binding | Non-binding | Non-binding | Binding | Binding |
| **Responsible entity** | Government | Governments and industry associations | Government | Companies | Private entity (company) | Private entity (company) | Government | Government | Government |
| **Regional coverage** | National | Transnational / global | National / transnational / global | Transnational / global | National | National | National | National | National |
| **Scope** | Sectoral / economy wide | Sectoral | Sectoral | Sectoral | Project based | (Multi-)Project / sectoral | Sectoral | Sectoral | Economy wide |
| **Target type** | Policy implementation | Technology / R&D | Standard implementation | absolute / intensity emission target | absolute/intensity | absolute/intensity | absolute / intensity | absolute / intensity | absolute |
| **Stringency** | Defined by government | n.a. | Uniform base, with some regional differentiation | To be determined | Project-individual cut on current emissions / BAU | Country-identical cut on current emissions / BAU for all projects in sector in country | Country-individual cut on current emissions / BAU | Country-individual cut on current emissions / BAU | To be determined |
| **Implementation** | Up to government | Voluntary | Up to government | Up to company | Built-in design | Built-in design | Up to government | Up to government | Up to government |
| **Relation to carbon market** | None | None | None / carve-out / within | None / seperate market | Within | Within | Within | Within | Within |
| **Financing** | Private sector finance / international funds / ODA | Public and private sector finance | Private sector finance / international funds / ODA | Internal carbon market / international funds / ODA | Carbon market | Carbon market | Carbon market / international funds | Carbon market / international funds | Carbon market / international funds |
| **Focus** | Engaging developing countries | Technology development and diffusion | Competitiveness / technology development and diffusion | Competitiveness / cost efficiency | Cost efficiency, sustainable development | Cost efficiency, sustainable development | Engaging developing countries | Engaging developing countries | Engaging developing countries |
| **Governing body** | Commitment proposed by national governments, acknowledged / accepted by COP | New body with government and industry participation | Agreement by COP | Industry association | CDM EB | CDM EB | Agreement by COP, advice by new technical body? | Agreement by the COP | Agreement by the COP |
| **Example** | **South Africa:** promotion of energy efficient low cost housing | **Steel:** APP steel sectoral task force - SOACT Steelmaking Handbook | **Automotive:** Top-Runner-Approach Japan; Canadian automobile industry commitment for total reduction by 2010 | **Aviation:** Emission trading system for international aviation linked to Kyoto Protocol carbon market | **Steel:** Introduction of heat recovery for blast furnaces | **Electricity:** Multi-project baseline of 600g/kWh **Cement:** Country average baseline measured in $tCO_2$ / t | **Cement:** National baseline measured in $tCO_2$ / t | **Cement:** National baseline measured in $tCO_2$ / t | Kyoto style targets |

n.a. = not applicable

Sectoral approaches which are the focus of this paper

## Three designs

We provide a detailed description of three promising approaches and evaluate them.

**Negotiated binding sectoral targets:** A commitment to keep emissions of a sector below a certain level is defined *a priori*. This level of greenhouse gas emissions (the target) can be set in absolute terms – i.e. as a cap on total sectoral emissions. Alternatively, a target can be chosen that is expressed as emission intensity, for example in the form of tons $CO_2$eq. per ton of product. International emission trading can be applied. "No regret" measures at less than zero net cost are undertaken by the country, measures with a co-benefit on e.g. energy security are partly internationally funded and ambitious reductions are fully funded through this mechanism.

**Best Available Technology and Best Practice commitments:** Developing country would need to achieve certain predefined advanced technology standards in selected sectors. In practice, this includes a binding commitment to use best available technology (BAT) in new installations and to upgrade existing installations to a best practice (BP) level. The commitments cover sectors separately and independently and do not extend to a commitment for the whole economy. "No regret" measures at less than zero net cost are undertaken by the country, measures with a co-benefit on e.g. energy security are partly internationally funded and remaining reductions are fully funded by developed countries.

**Sectoral sustainable development policies and measures (SD-PAMs):** A developing country government commits to implementing a range of policies and measures in a certain sector aimed at sustainable development that are also beneficial for climate change mitigation. The policies and measures proposed by the developing country do not have to have greenhouse gas emission reduction as their core objective, but as a co-benefit, and they should focus on sustainable development as defined by the implementing country. In return, it receives financial or other support by developed countries according to a fixed set of rules under the UNFCCC. The support can be tied to the requirement that the policies are estimated to achieve a necessary level of reductions.

The following Table B provides a summarized comparison of the three approaches. Each approach has its advantages and disadvantages. While negotiated binding sectoral targets score well on environmental effectiveness and economic efficiency, they are complex to negotiate. Best available technology and best practice commitments can be less effective if they do not achieve movement to from one technology to another (e.g. to renewables) and defining the BAT and BL levels can be difficult, but they build on the concept of technology upgrading and support. Sectoral sustainable development policies and measures may not target all possible mitigation options, but would be simpler to implement.

Table B: Summary of the evaluation of three sectoral appraoches

| | Sectoral sustainable development policies and measures | Best available technology and best practice commitments | Negotiated binding sectoral targets |
|---|---|---|---|
| **Environmental** | Impact on emissions depends on stringency of policies, hard to predict<br>Possibly not covering all emission reduction options, since some may not have a sustainable development benefit | Impact potentially high but depends on stringency<br>Special consideration needs to be taken to reduce demand for products and to achieve movement to low carbon technologies (e.g. renewables) | Impact potentially high but depends on stringency<br>If intensity based, special consideration needs to be taken to reduce demand for products |
| **Economic** | Sources and distribution of financing need to be defined<br>Emission trading cannot be applied, but long-term perspective is taken | Sources and distribution of financing need to be defined<br>Emission trading cannot be applied | Carbon market is a major funding source<br>Globally cost effective through emission trading if broad participation |
| **Distribution and equity** | Builds on host country development objectives and characteristics | Builds on the concept of technology upgrading, energy security, etc.<br>Accommodation of national circumstance by adjustments for availability of natural resources and differentiated timelines for implementation | Bottom up development and negotiation leads to adequate consideration of national circumstances<br>May be seen as a limiting economic growth |
| **Technical and institutional** | Only the *implementation* of the policies has to be monitored, not their effect<br>Difficult to determine the stringency of the effort and level of financial support needed | Agreement on the approach possible in December 2009<br>Technical specification of the BAT and BP levels is very difficult, taking place after 2009<br>Determination of the national contribution and the financing needs difficult | Exact amount of emission reductions from sectoral targets will not be available in December 2009, but will only emerge after subsequent detailed negotiations<br>High government capacity needed to implement national measures to reach the target |

Yellow indicates a medium evaluation
Green indicates a positive evaluation

**What needs to be in a Copenhagen agreement?**

The options for a sectoral approach discussed above require large amounts of work to be completed before their full implementation. Only some elements can be agreed in Copenhagen in 2009.

In the case of **negotiated binding sectoral targets**, the actual targets will remain open for negotiation after Copenhagen. COP 15 could agree on the following points:

- Developed countries agree on a level of funding available for this approach. Funding could be in terms of tighter emission targets to generate the additional demand or a fixed level of funding to purchase emission credits from such a sectoral mechanism
- Developing countries as a group agree on an indicative level of emission reductions from this approach
- Definition of sectors and boundaries

- Minimum requirements for the in-country bottom-up analysis
- Mandate for SBSTA to review individual country proposals for sectoral baselines and prepare recommendations for negotiations at COP level
- System of penalties to be applied in the case of non-compliance with sectoral target, if different to that of Annex I countries

Following the *modus operandi* decided in Copenhagen, the COP will annually negotiate binding sectoral targets proposed by developing countries, starting at COP 16 in 2010

In the case of **BAT and BP commitments**, the agreement in Copenhagen will likewise not include the actual definition of BAT and BP levels, but COP 15 could agree on the following points:

- Developed countries agree on a total minimum budget for financing and agree on the provisions of its origin and split among countries
- Qualified developing countries commit to apply BAT/BP in specific sectors
- Definition of sectors and boundaries
- Mandate for the establishment of a BAT/BP-setting committee under SBSTA, including its composition
- Mechanism for generating financial resources from developed countries (e.g. auctioning of allowances) and allocating them to developing countries
- System of penalties to be applied in the case of non-compliance with technology commitments

Following the timeline agreed in Copenhagen, the committee under SBSTA will prepare recommendations for BAT/BP levels that need to be adopted by the UNFCCC with a specific time schedule, depending on the speed of this process.

**Sectoral sustainable development policies and measures** in an agreement at Copenhagen require the following preparatory work and decisions at COP 15:

- Developed countries agree on amounts of financing and technological support available, including rules that provide incentives for ambitious SD-PAMs
- Qualified developing country parties commit to applying SDPAMS in specific sectors (without details)
- Parties agree on a format for the proposals of SD-PAMs, the review process (including necessary institutional setup) and the modalities to monitor and sanction effective implementation
- SBSTA receives the mandate to provide transparent and comparable assessment of the SD-PAM proposals by developing countries
- The parties agree at COP 15 in Copenhagen on the modalities of reviewing SD-PAMs and on the allocation of developed country support, as well as rules for the progression from this approach to more stringent targets after 2020 or any other date.

Following an agreed timeline, Parties negotiate the individual country proposals and agree on their financial support, clearing the way to implementation.

## Table of contents

# 1 Introduction

The agreement on the Bali Road Map in December 2007 accelerated the pace of the international climate negotiations. This decision set the framework to come to a comprehensive international agreement on climate change by the end of 2009. This includes the assignment of new emission reduction targets for countries covered by the Kyoto Protocol, mitigation commitments or actions by all developed countries (including the USA) and mitigation actions by developing countries by the end of 2009.

Multiple process support this goal, but the pace is slow. The G8 summit in July 2008 failed to move beyond the previously stated ambition level and has also influenced the outcome of the Major Economies Meeting (MEM) held at the same time. The major economies have reinforced their commitment to the UNFCCC process, but have not moved beyond that.

The current efforts are much too limited in scale (amount of reductions), scope (geographical coverage) and timeframe (up to 2012) to ensure stabilization of GHG concentrations.

To broaden the efforts, sectoral approaches have come into focus. Sectoral approaches have also been discussed as a possible alternative to the Kyoto system for Annex I countries post 2012. However, the chair of the ad hoc working group on further commitments for Annex I Parties under the Kyoto Protocol (AWG-KP) summarized at fifth session in Bonn that sectoral approaches "*should not replace nationwide targets but should instead complement them*", indicating that they are no alternative approach for Annex I parties, but could be well suited to engage developing countries (UNFCCC 2008).

However, when seeking to engage developing countries the development aspect comes into focus. While the contribution of developing countries to global GHG emissions is increasing rapidly, per capita emissions are still low and developmental challenges remain significant. Future efforts with a sectoral focus however could offer the possibility of creating new opportunities in developing countries, especially through technology transfer and capacity building, which can contribute to sustainable development (IGES 2008).

There is a range of incentives to engage in sectoral approaches, the role they can play in a future climate regime (Watson et al. 2005) and why they are specifically apt to motivate developing country involvement. Sectoral agreements could:

- be negotiated while a more comprehensive approach is being developed;
- enable accessibility and affordability of more efficient technologies for developing countries;
- be less cumbersome than the current project-by-project approach;
- make cost of burden sharing clearer;
- address competitiveness issues;
- focus attention on where the key breakthroughs have to be made. A small number of sectors account for the bulk of emissions. With forecast growth in these sectors, only significant technology transformation will enable restrictions in emissions;
- provide synergies with important social and economic development goals.

Demand for power and industrial products is growing strongly in advanced developing countries. Growth in these sectors in developed countries is by far lower. Combined with a large share of worldwide production and often lower average efficiency this offers a strong incentive to include emerging economies in GHG mitigation efforts. Developing countries are estimated to contribute 74% of the increase in global primary energy use in the BAU scenario between 2005 and 2030, with China and India alone accounting for 45% (Egenhofer and Fujiwara 2008). Developed countries clearly have to take the lead in emissions reductions. In addition, efforts have to be made to avoid emission intensive development in developing countries.

Overarching for the participation emerging economies in the mitigation activities is the UNFCCC principle to act on the basis of "common but differentiated responsibilities and respective capabilities" (see also Höhne et al. 2003). To which extent sectoral approaches observe this principle depends on the design. Depending on the stringency of the design there are large potentials to achieve additional emissions reductions, if sectoral approaches are not used to offset activities in industrialized countries (as in CDM). Most design options offer sufficient incentives for developing countries to participate, as most of them take the specific situation of the country into account and are not likely to hamper development, but rather enhance it through technical and financial support.

Limitations of sectoral approaches are however apparent. As they cover only certain sectors, the extent of possible reductions is lower than in comprehensive schemes, reducing their environmental effectiveness. Leakage to non-participating countries or to other sectors, like for example wood to substitute for cement in buildings, increases the problem unless the approach is transnational or global and includes at least the major producing countries. If applied in such a global way sectoral agreements can actually reduce competitiveness and leakage problems. Economically the possibilities to engage in mitigation efforts in those sectors that are the most cost-effective is restricted, unless some trade mechanism with other sectors or cap-and-trade systems is included (Schmidt et al. 2006). However, CDM might be an option that could be used also for sectoral approaches to reduce cost to achieve given targets. While environmentally and economically a global cap-and trade system might be the preferred approach, this is however not a likely option in the post-2012 timeframe (Bodansky 2007).

Within this paper, we give an overview over the most important approaches currently in the discussion, since "sectoral approaches" can mean a wide variety of things. In a first step we provide an introduction of three of the prominently discussed sectors - electricity, cement and iron and steel. We will outline the main production processes, the reduction potentials as well as some key indicators for these sectors for a range of countries. We concentrate on the 6 most important emerging countries, China, India, Brazil, Mexico, South Africa and Korea. To provide a basis for comparison we will also look at data from the US, Japan, Russia and EU (27).

We then examine some of the concepts that are discussed under the term "sectoral approach" and summarize the outcome of the current discussions on the categorization of approaches. These approaches are then evaluated against the UNFCCC framework as well as in relation to other mechanisms that could be envisaged to increase the mitigation efforts in developing countries.

Chapter 4 describes three relevant approaches in more detail – a bottom-up negotiated sectoral target, a "Best Available Technology" (BAT)-based approach and sectoral sustainable development policies and measures. It assesses them against a set of environmental, economic and technical criteria.

# 2 Data compilation for sectoral approaches

Once the need for sectoral approaches has been identified, the next question revolves around which sectors are to be targeted. There are a number of factors to be considered like the share of global emissions, the rate of emissions growth, capital replacement and technology development and adoption, the concentration of the sector (Watson et al. 2005), energy intensity, the potential for efficiency improvement, the ability to switch to low carbon energy sources as well as product demand elasticity (Houser et al. 2008). The danger of a "lock in" of major investments with high GHG intensity for a long time – especially in fast growing emerging economies – also plays an important role (Baron 2006). The ongoing discussion focuses mainly on the electricity sector and some major manufacturing sub-sectors - cement, aluminum, iron & steel and transport (UNFCCC 2008).

The following subchapters provide information on the electricity & heat sector, the cement sector and the iron & steel sector.

Electricity and heat account for about 13 $GtCO_2$-eq representing 26 percent of global GHG emissions, making it the largest sector. This is equivalent to 32 percent of global $CO_2$ emissions and 43 percent of $CO_2$ emissions from energy-related sources (figures exclude land-use change and forestry). Within this sector, electricity generation accounts for the largest share, at 68 percent of the sector and 17 percent of global GHG emissions (Bradley et al. 2007). This makes it the most obvious candidate for a sectoral approach. Additional elements that make this sector interesting are the usually high degree of concentration within the sector and the only limited competitiveness concerns.

The cement industry emits about 5% of the global $CO_2$ emissions. The cement industry is relatively fragmented, at least on a global scale, with the ten largest international firms accounting for about one third of global production and with a large number of small producers, especially in China. The 18 member companies of the WBCSD Cement Sustainability Initiative represent around 50% of the cement production outside of China. Over 90% of all new plants will be built in emerging and developing countries in the coming 40 years. It is essentially a local product with a market restricted to 200-300km around the plant. Long-distance trade is limited due to the weight and resulting high cost for transportation compared to the low price per tonne of the product. World trade has typically accounted for approximately 6-7% in aggregate terms. This lowers competitiveness concerns. Nevertheless, imports of cement to the USA, the EU and other coastal areas have increased.

The iron and steel sector emits about 1500-1600 $MtCO_2$-eq (IPCC, 2007), equivalent to roughly 3% of global GHG emissions. The sector is slightly more concentrated than the cement sector, with the 20 largest companies accounting for almost 40% and the largest 80 companies for 70% of world production. Unlike cement, trade is quite substantial in the sector. Finished steel as well as crude steel and iron products are traded with shares of up to 40% of total production (IISI 2007).

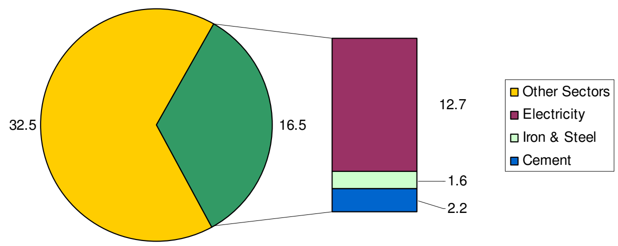



Illustration 2 - 1 Total GHG emissions by sector in Gt $CO_2$-equivalent (approximate values for 2004 to 2006).

## 2.1 Electricity

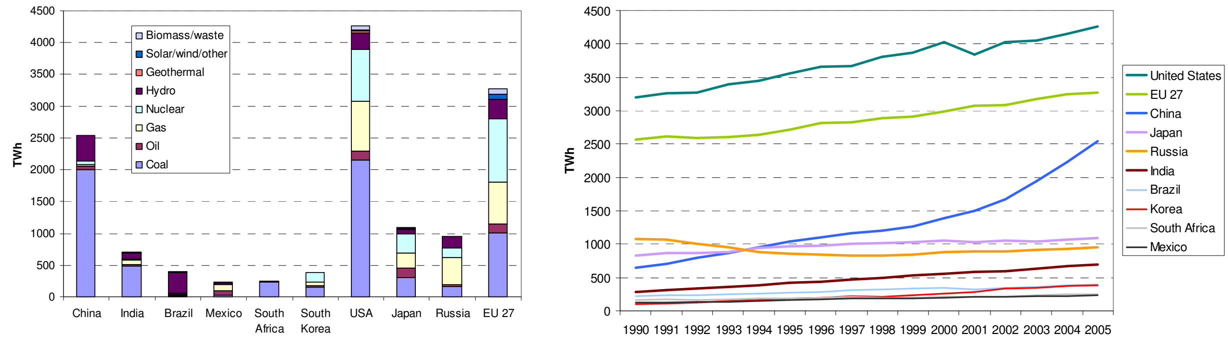
### Production

The power sector comprises plants transforming primary energy into electricity and heat, which is then distributed to final consumers by a grid.[1] Electricity for the grid can be produced in

- Fossil fired power plants (coal, lignite, gas or oil)
- Nuclear power plants
- Renewable energy power plants using wind, photovoltaic, geothermal, hydro or biomass.

Power generation units are either base-load units designed to run at high capacity or peak-load units (also called load-following plants) providing electricity only during those times of the day where demand increases. Normally, the sources with the lowest marginal cost and must-run plants (e.g. certain hydro, geothermal, coal, nuclear) are used as base-load plants, while more expensive plants are used during peak-hours. Generation mostly takes place in large central installations, but small decentralized generation units play an increasing role especially for the integration of renewable energy and combined heat and power (CHP) production.

[1] Electricity can also be produced off-grid. However, with a view to the commercial power sector, we are only focussing on electricity production for the grid.




Note: Power production including CHP and autoproduction
Source: IEA energy balances 2007

Illustration 2 - 2 Fuel mix in 2005 and power production since 1990

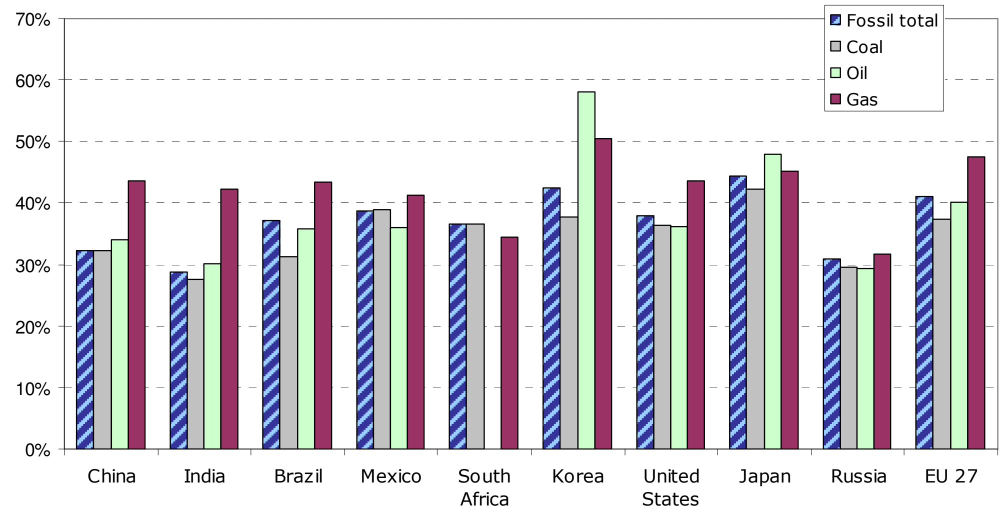
The US and EU are by far the largest producers with fairly steady growth rates (see Illustration 2-1). Power production in China today is at a level of EU production in 1990, but with higher growth rates. India is still on a relative low level, but has more than doubled production since 1990. The only country with a small reduction in production is Russia, which is mainly due to the closing down of old industry installations in the 90s.

The fuel mix shows large differences between countries with Brazil relying for 84% on hydro, while South Africa has 94% coal. Nuclear power plays no significant role in China, India, Brazil, Mexico and South Africa, whereas it has a significant share in the US, Japan and Europe.

### Emissions

Greenhouse gas emissions from electricity production vary with the energy source used and with the efficiency of the process. Burning fossil fuels in power plants is a $CO_2$-intensive process, while electricity production from nuclear power plants and renewable energy sources is climate-friendly. However, each energy source may have other advantages and disadvantages which have to be taken into account (e.g. nuclear waste disposal, resource availability, security of supply). Due to different historical and political reasons and the availability of primary energy sources, each country has its own generation mix. The latter is the main factor determining the emission intensity of electricity.

The efficiency between the different fossil fuel sources varies. Power production from natural gas tends to be more efficient than oil, and coal usually has the lowest efficiency of fossil sources. The age of installations and quality of fuel available also plays an important role. The degree of heat use (CHP) also influences overall efficiency. Data have been calculated to include heat production with a standard heat generation efficiency value. In Korea for example there is a high amount of autoproduction CHP plants on oil basis, which increases efficiency in this area significantly.




Note: Power production including CHP and autoproduction (efficiency including heat production adjustment).
Source: Own calculations based on IEA energy balances 2007

Illustration 2 - 3 Efficiency of power production by source. Average 2003-2005

Total energy efficiency includes non-fossil generation, which explains the in some cases large difference between fossil and total efficiency: In the case of Brazil due to the large share of hydro; in the case of the EU due to the significant amount of nuclear and renewable energy. Fuel mix also has a large impact on carbon intensity (see Table 2 - 1).

| | Production | Fossil generation efficiency | Total generation efficiency | Share of world production | Total primary energy use | Carbon intensity | Carbon emissions | Share of carbon emissions |
|---|---|---|---|---|---|---|---|---|
| | TWh | % | % | % | PJ | $kgCO_{2eq}/kWh$ | $MtCO_{2eq}$ | % |
| China | 2,535.89 | 32.3% | 36.7% | 14.0% | 24,870 | 0.93 | 2,363.29 | 21.4% |
| India | 699.04 | 27.9% | 31.9% | 3.8% | 7,882 | 1.12 | 781.54 | 7.1% |
| Brazil | 402.29 | 36.4% | 81.9% | 2.2% | 1,768 | 0.12 | 49.58 | 0.4% |
| Mexico | 234.90 | 39.4% | 44.1% | 1.3% | 1,918 | 0.64 | 149.24 | 1.3% |
| South Africa | 242.92 | 37.0% | 38.4% | 1.3% | 2,279 | 0.99 | 240.13 | 2.2% |
| South Korea | 387.83 | 43.3% | 55.2% | 2.1% | 2,586 | 0.44 | 169.57 | 1.5% |
| USA | 4,268.38 | 38.3% | 45.3% | 23.5% | 33,981 | 0.69 | 2,936.21 | 26.5% |
| Japan | 1,094.19 | 44.3% | 55.3% | 6.0% | 7,128 | 0.45 | 490.84 | 4.4% |
| Russia | 951.16 | 30.7% | 38.5% | 5.2% | 10,113 | 0.75 | 712.79 | 6.4% |
| EU 27 | 3,273.38 | 41.7% | 54.0% | 18.0% | 22,536 | 0.39 | 1,275.12 | 11.5% |
| Rest Developing | 2,923.13 | n.a. | 39.7% | 16.1% | 26,226 | 0.51 | 1,487.22 | 13.4% |
| Rest Developed | 1,162.13 | na. | 43.6% | 6.4% | 9,571 | 0.35 | 405.30 | 3.7% |
| WORLD TOTAL | 18,175.24 | | | 100.0% | 150,859 | | 11,060.83 | 100.0% |

Production: 2005 (IEA energy balances 2007)
Energy intensity: own calculation based on IEA energy balances 2007
Carbon intensity: own calculation based on IEA CO2 Emissions from Combustion 2007

Table 2 - 1 Electricity production, efficiency and emissions in 2005.

**Reduction potentials**

The emission intensity of a country's electricity grid can be decreased by the following options.

⇨ Improving existing processes

1. Improving the energy efficiency of existing and new generation units, e.g. by more efficient power plant technologies, better management and maintenance of power plants, using better quality fuels
2. Switching to lower carbon fuels (e.g. from coal to gas)

- ⇨ Increasing the proportion of renewable or nuclear energy in the generation mix
- ⇨ Increasing the share of combined heat-and power generation
- ⇨ Reducing transmission losses
- ⇨ Demand side measures to reduce total and peak consumption
- ⇨ Capturing and storing carbon (CCS)

Table 2 - 2 summarises the savings potential of the different options and the related cost assuming that there are no additional electricity savings in the building and industry sectors beyond those already included in the baseline.

Additional savings in electricity use are included in the potentials given in Table 2 - 3. The differences between bottom-up and top-down figures are due to differences in the mitigation options included and the fact that top-down estimates include the effects of energy savings in other sectors as well as structural changes.

| | | Region | Mitigation potential: emissions saved in 2030 in Mt CO2-eq < 0 US$/t CO2-eq | 0 - 20 US$/t CO2-eq | 20 - 50 US$/t CO2-eq | 50 - 100 US$/t CO2-eq | > 100 US$/t CO2-eq | Total |
|---|---|---|---|---|---|---|---|---|
| **Improving existing processes** | **Fuel switch and plant efficiency** | OECD[a] | | 390 | | | | 390 |
| | | EIT[b] | | 40 | | | | 40 |
| | | Non-OECD | | 640 | | | | 640 |
| | | **World** | | **1,070** | | | | **1,070** |
| **Increasing the proportion of renewable or nuclear energy** | **Nuclear** | OECD | 465 | 465 | | | | 930 |
| | | EIT | 115 | 115 | | | | 230 |
| | | Non-OECD | 360 | 360 | | | | 720 |
| | | **World** | **940** | **940** | | | | **1,880** |
| | **Hydro** | OECD | 332 | 58 | | | | 390 |
| | | EIT | | | | | | |
| | | Non-OECD | 120 | 168 | 192 | | | 480 |
| | | **World** | **452** | **226** | **192** | | | **870** |
| | **Wind** | OECD | 158 | 180 | 112 | | | 450 |
| | | EIT | 21 | 27 | 12 | | | 60 |
| | | Non-OECD | 147 | 210 | 63 | | | 420 |
| | | **World** | **326** | **417** | **187** | | | **930** |
| | **Bio-energy** | OECD | 40 | 50 | 80 | 30 | | 200 |
| | | EIT | 14 | 18 | 28 | 11 | | 70 |
| | | Non-OECD | 190 | 285 | 428 | 47 | | 950 |
| | | **World** | **244** | **353** | **536** | **88** | | **1,220** |
| | **Geothermal** | OECD | 32 | 36 | 22 | | | 90 |
| | | EIT | 11 | 14 | 5 | | | 30 |
| | | Non-OECD | 109 | 155 | 46 | | | 310 |
| | | **World** | **152** | **205** | **73** | | | **430** |
| | **Solar PV and concentrated solar power** | OECD | | | | 6 | 24 | 30 |
| | | EIT | | | | 2 | 8 | 10 |
| | | Non-OECD | | | | 53 | 157 | 210 |
| | | **World** | | | | **61** | **189** | **250** |
| **CCS** | **CCS + coal** | OECD | | | 280 | | | 280 |
| | | EIT | | | 10 | | | 10 |
| | | Non-OECD | | | 200 | | | 200 |
| | | **World** | | | **490** | | | **490** |
| | **CCS + gas** | OECD | | | | 90 | | 90 |
| | | EIT | | | 12 | 28 | | 40 |
| | | Non-OECD | | | | 90 | | 90 |
| | | **World** | | | **12** | **208** | | **220** |
| **Total reduction** | | OECD[a] | 1,027 | 1,179 | 494 | 126 | 24 | 2,850 |
| | | EIT[b] | 161 | 214 | 67 | 41 | 8 | 490 |
| | | Non-OECD | 926 | 1,818 | 929 | 290 | 157 | 4,120 |
| | | **World** | **2,114** | **3,175** | **1,490** | **357** | **189** | **7,360** |

[a] Organization for Economic Cooperation and Development
[b] Economies in Transition

Source: IPCC 2007

Table 2 - 2 Power generation mitigation potentials and costs by reduction option.

| | | Mitigation potential including end-use electricity savings: emissions saved in 2030 in Mt CO2-eq < 20 US$/t CO2-eq | < 50 US$/t CO2-eq | < 100 US$/t CO2-eq |
|---|---|---|---|---|
| **Sector-based 'bottom-up' potential** | **Low** | 4,400 | 5,600 | 6,300 |
| | **High** | 6,400 | 8,400 | 9,300 |
| **Economy-wide 'top-down'** | **Low** | 3,900 | 6,700 | 8,700 |
| | **High** | 9,700 | 12,400 | 14,500 |

Table 2 - 3 Power generation mitigation potentials including energy savings.

## 2.2 Iron and steel

### Production

The iron and steel sector has a complex industrial structure. However, energy consumption is dominated by a limited number of processes. The production process starts with iron ore, which is processed into either pig iron ("hot metal") or direct reduced iron (DRI). Using these intermediate products and/or scrap, various end products – steel, wrought iron and cast iron - are derived. Steel production has by far the biggest and most important role within the iron processing and accounts for about 95% of the use of iron. Steel production involves several processing stages including iron making, steelmaking, casting and hot rolling and finishing processes (IISI 2008).

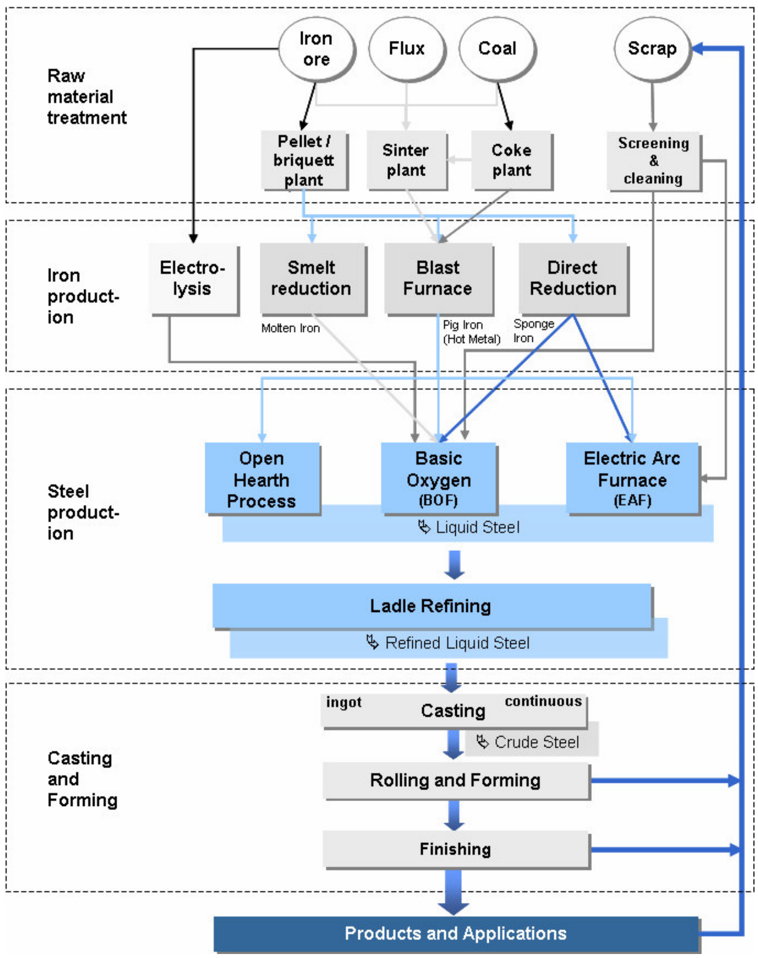



Illustration 2 - 4 Steel production process

Steel can be made either from raw materials (e.g. iron ore, coal and limestone) or by recycling steel scrap. First, the raw materials - either iron ore or scrap, are converted into molten steel. The ore-based process uses a blast furnace and then refines the steel in the basic oxygen furnace. This process is also referred to as primary steelmaking taking place mainly in integrated steelmills. They have most of the processes within one plant to save energy for treatment and re-heating. The scrap-based process uses an electric arc furnace to produce secondary steel. These are called "minimills" as the necessary size for the installation is a lot smaller, which has large impact on necessary investment. There are also other production options, including direct reduction and smelt reduction, which can be integrated into the main production processes (Beer et al. 2000).

World steel production has increased by 108% between 1990 and 2007 with the largest growth happening in China. In 1996 China became the world's largest steel producer and today accounts for 35% of world production.

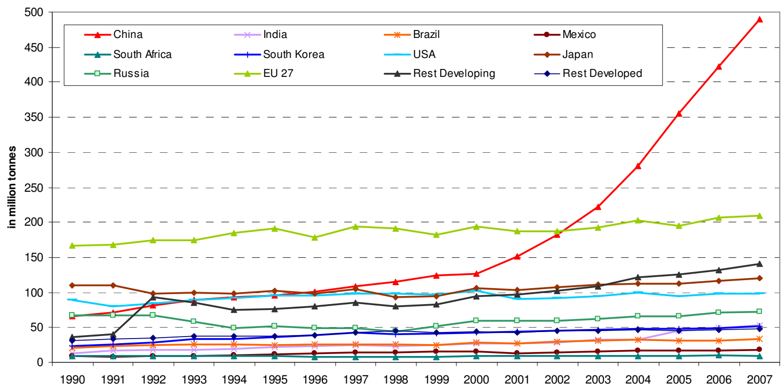
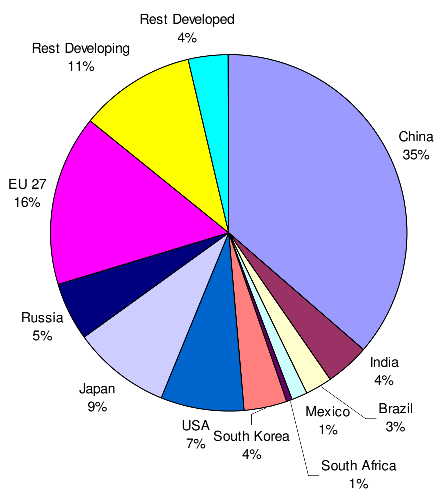



Illustration 2 - 5 Crude steel production per country

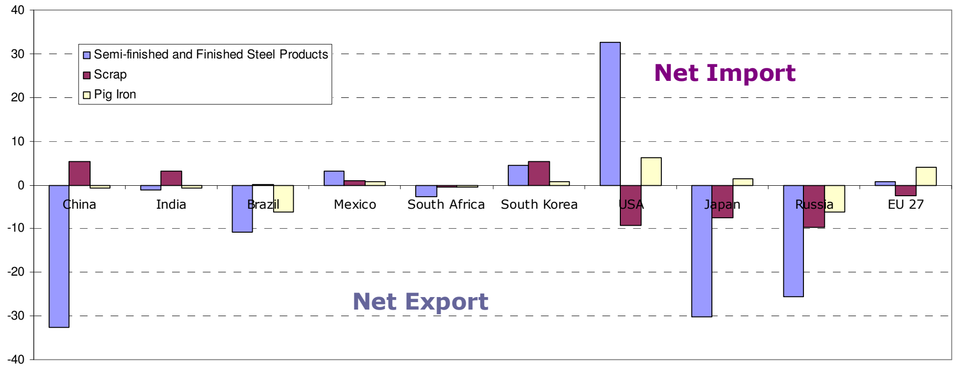
The countries analysed in this report together produce 75% of the steel worldwide with 59% originating from emerging or developing countries. Growth rates in these countries also by far exceed these in the industrialised world which will enhance this characteristic even further in the future.




| | Average annual growth | |
|---|---|---|
| | 1990-1999 | 2000-2007 |
| China | 6.67% | 15.60% |
| India | 6.41% | 8.91% |
| Brazil | 2.07% | 3.52% |
| Mexico | 5.80% | 1.40% |
| South Africa | -1.15% | 1.74% |
| South Korea | 6.00% | 2.75% |
| USA | 0.78% | -0.07% |
| Japan | -1.93% | 2.92% |
| Russia | -3.45% | 4.05% |
| EU 27 | 0.85% | 1.67% |
| Rest Developing | 6.03% | 6.34% |
| Rest Developed | 3.26% | 1.44% |
| WORLD TOTAL | 2.20% | 6.41% |

Illustration 2 - 6 Crude steel production 2007 by country and average annual growth rates

The focus for trade is on steel products. The amounts of iron traded are a lot smaller with substantial amounts of pig iron export only in Brazil and Russia with the US and EU as main importers. Scrap, however, is a globally traded commodity. Industrialized countries have larger resources of scrap and export to the emerging countries where demand is rising fast.




Source: UNData

Illustration 2 - 7 Trade balance 2006 per product in million tonnes

### Emissions

Blast furnace, sinter plant and coking plant consume 70-75% of the energy of an integrated steelworks. The main part is covered by metallurgical coke. Emissions result from the energy use in production, reduction processes in iron and steel processing and electricity use either directly or indirectly for the production of oxygen. The production process has significant impact on emissions. The scrap-based minimill for example causes substantially less emissions as the energy intensive ore refining process is eliminated. The influence of alternative process routes on overall emissions varies with the chosen technology and the used feedstocks. DRI production can be based on coal or on gas, which has significant influence on emissions.

### Reduction potentials

There are numerous gas streams from various process steps that contain energy in the form of heat, pressure or combustible content. The recovery of this energy as well the increase in energy efficiency form a large part of available technologies for $CO_2$ reduction. The main options for reducing $CO_2$ emissions within the iron and steel production process are summarized in Illustration 2 - 2.

**Introduction of available technology**

***Heat recovery***

Sinter plant heat recovery
BOF gas + sensible heat recovery
Scrap preheating - Tunnel furnace (CONSTEEL)
Recuperator hot blast stove

***Process optimization***

Improved process control
Coal moisture control
Fluegas Monitoring and Control
Preventative Maintenance
Energy monitoring and management system

***Production processes***

Coke dry quenching
Top pressure recovery turbines (wet type)
Improved blast furnace control systems
Hot blast stove automation
Bottom Stirring / Stirring gas injection
Furnace wall and roof insulation
Direct current -Arc furnace
Adopt continuous casting
Thin slab casting
Hot charging

***Gas recovery and use***

Recovery of coke oven gas
Recovery of blast furnace gas
Cogeneration

**Introduction of new and emerging technology**

Coke advanced wet quenching
FUCHS Shaft furnace
Contiarc
Comelt
Near net shape casting (thin strip)

**Change of Production Process**

Increase share of scrap based EAF
Smelt reduction
Electrolysis
Increase DRI (gas-based)

**Fuel switch**

Use of waste fuels / plastics / tyres (sinter plant, BF)
Pulverized coal injection to 130 kg/thm (substitute coke)
Pulverized coal injection to 225 kg/thm (substitute coke)
Injection of natural gas to 140 kg/thm (substitute coal)
Injection of charcoal (substitute coal/natural gas)
Use of charcoal in sintering
Use of charcoal in blast furnace
Oxy-fuel burners for EAF

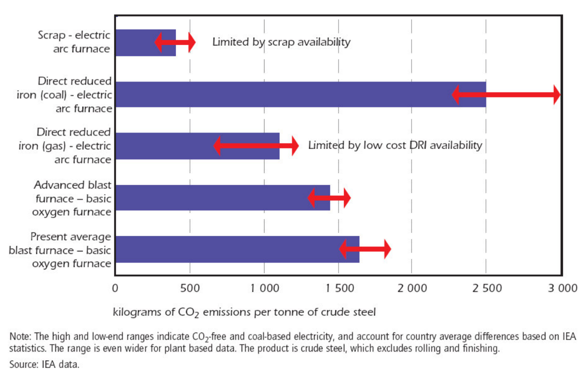
**Carbon Capture and Storage (CCS)**

Source: LBNL and AISI 2007, Worrell et al. 1999

Illustration 2 - 8 Examples of $CO_2$ reduction methods in iron & steel production

Currently, no single breakthrough technology is available in the iron and steel sector that could reduce emissions drastically. However, the international ULCOS (Ultra-Low CO2 Steel) project aims to develop steel production routes with low CO2 emissions through the combination of technologies such as smelt reduction, blast furnace and CCS. Currently, the largest potential is the switch to scrap based electric arc furnace production, as the emissions are by far the lowest possible (see Illustration 2 - 7). This is however limited by scrap availability, which varies significantly between countries and is not able to satisfy the growing demand for steel products. The rapidly growing stock of steel in society will eventually become available as scrap. However, even without a growing demand for steel, primary steel production will always remain necessary.

An increase in gas-based DRI production is also beneficial from an emissions point of view, but limited mainly by economic factors. Note that increased use of DRI will increase the electricity intensity of the electric arc furnace. Hence, the reduction in $CO_2$ emissions will depend on the share of DRI, efficiency of the DRI production and EAF, as well as the $CO_2$ intensity of the purchased power (see Illustration 2 - 9).




Source: IEA/OECD 2008

Illustration 2 - 9 CO2 emissions per tonne of crude steel

For most countries a fairly steady shift away from primary production processes can be observed. In Mexico the share of gas-based DRI combination with EAF has been historically high and growing, due to the availability of low-cost natural gas. In India the share of DRI-EAF production has been increasing drastically in the last 10 years, but the DRI production is mainly coal based in India as they are very suited for small scale industry with short investment recovery cycles. This share is likely to increase as new coal-based DRI plants are currently being planned and built (IEA 2007).

| | Iron production | Steel production | Share of primary steel[1] | Share of EAF | Estimated energy intensity | Total primary energy use | Estimated $CO_2$ intensity | Estimated carbon emissions | Share of carbon emissions | Savings potential best practice[2] | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mt | Mt | % | % | GJ/t steel | PJ | $tCO_{2eq}/t$ | $MtCO_{2eq}$ | % | $MtCO_{2eq}$ | % change to current emissions |
| China | 414 | 423 | 89.3 | 10.7 | 26.7 | 11,296 | 2.51 | 1,060 | 52.7% | 536 | 50.6% |
| India | 43 | 49 | 44.1 | 55.9 | 24.5 | 1,212 | 2.16 | 107 | 5.3% | 49 | 46.1% |
| Brazil | 33 | 31 | 73.9 | 26.1 | 24.2 | 749 | 1.03 | 32 | 1.6% | 14 | 45.5% |
| Mexico | 10 | 16 | 25.7 | 74.3 | 16.1 | 262 | 1.01 | 16 | 0.8% | 3 | 17.9% |
| South Korea | 28 | 48 | 54.3 | 45.7 | 15.3 | 741 | 1.00 | 49 | 2.4% | 7 | 13.7% |
| USA | 38 | 99 | 43.1 | 56.9 | 15.2 | 1,502 | 0.96 | 95 | 4.7% | 13 | 13.4% |
| Japan | 84 | 116 | 74.0 | 26.0 | 16.4 | 1,910 | 0.96 | 111 | 5.5% | 22 | 19.6% |
| Russia | 55 | 71 | 81.4 | 18.6 | 32.3 | 2,286 | 2.32 | 164 | 8.2% | 97 | 59.1% |
| EU 27 | 116 | 207 | 59.9 | 40.1 | 13.2 | 2,731 | 0.64 | 133 | 6.6% | 0 | 0.0% |
| Rest Developing | 89 | 141 | n.a. | n.a. | 27.3 | 3,848 | 1.51 | 213 | 10.6% | 110 | 51.7% |
| Rest Developed | 26 | 47 | n.a. | n.a. | 14.1 | 663 | 0.64 | 30 | 1.5% | 2 | 6.3% |
| WORLD TOTAL | 936 | 1,248 | 68.6 | 31.4 | 21.8 | 27,201 | 1.61 | 2,011 | 100.0% | 853 | 42.4% |

**Best practice energy intensity (EU 27)** **13.20 GJ/t steel**

Production: 2006 (IISI)

Energy intensity: based on IEA energy balances 2007 (excluding coke) estimated on 2005 values except Russia and India (2004)

Carbon intensity: based on IEA Emissions from fuel combustion 2007 (without process emissions)

[1] Primary steel includes BOF (66.2%) and OHF (2.4%)

[2] Emissions saved if EU is taken as best practice energy intensity and applied worldwide (to 2006 production)

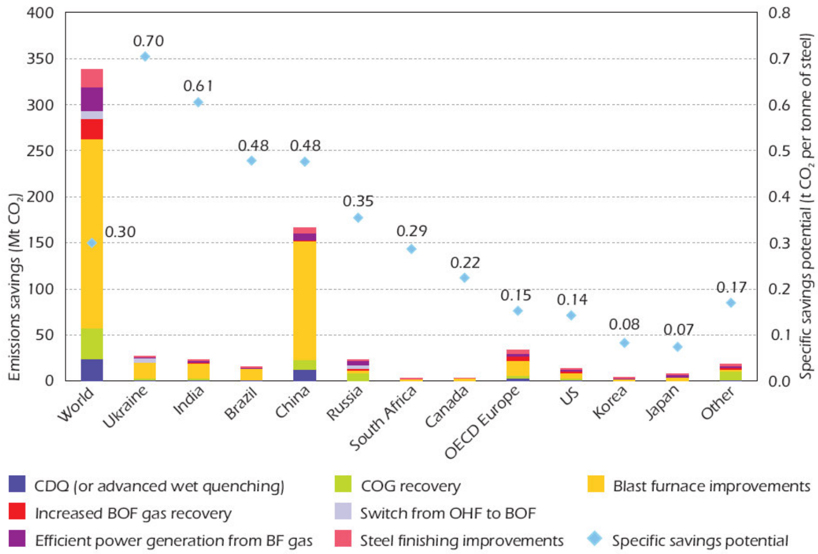
Table 2 - 4 Steel production, energy use and emissions from iron & steel production.[2]

The energy and carbon intensities vary substantially between countries. This is due to differences in production processes and in efficiency of installations. Table 2 - 4 gives an impression on the effects on emissions if all existing installations would apply best practice (EU performance). Using 2006 production volumes, this could lead to 853 Mt or 42% fewer emissions. This is only an illustrative estimate and very optimistic. It does not explicitly take into account the different shares in production processes or capital investments or time needed to move to best practice. It also assumes a constant carbon intensity of the energy mix. So additional emissions could be saved by decreasing carbon intensity of the used fuels and electricity.

A very similar picture is gained from the IEA survey on trends in energy and efficiency (Illustration 2-8). Here only specific reduction potentials are looked at and analysed more detailed, which results in a lower savings potential than the rough estimate given in Table 2 - 4. Improvements in the blast furnace are identified as the main savings potential. However, also in this analysis the switch to other production processes (BOF to EAF, smelt reduction, DRI) is not considered. The illustration shows absolute reduction potentials as well as the difference between the current emissions intensity of the countries compared to BAT, i.e. the specific savings potential.

CCS, used together with oxygen injection, is estimated to result in an 85% to 95% reduction in $CO_2$ emissions. Cost for CCS for blast furnaces is currently estimated at about USD 40-50 / $tCO_2$, and around USD 25 / $tCO_2$ for DRI facilities (IEA 2008). The ULCOS project aims to develop primary steel production routes that integrate CCS in the process.

[2] South Africa could not be analysed in detail due to lack of reliable data regarding energy consumption.




Source: IEA 2008

Illustration 2 - 10 Iron & steel $CO_2$ emission reduction potentials 2005, based on BAT

## 2.3 Cement

### Production

Cement production is an energy-intensive process in which a combination of raw materials is chemically altered through intense heat to form a compound with binding properties.

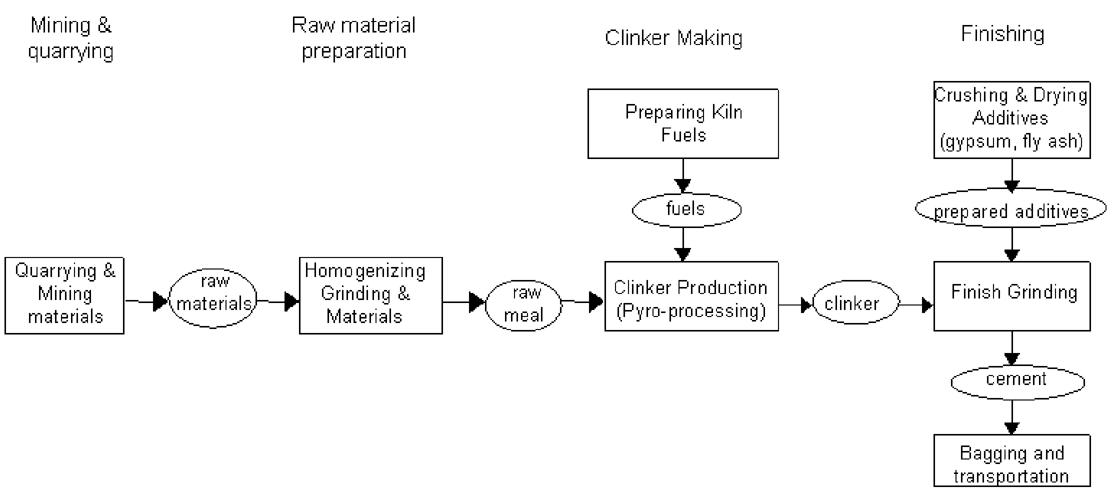
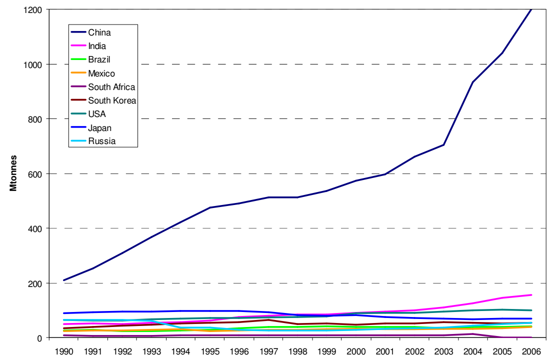



Illustration 2 - 11 Schematic representation of the cement production process

Raw materials, including limestone, sand, and clay, are mined or quarried, usually at a site close to the cement mill. These materials are then ground to a fine powder in the proper proportions needed for the cement. Production can be categorized as dry process (limestone fed to kiln as dry ground powder) and wet process (limestone fed as water-slurry). Additionally, equipment can be added to remove some water from the slurry after grinding; the process is then called semi-wet or semi-dry. This mixture of raw materials enters the clinker production (or pyro-processing) stage. The mixture is passed through a kiln (and possibly a pre-heater system) and exposed to increasingly intense heat, up to 1400 degrees Celcius. This process drives off all moisture, dissociates carbon dioxide from calcium carbonate, and transforms the raw materials into new compounds. The output from this process, called clinker, must be cooled rapidly to prevent further chemical changes. Finally the clinker is blended with certain additives and ground into a fine powder to make cement. The additives affect the strength, curing time, and other characteristics of the final product. The most common cement type produced is Portland cement which consists of 95 % clinker. The cements with lower clinker-to-cement ratios are called "blended cements". Increasing the fraction of additives with respect to Portland cement leads to longer curing times, but ultimately greater strength in the final product.

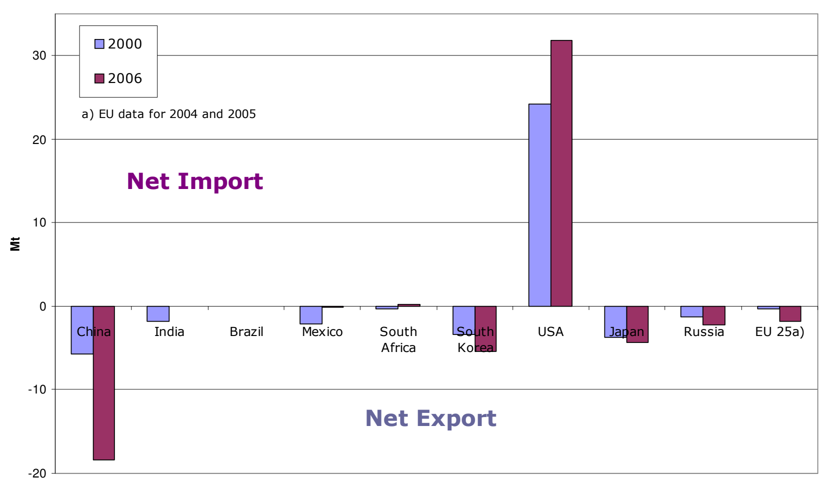



| | Average annual growth | |
| --- | --- | --- |
| | 1990-1999 | 2000-2007 |
| China | 9.67% | 10.63% |
| India | 5.79% | 8.17% |
| Brazil | 4.43% | 0.32% |
| Mexico | 1.88% | 3.47% |
| South Africa | 1.02% | 5.60% |
| South Korea | 4.12% | 0.55% |
| USA | 2.00% | 3.45% |
| Japan | -1.13% | -2.16% |
| Russia | -12.00% | 10.05% |

Source: USGS

Illustration 2 - 12 Production 1990 – 2006 and average annual growth rates

China is by far the largest producer of cement with growth rates of more than 10% annually over the last 6 years. India has comparably high growth rates, but is still on a much lower level. Trade in cement is growing, but is still low in relation to overall production. Only the US has a substantial share of imports.




Source: UNdata

Illustration 2 - 13 Trade balance cement for 2000 and 2006

### Emissions

In cement making, carbon dioxide emissions result from the decomposition of calcium carbonate (calcination) during clinker production, from fuel use and from use of electricity.

The most energy-intensive stage of the process is clinker production, while the grinding of raw materials and of the cement mixture both are electricity-intensive steps.

### Reduction potentials

There are basically five options for reducing $CO_2$ emissions in the cement production process:

- ⇨ Use of alternative raw materials for clinker production (clinker adaptation)
- ⇨ Improve efficiency of the kiln
- ⇨ Fuel switch
- ⇨ Decrease electricity use in grinding and blending
- ⇨ Increase share of additives to cement other than clinker

| | Production | Clinker/ cement ratio | Primary intensity | Primary energy | Process carbon emissions | Carbon emissions energy use | Total carbon emissions | Emission intensity | Share of world total | Savings potential energy efficiency | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mt | | GJ/t cement | PJ | $MtCO_2$ | $MtCO_2$ | $MtCO_2$ | $tCO_2/t$ | % | $MtCO_2$ | % change to current emissions |
| China | 1200 | 75% | 5.7 | 6,840 | 472.5 | 652.1 | 1124.6 | 0.937 | 51.1% | 317.5 | 28.2% |
| India | 155 | 88% | 4.6 | 713 | 71.6 | 68.0 | 139.6 | 0.901 | 6.3% | 17.3 | 12.4% |
| Brazil | 40 | 81% | 3.6 | 144 | 17.0 | 10.6 | 27.6 | 0.689 | 1.3% | 1.3 | 4.7% |
| Mexico | 41 | 86% | 4.5 | 185 | 18.5 | 12.9 | 31.4 | 0.765 | 1.4% | 3.3 | 10.4% |
| South Africa | 13 | 90% | 4.6 | 60 | 6.1 | 5.9 | 12.1 | 0.928 | 0.5% | 1.4 | 11.6% |
| Korea | 55 | 89% | 3.6 | 198 | 25.7 | 15.2 | 40.9 | 0.744 | 1.9% | 0.5 | 1.3% |
| USA | 98 | 90% | 5.6 | 549 | 46.3 | 42.3 | 88.6 | 0.904 | 4.0% | 15.8 | 17.8% |
| Japan | 70 | 90% | 3.6 | 252 | 33.1 | 18.5 | 51.6 | 0.737 | 2.3% | 0.5 | 0.9% |
| Russia | 55 | 80% | 6.0 | 330 | 23.1 | 25.4 | 48.5 | 0.882 | 2.2% | 12.2 | 25.1% |
| Europe (27) | 245 | 76% | 3.8 | 931 | 97.8 | 65.4 | 163.2 | 0.666 | 7.4% | 14.4 | 8.8% |
| ROW | 578 | 80% | 4.6 | 2,636 | 242.8 | 228.3 | 471.1 | 0.815 | 21.4% | 72.1 | 15.3% |
| WORLD TOTAL | 2550 | 84% | 4.6 | 11,628 | 1054.5 | 1144.5 | 2199.0 | 0.862 | 100.0% | 322.3 | 14.7% |

Production: all 2006, except for South Africa and EU-27 (2005) **Best Practice:** **3.9 GJ/t clinker**

C/C ratio: based on 2004 data, except for EU-27 (2005) and US (2006)

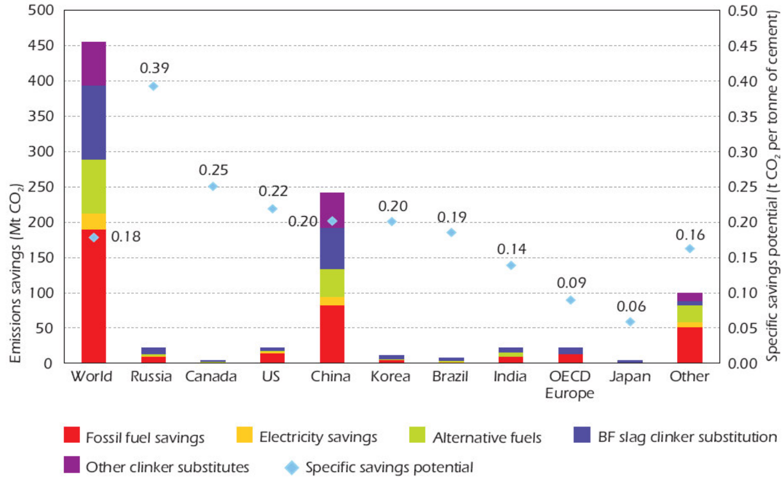
Carbon intensity: based on 2003 data for carbon intensity of fuel mix, except for EU-27 (based on data Cembureau)

Process emissions: based on an emission factor of 525 kg CO2/tonne clinker

Table 2 - 5 Cement production, blending practices and $CO_2$ emissions.

Adopting best practice in energy efficiency globally at 2005 production levels would result in 322 Mt $CO_2$ or 15% less emissions (Table 2 - 5). Another important reduction method is the substitution of clinker either with slags from iron production (blast furnace slag) or with other less energy intensive substitution materials.

Analysis by the IEA yields in reduction potential of similar magnitude (Illustration 2-11).




Source: IEA 2008

Illustration 2 - 14 Cement CO2 emission reduction potentials 2005, based on BAT

# 3 Sectoral approaches – an overview

## 3.1 Different forms of 'sectoral approaches'

This section provides a short overview of terminology for sectoral approaches. "Sectoral approaches" mean very different things to various stakeholders. It is therefore useful to define the criteria that differentiate the various approaches:

- Legal status
- Responsible entity
- Regional coverage
- Scope
- Target type
- Stringency
- Implementation
- Relation to carbon market
- Financing
- Focus
- Governing body

Taking these elements, some of the most-discussed approaches can be categorized as illustrated in Table 3 - 1. There is a huge variety of theoretically possible options and in the current discussion a wide range is in the table. Even small variations in one element can have large impact on the evaluation of an approach, like environmental impact, distributional effects or simplicity of negotiation.

| | Policy-based | Technology-based | | Emissions-based | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | | F | | G |
| | SD-PAMs | Technology cooperation | Technology standards sector-based | Transnational / emission global targets | CDM | | Sectoral Targets | | Binding national targets |
| | | | | | Classic | Sectoral | Sector no lose targets | Binding sectoral targets | |
| **Legal status** | Binding / non-binding | Non-binding | Binding / non-binding | Non-binding | Non-binding | Non-binding | Non-binding | Binding | Binding |
| **Responsible entity** | Government | Governments and industry associations | Government | Companies | Private entity (company) | Private entity (company) | Government | Government | Government |
| **Regional coverage** | National | Transnational / global | National / transnational / global | Transnational / global | National | National | National | National | National |
| **Scope** | Sectoral / economy wide | Sectoral | Sectoral | Sectoral | Project based | (Multi-)Project / sectoral | Sectoral | Sectoral | Economy wide |
| **Target type** | Policy implementation | Technology / R&D | Standard implementation | absolute / intensity emission target | absolute/intensity | absolute/intensity | absolute / intensity | absolute / intensity | absolute |
| **Stringency** | Defined by government | n.a. | Uniform base, with some regional differentiation | To be determined | Project-individual cut on current emissions / BAU | Country-identical cut on current emissions / BAU for all projects in sector in country | Country-individual cut on current emissions / BAU | Country-individual cut on current emissions / BAU | To be determined |
| **Implementation** | Up to government | Voluntary | Up to government | Up to company | Built-in design | Built-in design | Up to government | Up to government | Up to government |
| **Relation to carbon market** | None | None | None / carve-out / within | None / seperate market | Within | Within | Within | Within | Within |
| **Financing** | Private sector finance / international funds / ODA | Public and private sector finance | Private sector finance / international funds / ODA | Internal carbon market / international funds / ODA | Carbon market | Carbon market | Carbon market / international funds | Carbon market / international funds | Carbon market / international funds |
| **Focus** | Engaging developing countries | Technology development and diffusion | Competitiveness / technology development and diffusion | Competitiveness / cost efficiency | Cost efficiency, sustainable development | Cost efficiency, sustainable development | Engaging developing countries | Engaging developing countries | Engaging developing countries |
| **Governing body** | Commitment proposed by national governments, acknowledged / accepted by COP | New body with government and industry participation | Agreement by COP | Industry association | CDM EB | CDM EB | Agreement by COP, advice by new technical body? | Agreement by the COP | Agreement by the COP |
| **Example** | **South Africa:** promotion of energy efficient low cost housing | **Steel:** APP steel sectoral task force - SOACT Steelmaking Handbook | **Automotive:** Top-Runner-Approach Japan; Canadian automobile industry commitment for total reduction by 2010 | **Aviation:** Emission trading system for international aviation linked to Kyoto Protocol carbon market | **Steel:** Introduction of heat recovery for blast furnaces | **Electricity:** Multi-project baseline of 600g/kWh **Cement:** Country average baseline measured in $tCO_2$ / t | **Cement:** National baseline measured in $tCO_2$ / t | **Cement:** National baseline measured in $tCO_2$ / t | Kyoto style targets |

n.a. = not applicable

Sectoral approaches which are the focus of this paper

Table 3 - 1 Design elements of the some important approaches.

The chair of the UNFCCC negotiation group for the Kyoto Protocol (AWG-KP) summarized the political discussion defining the following sectoral approaches (Annex V of UNFCCC 2008):

- *Cooperative sectoral approaches supported and enabled by finance and technology:* Technology-based coordination of R&D activities and support for diffusion and deployment of efficient technologies. (B in Table 3 - 1)
- *Complementary sector-specific goals for Annex I Parties:* Voluntary/mandatory, quantified/qualitative goals in specific sectors are agreed in addition to the national emission target. Examples include "all new coal power plants as of 2015 have to be CCS ready", "all cement plants less efficient than a benchmark are phased out by 2020" or "emissions of average new passenger cars in 2020 should be x $gCO_2$/100km"). (B, C, D)
- *Sectoral crediting in non-Annex I Parties:* Emission reductions within a sector of a country below a baseline are credited (Binding or non-binding), similar to CDM but at the sectoral scale. The baseline is country specific, either based on, or only informed by, international benchmarks. (F)
- *Bottom-up sectoral analysis to inform the discussion on mitigation potentials of Annex I Parties:* A quantitative nation-wide emission reduction target determined by analyzing the reduction goals in each country for each sector in detail and totalling the results with a bottom-up process. To be applied to all major economies including those in the developing countries. This is the Japanese notion of a sectoral approach presented at the UNFCCC meetings in Bangkok in March 2008 and in June 2008. Here it is important to distinguish between approaches relating to the scope of commitment, and a sectoral way of determining and agreeing an overall target, like this, which is rather a methodology.

Other approaches are also discussed but not included in the chair's summary:

- *Policy-based approach (SD-PAMs):* Countries pledge to implement certain policies in a sector. Emission reductions are not credited. (A)
- *Technology standards:* Governments commit to achieve certain predefined advanced technology standards in selected sectors. This could be the adoption of best available technology (BAT) for new installations and best practice (BP) for existing plants. (C)
- *Transnational sectoral approach:* Global industry of one sector agrees to a certain emission or technology standard. This could involve quantification of emissions and emission trading within the sector.  (D)
- *Sectoral approach to CDM*: Up-scaling of CDM through a sectoral approach for baseline setting to reduce transaction cost, address competitiveness and increase project volume. (E)

## 3.2 Evaluation of different approaches for developing countries

We evaluated the approaches given above using four principal criteria commonly used to evaluate climate policy approaches: environmental effectiveness, cost effectiveness, equity and distributional issues as well as technical and institutional feasibility (e.g. IPCC 2007, Fourth Assessment Report, Working Group III, Ch.13, pp.751.) and a number of sub-criteria (see also Höhne and Ellermann 2008). The detailed analysis of the above defined approaches is given in Table 3 - 2.

Generally there exists a trade off between environmental effectiveness and technical and institutional complexity. The more stringent and the broader the coverage of an approach, the more complex are the requirements regarding capacity and data issues which makes negotiations more complicated and an agreement more unlikely.

In the following section we will highlight some of the strengths and weaknesses of the various approaches.

(A) *SD-PAMs*: The purely policy based approach raises the question whether the environmental impact of such a commitment will be sufficient to achieve the necessary mitigation effort. In such a case additional measures have to be chosen. With a strong focus on sustainable development the approach contributes to the individual countries' overall development, taking into account the specific circumstances of each country. This increases the potential acceptability of a commitment by developing countries. Acceptability is even further increased if the approach focuses on specific sectors instead of the whole economy as efforts can be better targeted.

(B) *Technology cooperation*: Similar to SD-PAMs, the environmental effectiveness of the approach is uncertain. As it is a voluntary, cooperative effort from all participants, the approach is likely to enhance development, take into consideration the individual country perspective and trigger engagement of developing countries.

(C) *Technology standards*: An agreement on the use of technology standards is relatively easy to negotiate, but it is extremely difficult to define and agree on the explicit standards for different sectors in a second step. The sectoral focus of the approach allows for the transfer of technology and know-how, thus having a positive influence on development if sufficient support is provided. CDM projects in the respective sectors would only be able to generate credits if they achieve emission reductions which go beyond the defined standard. As there is no direct access to the carbon market it would be more interesting for ambitious countries to directly agree to sectoral targets (no-lose or binding).

(D) *Transnational emission targets*: The environmental effectiveness of this approach could be potentially positive, especially if there is broad transnational coverage. Experience in the past has however shown that ambitious targets are unlikely in industry-led decision making processes. On the other hand, the approach has the potential to address competitiveness and leakage concerns, if there is broad coverage.

(E) *CDM*: Projects under the CDM generally do not contribute to global mitigation as they offset emissions that would otherwise have been reduced in Annex I countries. Therefore efforts to scale-up investment in CDM do not have any positive environmental effect, unless the expected volume of generated credits is taken into account by increasing demand for credits through a reduction in targets from Annex I countries. This is especially relevant for sectoral approaches to CDM where a benchmark is set as a common baseline for all projects in the sector. Depending on the level of the baseline chosen, there is the possibility that a range of projects generates considerable amount of credits without actually being additional. Thus, it will have to be considered how additionality of projects can be guaranteed. Sectoral

CDM, however, has the potential to significantly enhance investment and this way development possibilities for the host country. At the same time it potentially reduces transaction cost once the baseline is set. However, it is probably only viable for certain sectors.

(F) *Sectoral targets*: The potential impact on development is comparatively large for sectoral targets, irrelevant of the question whether they are binding or non-binding. If taken into consideration when defining Annex I targets, emission mitigation contributions could be large and additionality would be no longer an issue. Those countries with a sector target would no longer be eligible for CDM in the respective sectors. However, CDM projects in other sectors would still be possible, and existing CDM projects in the sector covered by sector targets could continue. The approach involves complexity, though, which translates into high demands regarding the capacity of involved stakeholders. Baseline setting requires substantial data definition and collection efforts at national level.

| | | | Policy-based | Technology-based | | Emissions-based | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | D | E | | F | | G |
| | | | SD-PAMs | Technology cooperation | Technology standards sector-based | Transnational / global emission targets | CDM | | Sectoral Targets | | Binding national targets |
| | | | | | | | Classic | Sectoral | Sector no lose targets | Binding sectoral targets | |
| Evaluation | Environmental | Contribute to overall global reductions / Environmental effectiveness | Potentially positive depending on scale of policies; not all potential emission reductions have also a direct SD benefit | Potentially positive, but on its own not sufficient | Potentially positive, but depends on stringency | Potentially positive, but ambitious targets are unlikely due to industry led decision making process | Zero sum at best | Zero sum at best | Potentially positive, but depends on stringency; implementation uncertain due to no-lose nature | Potentially positive, but depends on stringency | Potentially positive, but depends on stringency |
| | | Prospects for achieving large-scale transformation of sectors / economy | High, depending on suitability of sector | Depending on technology and scale | Potentially high, depending on technology , scale and implementation method | Depending on technology and scale | Small | Depends on the level of the baseline / applicability of sector | High, depending on suitability of sector | High | High |
| | | Incentive for countries to adopt approach | Technical / financial assistance; alternative to emission targets | Technical assistance with little cost and effort involved | Technical / financial assistance; alternative to emission targets | n.a. | Credits | Credits | Credits | Credits | Credits |
| | | Additionality | Not an issue as no credits are issued. Difficult to determine GHG co-benefits of policies. | n.a. | n.a. | Not an issue once target is set | Difficult to determine | Projects with current emissions lower than baseline (non-additional) receive credits. Depends on stringency of baseline. Ok if demand for credits is increased | No longer an issue once target is set taking into account Annex I targets | No longer an issue once target is set taking into account Annex I targets | No longer an issue once target is set taking into account Annex I targets |
| | Economic | Global cost effectiveness | Depends on policy set | High, but possible little impact | Depends on policy set, lack of emission trading may attribute reductions per sector that are not the most cost effective | High, if linked to the global carbon market | Globally more cost effective than Kyoto-scheme without CDM, but less cost effective than comprehensive scheme. | Globally more cost effective than Kyoto-scheme without CDM, but less cost effective than comprehensive scheme. | Globally less cost effective than comprehensive scheme. Nationally within sector depending on implementation. | Globally less cost effective than comprehensive scheme. Nationally within sector depending on implementation. | High |
| | | Accounting for structural differences between countries | Focus on sustainable development | Yes | Only if there is regional differentiation of the standards | Depends on details of commitment | Yes | Yes | Yes | Yes | Yes |
| | | Transaction costs | Depends on policy set | Low | Depends on the type of standard, implementation method and verification possibilities | Low once baseline is set, but higher for baseline setting and monitoring | High since project by project | Lower effort for project development, once baseline is set | Low once target is set. Transaction cost nationally depends on implementation. | Low once target is set. Transaction cost nationally depends on implementation | Low once target is set. Transaction cost nationally depends on implementation |
| | Distribution and equity | Common but differentiated responsibility | Special consideration of developing country needs | Cooperation approach | Automatically differentiates per sector; further if there is regional differentiation of the standards, delayed implementation or non-binding for (some) developing countries | Only if there is regional differentiation of the standards, delayed implementation or non-binding for (some) developing countries | Treating Non-Annex I countries distinct from Annex I countries | Treating Non-Annex I countries distinct from Annex I countries | Depends on target stringency | Depends on target stringency | Depends on target stringency |
| | | Competitiveness / Carbon-leakage | Competitiveness not the focus; potential leakage between countries depending on coverage and national implementation | Cooperation approach ensures broad coverage | Depends on coverage and implementation policy. Potential to address both issues if broad coverage. | Potential to address both issues if broad coverage. | Competitiveness not the focus; increase in coverage decreases competitiveness concerns; potential leakage between countries depending on coverage and national implementation | Competitiveness not the focus; increase in coverage decreases competitiveness concerns; potential leakage between countries depending on coverage and national implementation | Competitiveness not the focus; increase in coverage decreases competitiveness concerns; potential leakage between countries depending on coverage and national implementation | Competitiveness not the focus; increase in coverage decreases competitiveness concerns; potential leakage between countries depending on coverage and national implementation | Competitiveness not the focus; increase in coverage decreases competitiveness concerns; potential leakage between countries depending on coverage and national implementation |
| | Technical and institutional | Required government capacity | Depends on policy set | Low | Capacity to develop the standards together with the industry | Low | Low | Low | High, since credits are issued to governments, which have to pass on the incentive | High, since credits are issued to governments, which have to implement policies to meet target | High, since credits are issued to governments, which have to implement policies to meet target |
| | | Required private sector capacity | Depends on policy set | Low | Capacity to develop the standards together with the governments | Depends on national rules. Potentially higher with binding targets | High | Lower than under CDM due to standardisation | Depends on national rules | Depends on national rules. Potentially higher with binding targets | Depends on national rules. Potentially higher with binding targets |
| | | Data availability, monitoring, reporting, verification | Reporting on implementation only. No need for data collection / verification / maybe review | No MRV necessary | Depends on type of standard. Confidentiality issues can play a role in baseline setting | preparation and review of greenhouse gas inventories as current practice. | Project specific monitoring and verification; risk of use of different strictness | Standardized monitoring and verification | Preparation and review of greenhouse gas inventories as current practice; definition of the sector and confidentiality difficult | Preparation and review of greenhouse gas inventories as current practice; definition of the sector and confidentiality difficult | Preparation and review of greenhouse gas inventories as current practice. |
| | | Simplicity / possibility of negotiation | Difficult to determine stringency of commitment | Easy to negotiate, high agreement from all parties. Industry involvement necessary. | Agreement on the approach as such is relatively simple, but agreement on standards itself is difficult | Very difficult to negotiate as involving governments and industry in decision making | COP agreement achieved, but cumbersome decision making by CDM Executive Board. Careful decision making to avoid manipulation | Complex determination of sector baseline but overall improvement decision making. Careful decision making to avoid manipulation | Complex determination of sector target and appropriate consideration of country specific circumstances. Best if magnitude is known when Annex I targets are set. Requires rules to avoid manipulation | Complex determination of sector target and appropriate consideration of country specific circumstances. Best if magnitude is known when Annex I targets are set. Requires rules to avoid manipulation | Complex determination of sector target and appropriate consideration of country specific circumstances. Best if magnitude is known when Annex I targets are set. Requires rules to avoid manipulation |

n.a. = not applicable

Limitations / problematic issues
Medium evaluation
Positive evaluation

**Sectoral approaches which are the focus of this paper**

Table 3 - 2 Evaluation of sectoral approaches (see also Ward et al. 2008)

# 4 Sectoral approaches for developing countries: Three design options

The previous section has made evident the variety of design options that are possible for a sectoral greenhouse gas mitigation approach. In this section, we go one step further and describe three concrete design options and analyse them in detail. These design options are not pure representations of the theoretical approaches, but may combine their characteristics or add new features. They are aimed to achieve greenhouse gas emission reductions in developing countries consistent with susatainable development and exist in the context of developed country emission reduction targets under the UNFCCC/Kyoto Protocol.

While the main features of the three design options are described separately, they are subsequently analysed and compared with regard to the following commonly used criteria: environmental effectiveness, cost effectiveness, equity and distributional issues as well as technical and institutional feasibility.

We conclude this section by giving an assessment of each option's likelihood to contribute to the success of an agreement at COP15 in Copenhagen, 2009 and the degree to which its components can by design be finally negotiated at that time.

## 4.1 Description

### 4.1.1 Bottom up negotiated binding sectoral targets

A commitment to keep emissions of a sector below a certain level that is defined *a priori* is at the heart of this design option for a sectoral approach. This level of greenhouse gas emissions (the target) can be set in absolute terms – i.e. as a cap on total sectoral emissions. Alternatively, a target can be chosen that is expressed as emission intensity, for example in the form of tons $CO_2$eq. per ton of product. In any case, the developing country party commits to achieving the target emission level in the given sector. The boundary of this sectoral approach can be defined as covering emissions of a whole sector of a country, or in a certain well-defined part of the country – e.g. certain provinces with sufficient data availability.

A bottom-up process guides the setting of the emissions target through a detailed, transparent and standardized mitigation analysis of the sector, which provides background data. Based on these data, the developing country proposes a target.

The sector target is normally set below the reference. How far below depends on the ability of a country to contribute to mitigation on its own and on how much other external support is expected. This includes additional ODA, funding mechanisms related to technology transfer or SD-PAMs which are not directly related to the sectoral target, but would also be carried out without carbon market incentive. The question remains, how much funding for this should be supplied externally and how much should be contributed by the countries themselves. We propose an economic approach to solve this problem by differentiating the necessary reductions into three categories – no regret, co-benefit and ambitious reductions. The necessary up front investment for no regret mitigation options that can be achieved at no net cost should be financed completely by the country or the respective companies. Depending on the development level of a country, costs for measures that include a co-benefits (e.g. energy security, local air pollution) could either be financed by the country or be partly supported by international funds. The ambitious reductions could be internationally funded, possibly with some own contribution for some of the most developed countries. These principles of a 'financing mechanism' could be agreed upon up front.

Additionally some early funding could be agreed, to compensate countries for the time lag between necessary investment and revenues from credit sales.

The reference scenario is calculated to include currently implemented national policies and measures as well as current external support and CDM projects. As an important element, this approach can also include a national contribution in the form of emission reductions (e.g. no regret and partly co benefit reductions), making this approach a real mitigation mechanism that goes beyond offsetting emissions. In view of the available information, its stringency is negotiated and ultimately agreed at the international level under the UNFCCC. In this way, the bottom-up process provides the basis for the formulation of a commitment using a binding target.

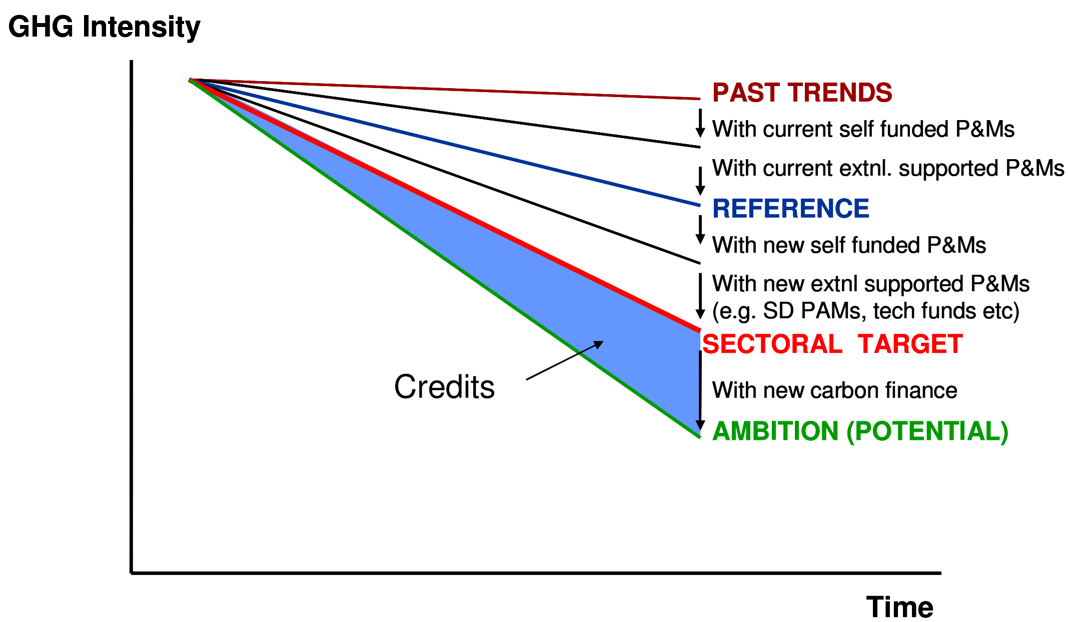



Illustration 4 - 1 Setting a sectoral target (source: Ward et al. 2008)

Emission credits are generated if the target is overachieved – i.e. if sectoral emissions are below the target during the commitment period.[3] Comparable to CERs generated in CDM projects, these may be sold on the international carbon market and used by developed countries for compliance purposes.

Developed country targets should ideally be negotiated at the same time as the they to ensure that there is sufficient demand for credits and additional environmental impact. As this seems unlikely presently, an agreement on a suitable mechanism must be reached to set developed country targets sufficiently low, set available funding appropriately or adapt them at a later stage.

Because the target of this mechanism is designed to be binding, there are penalties for not meeting the agreed emission baseline – just as income may be generated by beating it. The same rules would apply as for developed countries. The penalties increase proportionally to the difference of the observed emission level and the negotiated target. A credible institutional setup has to be defined at the international level to ensure the integrity of the binding side of the mechanism, e.g. the compliance

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[3] In the case of an intensity baseline, credits are generated in the amount of sectoral output multiplied by the difference of the intensity target and the actual (lower) sectoral emission intensity during the commitment period.

committee under the Kyoto Protocol. The binding nature of this approach is also the main characteristic distinguishing it from the proposal of 'sector *no-lose* targets'.

The developing country government administers the sectoral target that is set in this option. It is responsible for meeting the target and may employ those measures to achieve emission reduction which it considers appropriate for the specific situation of the sector and country. Consequently, it receives any income from the emission credits generated under this approach or has to pay the penalties if the target is not met. Individual companies at the sectoral level are not parties governed directly by the mechanism, but may profit or be restricted indirectly through the policies and measures implemented by the government.

This design option covers the emissions of individual sectors regardless of the participation of other sectors in a similar scheme. The definitions and boundaries of sectors are set at the international level.

Currently running CDM projects can continue to generate credits under this approach, but new projects cannot be set up in the sectors covered by negotiated binding targets. The advantage of such sector targets is that whole sectors are covered instead of individual projects at company level. This can drastically reduce transaction costs per ton of $CO_2$eq. reduced and ensures broad coverage and participation. It is in the government's interest to achieve large sector-wide reductions, whereas in the case of the CDM it can at most encourage companies to participate in the mechanism and provide a favourable institutional environment. The approach outlined in this section is more stringent, as it sets mandatory, binding targets compared to the opt-in, no-loose nature of the CDM. But it can lead to larger inflow of financial resources.

An illustrative timeline of decisions needed for this approach is provided in Illustration 4-2. It becomes apparent that substantial work lies ahead for the agreement on such targets. Many of the elements necessary for the implementation of the approach will not be available by the end of 2009. Therefore only a framework can be agreed at that point.

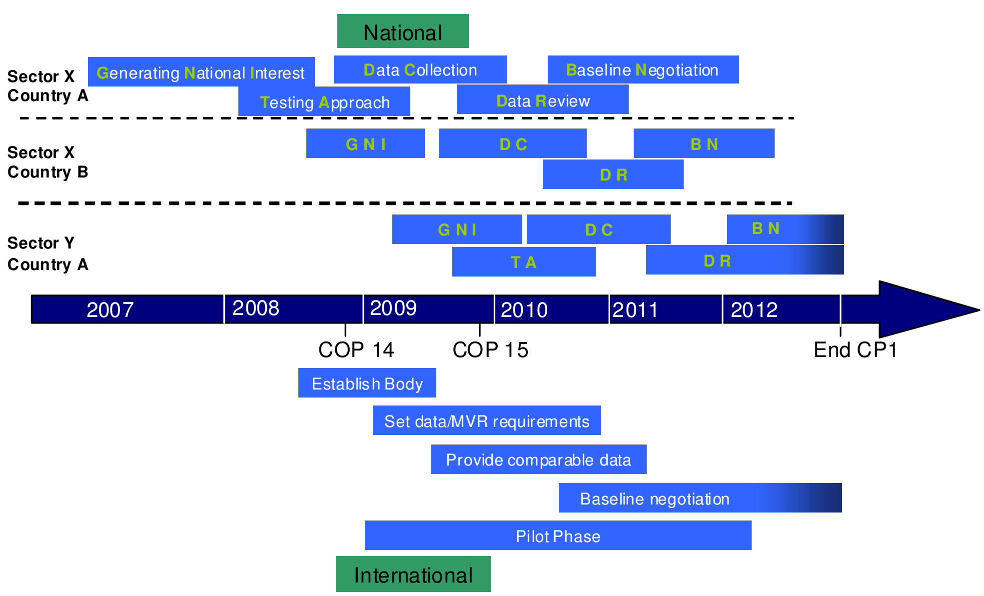


Illustration 4 - 2 Possible timeline for the international level and exemplary sectors.

### 4.1.2 BAT and Best Practice commitments

This option for a sectoral approach builds on developing country commitments to achieve certain predefined advanced technology standards in selected sectors, which in turn leads to a lower emissions intensity of the production. In practice, this includes a binding commitment to use best available technology (BAT) in new installations and to upgrade existing installations to a best practice (BP) level. The commitments cover sectors separately and independently and do not extend to a commitment for the whole economy. The boundary of this sectoral approach can be defined as covering emissions of a whole country, or in a certain well-defined part of the country – e.g. certain provinces with sufficient data availability.

Committees are established internationally under the UNFCCC to determine the applicable levels for best available technology and best practice to be used in each sector. They consist of industry representatives, academics and other experts and provide an independent assessment of the technology levels to be applied. The BAT level is reviewed regularly and adapted to technological progress in each sector. A country is deemed successful, when all new installations are built using BAT and a specified percentage of existing installations run with best practice technology at each given moment.

Developing countries have access to financial resources from developed countries to support them in reaching BAT and BP technology levels sector-wide. The size of these funds is negotiated at the international level based on a pledge by the developing country of the financial support needed in each sector. The mechanism could be similar to the one described in the section above. In a first step the total investment necessary to meet BAT/BP requirements would be estimated. Then gains from no regret and co-benefit measures would be estimated. Gains would be deducted from the overall investment. Also here the agreement would include the pledge to contribute to a certain share of co-benefit and ambitious investment cost, depending on the development level of the country. The receiving government is free to use these funds to help companies of the sectors comply with the BAT and BP mandates. This includes the possible uses to centrally purchase patents, arrange capacity building and other measures. Other measures like tax breaks or subsidies for companies that have to conform to new technology may be financed by the country or using the international supporting funds. Transition periods may be needed to enable the (national) suppliers of components for certain industries undertake the structural changes to supply the necessary quantities of BAT components.

The origin of the developed country financial support is set within the current negotiations on financing under the UNFCCC. Possible sources include the revenues from the auctioning of emission allowances as it is already practiced in the EU.[4] Apart from this source of financing, this approach contains no linkage to the international carbon market.

The transfer of funds to the developing country depends on a regular review of its success in meeting the BAT and BP commitments that it has made. Non-compliance with a commitment leads to the direct obligation to repay the financial support. The UNFCCC may delegate the tasks of monitoring and verifying to independent third parties to provide the data needed to make a balanced assessment.

If they desire to participate in emission trading, developing countries may opt to move to binding sectoral (intensity) targets – as described above in section 4.1.1 – after one commitment period. In this case, the greenhouse gas intensities achieved using the BAT and BP levels will be used as their initial crediting baseline.

Currently running CDM projects can continue to generate credits under this approach, but new projects cannot be set up in the sectors covered by BAT and Best Practice Commitments. Compared to project-based CDM, the commitments cover entire sectors and can thus lead to broad emission reductions at lower relative transaction

[4] A comparable source of funding would need to be found for funds from developed countries that do not employ emission trading based on auctioned allowances under the post-2012 regime.

costs. The CDM has so far failed to achieve the level of technology transfer that has originally been predicted. As this is a central component to the approach outlined in this section, BAT and Best Practice commitments can greatly enhance the technological transformation and upgrading of whole sector – making this option preferable to project-based CDM.

### 4.1.3 Sectoral sustainable development policies and measures (SD-PAMs)

In this option, a developing country government commits to implementing a range of policies and measures in a certain sector that support sustainable development and that also are beneficial for climate change mitigation. In return, it receives financial or other support by developed countries according to a fixed set of rules under the UNFCCC. The amount of financing and the division between internal and external funds is more difficult for this approach and will rather be the outcome of the political negotiation process than a funded economic analysis. The policies and measures proposed by the developing country do not have to have greenhouse gas emission reduction as their core objective, but as a co-benefit, and they should focus on sustainable development as defined by the implementing country.

The governments can propose to implement a principally unlimited number of policies and measures at the national level, either with economy-wide or sectoral coverage. The policies should further domestic policy objectives – e.g. energy security, local pollutant reductions, improved urban transportation – but be shaped in ways that lead to a lower emission path in reaching those objectives. Especially the focus on a few sectors and the involved technology transfer, capacity building and deployment of best practices helps to enhance the desired development of the country. The stringency of the policies and measures is defined and documented by the government. Rather than advocating a new set of priorities for developing countries, SD-PAMs engage precisely on the issues that these countries consider most pressing. This allows the leveraging of investment and policy efforts made in these core development areas, rather than trying to initiate wholly new efforts in climate change mitigation in these countries.

In proposing the commitment for those policies and measures, the developing country government describes and quantifies the emission reductions estimated to be the co-benefit of the SD-PAMs of the scale needed to change emissions and development trajectories will require additional funding, even if there exists a strong domestic interest in their implementation. The government therefore provides information on the funding needs to implement the described policies and measures. Developing countries have access to financial resources from developed countries to support them in implementing their SD-PAMS. The size of these funds is negotiated at the international level based on a pledge by the developing country of the financial support needed for each policy and measure. It could be tied to the requirement that estimated resulting emission reductions reach a necessary ambitious level. The split of domestic funding for no regret actions, co-funding for co-benefit activities and international funding for ambitious reductions cannot be applied for this approach, since SD-PAMS per se have a co-benefit. The receiving government is free to use these funds for the specified set of policies and measures. Optionally, the commitments to implement proposed SD-PAMs and achieve related emission reductions could be made binding. By agreeing to penalties in the case of non-accomplishment, host governments may be able to negotiate stronger support for their proposed actions, including increased financing. The financial support of the SD-PAMS may also be complemented by technology transfer and capacity building.

The institutional structure needed for this approach is relatively simple, as it consists mainly of the procedural structure of the review of proposed SD-PAMs, decision-making on financial support and monitoring of the process of implementation. These processes run under the aegis of the UNFCCC COP – i.e. they depend largely on negotiated outcome, but need to be technically supported by an appropriate body (e.g. SBSTA) to ensure transparency and comparability.

The approach is not linked to the carbon market. Additionality of emission reductions and their strict verification like in the case of a carbon crediting mechanism is therefore not needed to ensure the integrity of the approach. The level of greenhouse gas emission reductions achieved through SD-PAMs is not a market result, but rather a product of the will of the host country to reap these co-benefits through sustainable policies and measures and the will of the international community to support it.

Currently running CDM projects can continue to generate credits under this approach. New projects can be added, too, but they need to take into account the newly proposed policies and measures and their emission reduction effect in the calculation of their baseline. The possible financial flows and technology transfer supporting sectoral transformation under the SD-PAMs approach may also affect the demonstration of additionality of new CDM projects. Compared to project-based CDM, this approach covers entire sectoral policy areas and can thus lead to broad emission reductions at lower relative transaction costs. It is likely that the barriers for many new CDM projects are raised through this approach since CDM projects have to be additional to existing policies. However CDM project can still go beyond the SD-PAMs or be implemented in other sectors.

The focus of this approach is to engage developing countries and support them in undertaking policies and measures which put them on a more sustainable path of development domestically as well as with regard to climate change. It enables them to show-case their mitigation efforts internationally, implement nationally appropriate mitigation actions as demanded by the Bali Action plan, but refrain from taking on emission reduction targets if they are seen politically impossible.

Since the burden that SD-PAMs put on developing countries can be relatively low compared to other approaches, an international deal may include the requirement for those countries to take up other targets or commitments after 2020 or another date. The efforts promised under the SD-PAMs approach should then be taken into account when setting the baseline.

## 4.2 Evaluation

Four principal criteria for evaluating environmental policy instruments are reported in the literature and commonly used to evaluate climate policy approaches (e.g. IPCC 2007, Fourth Assessment report, Working Group III, Ch.13, pp.751.). In the following, we apply each to both design options for a sectoral approach as outlined above.

### 4.2.1 Environmental effectiveness

Environmental effectiveness concerns the extent to which the approach can contribute to the global greenhouse gas reduction effort – its intended environmental objective.

**Binding sectoral targets** have the potential to contribute greatly to this goal. The level of actual greenhouse gas reduction however depends on the stringency of the target used in comparison to the reference scenario, since reductions below the target are merely offsetting and do not result in a net emission decrease. Global emissions reductions are achieved through the countries' own commitments (difference between reference and target). The prospects for achieving a large-scale transformation of sectors through this approach are high, as the binding nature of the targets as well as the prospect of generating income through the sale of emission credits provide a strong impetus to decrease emission intensity or total emissions.

However, the approach has the clear disadvantage that it is not realistic to expect developing countries to agree on concrete sectoral targets in Copenhagen.

Nevertheless they need to be taken into account when Annex I targets are set to ensure that there is a demand for the credits or when financial support for this mechanism is agreed.

The contribution of **BAT and BP commitments** to this goal is equally positive. It nevertheless depends on the stringency of the implementation of BAT and BP, the number of sectors that participate (i.e. the share of the total economy that is covered) and sectoral characteristics like the efficiency of current installations compared to BAT/BP. The approach does not contain any element that constrains total emissions, but only works through emission intensity reductions. There is a good chance for large-scale technological upgrading at the sectoral level, depending on the efficiency of implementation. Technology standards for individual technologies however do not lead to economy-wide *structural* changes and may contribute to technological lock-in even at the sectoral level. Structural measures like demand reduction incentives, shifts in fuel or transport modes need to be triggered by separate actions. Regarding the incentive structure, we consider financial support – as foreseen in this approach – as inferior to the sale of emission credits, because there is not a direct proportionality between emission reduction and income generation. Additionality is not an issue in this approach, since it does not contain an emission trading or offsetting element. Overall, the approach can be considered as positive regarding environmental effectiveness, but the actual contribution depends to a large degree on the quality of implementation, coverage and other concrete design choices.

**SD-PAMs** will make a positive contribution to the environmental goal of global emission reductions as long as the commitment is kept to implement policies and measures with climate change mitigation co-benefits. The policies need to be ambitious so that large scale sustainable transformations towards a lower-carbon future can be induced. Although SD-PAMs do not generally include a direct emission (intensity) target, they represent a valuable option for reaching emission reductions and thus contributing to the environmental goal in case those kind of direct targets are politically infeasible. Additionality is not an issue in this approach, as no emission credits are generated through SD-PAMs. In making the proposal to the international community, it may however be difficult for developing countries to demonstrate the greenhouse gas emission co-benefit of sustainable policies and measures, the strength of causality between support and reduction as well as the fact that these policies were only implemented because of the climate regime ("additional"). In addition, some emission reduction options will not be covered by the approach, e.g. carbon capture and storage, which most likely has little sustainable development benefit in the long term. However, in the short and mid term CCS could have some positive effects on development by for example increasing energy security and allowing developing countries to use their domestic fuel resources (e.g. coal, oil).

### 4.2.2 Cost effectiveness

In this section we analyze whether the approach is cost-effective, referring to the extent, to which a policy can achieve its objective at a minimum cost. Against this background we look at how the proposed approach makes use of possible markets. The analysis includes possible direct (e.g. administrative costs) and indirect costs (inducing technological learning).

The approach built on **binding sectoral targets** is globally less cost effective than a comprehensive scheme with developing countries taking part in emission trading and trading between sectors, but most likely more cost effective than an approach that does not apply emission trading. Within each sector, the cost effectiveness depends entirely on the developing country implementation, that is the incentive structure etc. which it applies to achieve reductions at the sectoral level. Since all targets or baselines are based on a bottom-up data gathering process and consequently negotiated, the approach accounts for structural differences between countries and thus avoids transaction costs. These costs can generally be expected to be low once the target is set. They originate mainly from the necessary international and national MRV structure, but should be small relative to emission credit turnover compared to project CDM. In this approach, the overall cost effectiveness depends largely on the in-country implementation, and can be judged positively for the approach at the international level.

Since the design option building on **BAT/BP commitments** does not make use of market forces, it does not necessarily lead to the most cost effective outcomes: Emission reductions occur in areas and in quantities that are administratively chosen and cost effectiveness depend on the extend to which marginal cost calculus was part of the decision making process. In the basic design of the approach, the technology standards are not differentiated and where necessary adjusted based on natural differences between countries participating in such an agreement, such as access to renewable resource (e.g. use of charcoal as a substitute for coke in steelmaking). Differences in economic structure are considered, as the BAT and BP levels apply per technology and can be incorporated through differentiation of the time frame to reach the BAT target according to the socio-economic circumstances of a country.

Transaction costs can vary widely depending on the type of technology standard, method of implementation, necessary MRV structure, transition periods, as well as between sectors. Compared to a market-based approach in which the appropriate technology is "automatically" chosen, considerable resources may be needed to agree on the BAT and BP levels in this approach and revise them regularly. Generally, sector-based technology standards – like other administrative measures – do not represent a very cost effective method to reach environmental objectives.

It is the inherent strength of **sustainable development policies and measures** that they are built on domestic policy objectives – i.e. account for structural differences in countries. This fact may contribute greatly to reducing transaction costs, costs of setting up institutions, and learning and adopting new processes. The focus on sustainable development ensures that long-term costs and benefits are considered in proposing new policies and measures and favoured over short-term optimisation. Overall global cost effectiveness in reaching the climate-related goals nevertheless completely depends on the characteristics of the set of policies and measures proposed by the developing countries and the allocation of financial capital to support them. The relation of tons of GHG emissions reduced per dollar spent is a political outcome that does not follow an automated maximisation logic of a market-based approach and may therefore be sub-optimal. The design of the financial system can be designed to maximise the emission reduction benefit.

### 4.2.3 Equity and distributional issues

The proposed approaches can be compared with regard to equity and distributional outcomes. A comparison of policy regarding these criteria is difficult, as there is little consensus as to what constitutes an optimal distribution. With this caveat in mind, we highlight aspects of the options that have distributional effects.

A core aspect of this issue is the concept of "common but differentiated responsibilities". In the case of **binding sectoral targets**, its assessment depends largely on the stringency of the target. An emission intensity target that is easy to beat possibly represents only a small change from current project CDM as far as the perception of this concept is concerned, even if the target is binding. A tough absolute emissions target that may be seen as inhibiting economic growth in the sector will be seen as contradictory to this central equity principle. In general, increasing the share of a global sector with a carbon constraint would help to even out competitiveness concerns. However, national implementation of the target can greatly influence competitiveness. E.g. the EU member states allocated similar national targets differently to their industries and therewith created differences in competitiveness. A carbon constraint in the form of a binding target can potentially lead to leakage – i.e. the movement of production to countries in which the same sector has no binding target. Distributional effects may also occur inside the country and sector, depending on the incentive structure chosen.[5] Overall it is our judgement that developing countries will only accept the potential distributional effects of this approach if developed countries sufficiently tighten their own targets.

**BAT and BP commitments** at first sight break with the principle of "common but differentiated responsibilities" as developing countries commit to use internationally best available technology in new facilities and best practice in existing. The principle is upheld if these commitments are accompanied by sufficiently large financing from developed countries and if variation in timelines is agreed. Distributional effects occur unless the applicable BAT/BP levels are differentiated especially for non-competing sectors, like electricity, among regions or financial assistance is adjusted to account for differences among countries. There are large distributional effects – e.g. affecting mechanical engineering industries – if there is no transition period before 100% BAT employment by new installations. Competitiveness may be an issue if upgrading to BAT (financed by developing countries) also leads to quality/cost improvements in developing country industrial products which are internationally traded. Carbon leakage is unlikely to be problematic, if financing follows the above described methodology, unless the developing country contribution to additional costs is substantial enough to cause a price signal. All these distributional and equity issues highly depend on the many details of the approach that have to be decided. Since this set of issues is key to achieve an international agreement, as many details as possible need to be set at the time of COP15 in Copenhagen.

**Sustainable development policies and measures** are most clearly a way to implement the concept of common but differentiated responsibility, as they build on the domestic (development) objectives of developing countries, value their efforts to move on to a lower carbon path and include support from developed countries as their responsibility under the Bali Action Plan. From the viewpoint of developing countries, the evaluation of this approach regarding equity concerns is positive. Depending on the focus of the proposed policies and measures, they may however lead to competitiveness concerns in developed countries – e.g. if they strongly support technological upgrading in certain sectors at no or low cost to the covered companies. The lack of international coordination (SD-PAMs and their support are negotiated for each country separately) may therefore lead to carbon leakage to developing countries. It will be necessary to address these issues in a conclusive way, for example by negotiating all major emitting countries for a sector at the same time.

### 4.2.4 Technical and institutional feasibility

We evaluate how well the approaches are adapted to institutional constrains and how well they address technical feasibility issues. This takes account of the fact that economic theory does not always meet political reality.

Negotiated **binding sectoral targets** based on bottom-up analysis present large challenges in terms of technical and institutional feasibility to developing countries. Since credits are issued to the national governments, they are responsible for implementing policies in order to meet the sectoral targets, which is the crucial difference to the current CDM system. Depending on the policy choice, experience of the country with sectoral environmental regulation (and responsiveness of industry to it) and the complexity of the bottom-up analysis as well as the MRV effort at a later

[5] Leaving the choice of in-country instruments to the developing country is actually a main element allowing for country-specific solutions and aligning distributional effects in the country with government priorities.

stage, the required government capacity can be comparatively high. Private sector capacity is similarly needed, both in the installations covered by the approach to achieve emission (intensity) reductions, and in companies concerned with consulting, validation and (green) project finance and development. The approach requires a detailed sectoral greenhouse gas inventory to be in place for the negotiation of the sectoral baseline, and it needs to be updated annually for MRV purposes. In the case that an emission intensity baseline (e.g. GHG per ton of product) is chosen as a target and not an absolute emission level, detailed production data is necessary in addition to the information on GHG emissions. Its collection and verification may pose challenges as individual companies may be concerned about confidentiality or delay the process. The negotiation of the general design of this policy approach does not present great challenges and would revolve mainly around its integration with the other flexible mechanisms and MRV issues. The determination and negotiation of sector targets that would follow in the next step is however much more complex. Furthermore, the scope of participating developing country sectors and their targets should be known at the time of setting of developed country targets, which is unlikely to be the case in the timeline for the Copenhagen negotations. Therefore, solutions have to be found in order to deal with this timing issue. There are several options in the discussion, like adopting a formula to adjust Annex I commitments automatically when new sectoral targets are agreed, or the establishment of a 'sectoral budget' which acts as a placeholder for sectoral commitments and is taken into direct consideration in Annex I targets. Sectoral targets would then be negotiated until the budget is full. In conclusion, the technical and institutional demands of this approach are high and these challenges have to be met with concentrated and timely capacity building efforts in major countries and sectors.

The technical standards to be used in **sectoral BAT and BP commitments** are developed at the international level, and existing experience can be used. These standards need to be taken up by developing country governments and implemented within a possible transition period. Depending on their experience with the implementation of standards, host country capacity requirements may be high. It is furthermore necessary that the governments ensure the availability of best available technology and set up the institutions to make use of the financial support from developed countries. The private sector faces the challenge of employing 100% best available technology in new installations and best practice in existing ones. This not only concerns the ability to purchase this technology (which should be covered by financial support where necessary), but also the capability of (national) suppliers to provide it and the capacity of available human resources to install, run and manage it. Data on the sectoral technology level is required in order to determine the size of adequate financial support for this approach. Confidentiality issues of individual companies may complicate the data availability. An MRV structure has to be put in place at the international and national level, but it can be simpler than in the case of GHG emission reporting. Overall, there are no large hurdles for agreeing on the general terms of this approach. It will however face challenges in the setting of applicable BAT and BP levels and implementation of best available technology and best practice "on the ground" in developing country sectors.

In the case of **SD-PAMs**, the required institutional and technological capacity required by the government as well as the private sector depends largely on the set of policies and measures proposed. The level of ambition and focus can be catered to the capabilities of the country and the requirements by the international negotiation process that aims at avoiding dangerous interference with the climate system. The institutional capacity required for proposing the SD-PAMs and monitoring their implementation is modest, but the level of success that the country will have in negotiating its SD-PAMs at the international level may depend on the professionalism and credibility of its claims and predictions. A key institutional challenge of this approach lies at the negotiation phase at COP level. Processes and their supporting institutions have to be set up that can lead to speedy and conclusive negotiations.

### 4.2.5 Comparison of approaches

Table 4 -3 provides summarized comparison of the three approaches. Each approach has its advantages and disadvantages. While negotiated binding sectoral targets score well on environmental effectiveness and economic efficiency, they are complex to negotiate. Best available technology and best practice commitments can be less effective if they do not achieve movement to from one technology to another (e.g. to renewables) and defining the BAT and BL levels can be difficult, but they build on the concept of technology upgrading and support. Sectoral sustainable development policies and measures may not target all possible mitigation options, but would be simpler to implement.

Table 4 - 3 Summary of the evaluation of three possible approaches.

| | **Sectoral sustainable development policies and measures** | **Best available technology and best practice commitments** | **Negotiated binding sectoral targets** |
|---|---|---|---|
| **Environmental** | Impact on emissions depends on stringency of policies, hard to predict<br>Possibly not covering all emission reduction options, since some may not have a sustainable development benefit | Impact potentially high but depends on stringency<br>Special consideration needs to be taken to reduce demand for products and to achieve movement to low carbon technologies (e.g. renewables) | Impact potentially high but depends on stringency<br>If intensity based, special consideration needs to be taken to reduce demand for products |
| **Economic** | Sources and distribution of financing need to be defined<br>Emission trading cannot be applied, but long-term perspective is taken | Sources and distribution of financing need to be defined<br>Emission trading cannot be applied | Carbon market is a major funding source<br>Globally cost effective through emission trading if broad participation |
| **Distribution and equity** | Builds on host country development objectives and characteristics | Builds on the concept of technology upgrading, energy security, etc.<br>Accommodation of national circumstance by adjustments for availability of natural resources and differentiated timelines for implementation | Bottom up development and negotiation leads to adequate consideration of national circumstances<br>May be seen as a limiting economic growth |
| **Technical and institutional** | Only the *implementation* of the policies has to be monitored, not their effect<br>Difficult to determine the stringency of the effort and level of financial support needed | Agreement on the approach possible in December 2009<br>Technical specification of the BAT and BP levels is very difficult, taking place after 2009<br>Determination of the national contribution and the financing needs difficult | Exact amount of emission reductions from sectoral targets will not be available in December 2009, but will only emerge after subsequent detailed negotiations<br>High government capacity needed to implement national measures to reach the target |

Yellow indicates a medium evaluation
Green indicates a positive evaluation

### 4.3 What needs to be in a Copenhagen agreement?

The options for a sectoral approach discussed above require large amounts of work to be completed before their full implementation. Given the limited time leading to COP 15 in Copenhagen, the details of either of the three approaches cannot be ultimately finalized. The general structure of the approaches can be set at that time, plus a timetable for the negotiation of the remaining details.

In the case of **negotiated binding sectoral targets**, the actual targets will remain open for negotiation after Copenhagen. COP 15 could agree on the following points:

- Developed countries agree on a level of funding available for this approach. Funding could be in terms of tighter emission targets to generate the additional demand or a fixed level of funding to purchase emission credits from such a sectoral mechanism.
- Developing countries as a group agree on an indicative level of emission reductions from this approach.
- Definition of sectors and boundaries. Generally, the IPCC sector definitions will be used, combining energy and process emissions of sectors where necessary. In addition to these sector definitions, the emissions from electricity have to be assigned to the production sectors.
- Minimum requirements for and mechanisms governing the in-country bottom-up analysis (and related issues of monitoring, reporting and verification (MRV)). Generally, guidelines based on and consistent with the greenhouse gas inventory guidelines used in Annex I countries will be applied. The UNFCCC secretariat could provide standardized sectoral templates for transparent data reporting.
- Choice of absolute or intensity targets. If intensity targets are chosen, agreement has to be found on the denominators to be used and on methodologies for baseline projections. Additionally the in-country bottom-up analysis (see previous point) needs to be extended to include detailed production amounts, etc.
- Mandate for SBSTA to review individual country proposals for sectoral baselines and prepare recommendations for negotiations at COP level.
- System of penalties to be applied in the case of non-compliance with sectoral target, if different to that of Annex I countries.
- Agreement on no new project CDM in sectors covered by negotiated binding targets.
- A timeline (comparable to the Bali Action Plan) for the negotiation of sectoral targets.

Following the *modus operandi* decided in Copenhagen, the COP will annually negotiate binding sectoral targets proposed by developing countries, starting at COP 16 in 2010

In the case of **BAT and BP commitments**, the agreement in Copenhagen will likewise not include the actual definition of BAT and BP levels, but COP 15 could agree on the following points:

- Developed countries agree on a total minimum budget for financing and agree on the provisions of its origin and split among countries. This assures developing countries that their efforts will receive the necessary support.
- Qualified developing countries commit to apply BAT/BP in specific sectors.

- Definition of sectors and boundaries. Generally, the IPCC sector definitions will be used plus a division of emissions from electricity generation.
- A timeline (comparable to the Bali Action Plan) for the negotiation of sectoral process definitions and BAT and initial BP levels.
- Mandate for the establishment of a BAT/BP-setting committee under SBSTA, including its composition.
- MRV structure for developing country technology implementation.
- Mechanism for generating financial resources from developed countries (e.g. auctioning of allowances) and allocating them to developing countries.
- System of penalties to be applied in the case of non-compliance with technology commitments.
- Amendments to the CDM in sectors covered by this approach.

Following the timeline agreed in Copenhagen, the committee under SBSTA will prepare recommendations for BAT/BP levels that need to be adopted by the UNFCCC with a specific time schedule, depending on the speed of this process.

**Sectoral sustainable development policies and measures** in an agreement at Copenhagen require the following preparatory work and decisions at COP 15:

- Developed countries agree on amounts of financing and technological support available, including rules that provide incentives for ambitious SD-PAMs.
- Qualified developing country parties commit to applying SD-PAMS in specific sectors (without details).
- Parties agree on a format for the proposals of SD-PAMs, the review process (including necessary institutional setup) and the modalities to monitor and sanction effective implementation.
- SBSTA receives the mandate to provide transparent and comparable assessment of the SD-PAM proposals by developing countries.
- The parties agree at COP 15 in Copenhagen on the modalities of reviewing SD-PAMs and on the allocation of developed country support, as well as rules for the progression from this approach to more stringent targets after 2020 or any other date.

Following an agreed timeline, Parties negotiate the individual country proposals and agree on their financial support, clearing the way to implementation.

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