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Sectoral Approaches in the Case of the Iron and Steel Industry

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Title

Sectoral Approaches in the Case of the Iron and Steel Industry

Abstract

Sectoral approaches are discussed widely in international negotiations, governments and research institutes, because they are considered to enhance greenhouse gas mitigation and address competitiveness concerns of globally competing industry.

Developing countries have so far rejected binding commitments, industrial benchmarks or sectoral approaches. But according to IPCC, also they have to reduce emissions in a long term, if we want to achieve 2 °C target. Sectoral approaches could be considerable easier start than economy wide commitments.

Every sectoral approach includes (1) selecting a sector, (2) defining a sector, (3) designing the approach and (4) amending it to national legislations. The scheme's trustworthiness also requires proper monitoring, reporting and verification.

The iron and steel sector seems to suit well for a sectoral approach, due to its concentrated actors and uniform products and processes. The definition of a regulated sector could be only a blast furnace or it could reach also to other steel making sub processes or other reduction processes, e.g. ferrochrome. Emissions could be measured as absolute or with benchmarks, but benchmarks suit a sectoral scheme better.

Why developing countries would adopt any commitments is one of the key questions. They may 1) receive funds in exchange of GHG reductions or there can be 2) technology transfers and 3) training of professionals. Generally speaking, these options may look reasonable and sound, but they include many difficult questions.

This study gives a brief review of the literature on sectoral approaches and the global iron and steel industry. It carries out a case study of sectoral approaches on the iron and steel sector and discusses underlying barriers and possible solutions.

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Preface

This publication was written during the summer 2008 by Tomi J. Lindroos, who works as a research scientist at VTT Technical Research Centre of Finland (VTT). The publication was ordered and steered by the Finnish Ministry of Environment and the Ministry of Employment and the Economy and valuable guidance was received also from fellow colleagues and industrial associations, but all statements and conclusions are from clearly referred sources or the author's own.

Contents

1. Introduction

The Intergovernmental Panel of Climate Change (IPCC) published its Fourth Assessment Report in 2007. The report gave a clear signal that climate change is occurring and accelerating, that much of it is caused by the continued and increasing emissions of greenhouse gases from human activities and that it is very likely to have severe impacts.

At the Climate Change Conference in Bali in December 2007, all Parties to the UNFCCC (both developed and developing countries) agreed to step up their efforts to combat climate change. They decided to launch formal negotiations on long-term cooperative action. These negotiations are set to be concluded by the end of 2009 at the Climate Change Conference in Copenhagen.

In accordance with the UNFCCC, all Parties are required to undertake efforts to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system. One foundation of climate change convention is the principle of 'common but differentiated responsibilities and respective capabilities'.

The concept of sectoral approaches is suggested as a way to enhance mitigation and address various concerns that are related to the current climate regime. Sectoral approaches are discussed under the Kyoto Protocol (AWG KP) and Convention (AWG LCA). AWG LCA held a workshop on "Cooperative sectoral approaches and sector-specific actions" according to its work programme in Accra in August 2008 [AWG LCA]. Sectoral approaches have also been discussed in G8 and MEM.

The workshop held in Accra provided an opportunity to clarify the nature and scope of potential cooperative sectoral approaches and sector-specific actions. According to the report of the workshop, some parties saw these approaches and actions as one of several options to enhance national action on mitigation. The importance of underlying principles was also raised in the workshop. Several principles were suggested [AWG LCA]:

- ensuring that these approaches contribute to the ultimate objective of the Convention and deliver real climate benefits
- observing the principle of 'common but differentiated responsibilities and respective capacities'

- considering these approaches within the development context
- taking into account national circumstances
- ensuring compatibility with the global carbon market and existing or emerging regional emission trading schemes
- avoiding the application of international standards across countries.

This publication gives background information of sectoral approaches and carries out a case study on the iron and steel sector. Chapter 2 is a general overview of sectoral approaches. Chapter 3 contains key statistics of the global iron and steel sector and represents its most important properties. Chapter 4 provides information on the current situation of the European and Finnish steel industry. And Chapter 5 provides an assessment of selected sectoral approaches for the iron and steel industry.

2. Sectoral approaches for GHG mitigation

2.1 Why sectoral approaches?

Sectoral approaches are already widely used in a national and international context to achieve a wide range of goals, e.g., safety regulation in cars or energy efficiency of housing. This publication concentrates on sectoral approaches designed for global greenhouse gas mitigation and, more specifically, on sectoral approaches for greenhouse gas mitigation in heavy industry in global scale. Research institutes, industrial associations and governments have already started to discuss such approaches, but the issue is very complex. Various suggestions can be roughly divided into four categories [Ward 2008]:

- Transnational sectoral agreements
- No-lose sectoral targets and crediting mechanisms
- SDPAMs or policy-based instruments
- Sectoral approach to technology cooperation.

So far, China, India, and other developing countries have refused all binding targets in global climate negotiations. Meanwhile, the EU has adopted one-sided greenhouse gas reduction targets, creating an additional burden on European enterprises. The share of international trade is small in many important industry products (e.g. electricity), but some products are traded internationally to a great extent. Within trade-exposed sectors, EU's greenhouse gas policies make the companies' competitive position worse. From the point of the view of the western countries and companies, the primary motivation for sectoral approaches is to:

- enhance global climate change mitigation by offering an acceptable alternative
- address competitiveness concerns of industries exposed to global competition.

Sectoral approaches offer a major opportunity to concentrate on emission intensive industrial branches, but they also pose a number of challenges. First of all, sectoral approaches have a different meaning for different persons and there is no consensus what sectoral approaches can or should mean. Given the complexity and extremely tight schedule of negotiations, sectoral approaches will be supported only if they are well understood and are seen to facilitate rather than complicate negotiations. The concept of the sectoral approach can be broken down in to the following elements:

- Selection of a sector.
- Definition of a sector.
- Design of institutional and technical issues related to implementation. The reliability and trustworthiness require monitoring, reporting, and verification.
- Adopting a global agreement as a part of national policies.

2.2 Selection of a sector

The World Resource Institute (WRI) made an assessment across a range of sectors and criteria in the “Navigating the Numbers” publication in 2005 [WRI 2005]. The analyses consisted of 11 sectors and 7 criteria. Table 2.1 shows the results. Some industrial and transportation subsectors scored particularly well in the analysis, whereas electricity, agriculture, and LUCF sectors were considered to have several barriers to international sectoral approaches.

Table 2.1. Summary of WRI’s sector analysis. A “+” grade suggests high appropriateness or conduciveness and each “-” grade suggests a barrier to international sectoral cooperation. Analyzed sectors do not comprise 100% of global emissions. [WRI 2005.]

Sector	Share of Global GHG Emissions	International Exposure	Concentration of Actors	Uniformity of Products/Processes	Government Role	GHG Measurement Issues	GHG Attribution Issues
Electricity & Heat	24.6%		-	+	-		
Transport	13.5%						
Motor vehicles	9.9%	+	+	+	+		
Aviation	1.6%	+	+	+		+	+
Industry	21.1%						
Chemicals	4.8%	+	-	-			+
Cement	3.8%		+	+			
Steel	3.2%	+	+	+			+
Aluminium	0.8%	+	+	+			+
Buildings	15.4%		-	-	+		
Agriculture	14.9%		-	-	-	+	
Land-Use Change & Forestry	18.2%			-	-	+	
Waste	3.6%		-	+	-	+	

Figure 2.1 shows the proportion of the biggest sectors in the EU ETS during the first trading period. Combustion installations emit more than two-thirds of the total emissions while other sectors are considerably smaller [CITL viewer]. From these five biggest sectors, cement and steel received relatively high scores in the WRI analysis, but cement was not considered a globally competing industry.

The share of other industrial sectors is bigger in reality, because many combustion installations are integrated with, for example, steel mills.

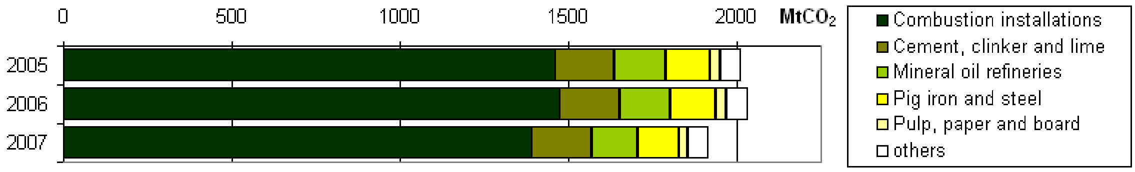

Figure 2.1. Emissions from the five biggest sectors in the EU ETS in the first trading period [CITL viewer].

2.3 Definition of a sector

Modern industrial installations are highly integrated and may contain several sub-processes seemingly far apart from each other in statistics (for example a coke oven, an industrial power plant and a steel mill). In most existing databases these are allocated under different categories.

An excellent example of the situation is the data of EU27's iron and steel sector from four data sources. Table 2.2 shows each data source in its own row; the unit of each number is $MtCO_2$. Though UNFCCC data is considerably larger than EU ETS data, it is not possible to say that it is wrong. Without knowing the definitions of a sector, included processes, and all emission calculation principles and rules, it is of little value to compare emissions from different sources.

Table 2.2. Emissions of EU27 iron and steel sector ($MtCO_2$) from 4 different sources.

		1990	1995	2000	2005	2006	2007
Data from EU ETS [CITL viewer]	Production of pig iron or steel				134	139	139
UN Greenhouse gas Inventories [UNFCCC locator]	Iron & steel (fuel combustion + process emissions)	256	235	212	207	212	
Calculated emissions from Energy use [IEA 2007c]	Iron & steel	204	167	139	129		
Center for Clean Air Policy [CCAP]	Iron & steel			155			

The EU ETS defines only a combustion installation instead of individual sectors. With certain exceptions, an installation is regulated if it emits enough CO_2 or produces enough heat or electricity for sale or for its own use. This approach is unambiguous, but it does not enable efficiency comparisons between installations, because every installation is different. In the case of sectoral approaches, it is fundamental to define a sector in such a way that it allows comparison of installations with selected criteria.

A sector definition may range from a single process to the entire process chain from raw materials to consumer. But the more processes are included the more complex the definition becomes. Every process has an alternative, and many can be out sourced to subcontractors. Legitimate responsibilities grow even more complex if a sector definition includes multiple companies. Every agreed sector definition should clearly state whether main raw materials, products and electricity, are included or not and who is responsible for their emissions.

An explicit definition is especially important due to boundary issues. Depending on the agreed targets and policy instruments, it may be preferable for a company to exclude or include its processes from the sectoral scheme. A sector definition should minimize this kind of decision possibilities.

2.4 Institutional and technical issues

The grand overall target of sectoral approaches should be to address the main reasons why they are considered at all. Sectoral approaches should

- enhance climate change mitigation by reducing global greenhouse gas emissions
- address the competitiveness concerns of global and trade exposed industries.

Two main methods exist to measure greenhouse gas emissions of selected sectors: absolute and relative emissions. The latter is often referred as benchmarks, but both require clarification.

Absolute emissions: Total CO_2 emissions during a certain time. In industrial installations, this is calculated by the mass balance method, which subtracts coal outflow (products and side products) from coal inflow (raw materials and fuels). The difference is emitted to the atmosphere as CO_2.

Relative emissions (benchmarks): Relative CO_2 emissions divide absolute CO_2 emissions by selected criteria, e.g. amount of products, raw materials or used energy. These are usually called benchmarks.

The choice between measuring total emissions or some of the benchmarks is arguable. Both have their strong and weak points and can be designed to suit the purposes of sectoral approaches. A much more limiting fact is that developing countries are very reluctant to adopt any kind of a cap on total emissions. Benchmarks, on the other hand, allow the amount of production and emissions to grow, because only relative efficiency is measured. In addition, well-designed benchmarks reward early actors and also handle several other problems with the total emissions method.

After the decision on the measured unit and target types, countries should agree on the numeric value of the target, which could be, e.g., reducing a sector's global greenhouse gas emissions by 10% during the next 15 years, or increasing the global average efficiency from 1000 kgCO_2 per tonne of product to 900 kgCO_2 per tonne of product. Target setting should take into account several crucial variables, including

- estimated development of a sector's growth and emissions
- a sector's estimated abatement potential
- emerging new technologies
- share of global emissions and agreed global emission reductions.

'Why developing countries would take part in sectoral approaches' is an interesting and often neglected question. The Kyoto protocol does not include any reduction commitments for developing countries, but emissions in China and India are growing very fast; and many developed nations have insisted on China and India participating actively to the post 2012 agreement. According to the 'common but differentiated responsibilities and capabilities' principle, selected targets can be agreed to be binding, voluntary, or no-lose targets.

This question gets even more complicated if the players in the sector are global and already have installations in both developed and developing countries. If the sectoral approaches, or any other global agreement, favour installations in developing countries, it could encourage these companies to invest only in developing countries.

Binding target sets a maximum level of emissions during a specified period of time.

Voluntary target is a level of emissions that a country or an installation has promised to reach, but does not get sanctions or benefits whether it succeeds or not.

No-lose target is a target-emission level, which is not binding, but the actor benefits if it succeeds in reducing emissions under the agreed target. Usually this is considered to allow selling a corresponding amount of emission reduction units.

The first and clearest reason is money. Developing countries or companies in developing countries could, for example, sell emission reduction units from sectoral CDMs or sectoral no-lose targets. To ensure the markets for emission reduction units, developed countries should adopt necessarily tight reduction targets and accept rather a large amount of imported emission reduction units.

Other possible options are sharing of technology, practices, and knowledge. But at the end, the biggest reason should be the same as for industrialized nations: preventing and mitigating climate change.

2.5 Arranging data monitoring, reporting and verification

It is fundamental to understand that there exists no extensive data of the current situation in most sectors in most countries. Especially developing countries lack sectoral emission data or only have estimates. Despite this, a global agreement is likely to be signed before this data have been collected. This influences whole target setting and may require that the first years are used only for data collection in most countries.

An installation **monitors** its emissions in such detail that it can fulfill the reporting responsibility.

Yearly, or after agreed intervals, every installation **reports** required data with forms designed specifically for reporting purposes of the selected sectoral approach.

After reporting, governments or third parties **verify** the reported data.

Also, the only way to confine the progress towards set targets is to arrange trustworthy surveillance of greenhouse gas emissions. An emissions tracking scheme can be set up on a sectoral level (as in the Kyoto protocol) or on an installation level (as in the EU ETS). Emissions can be verified precisely on an installation level, but the sectoral scale is open to much more doubt.

As a drawback, installation-level surveillance requires a huge amount of administrative capacity both in governments and companies. At the moment, there are only estimations about the number of industrial installations in China, and it is likely to take a long time before the emissions of all those installations could be effectively and reliably measured and verified. A broad greenhouse gas reduction program will most likely require at least one testing and training period. Even in the EU, the first trading period was a “training” period, but most importantly, during that time, the EU ETS started running and administrative capacities were built.

Global agreements with binding commitments are data intensive, but sectoral approaches allow the specified data collection in selected sectors. Extensive data collection in most of the installations in developing countries requires massive investments in administrative capacity. But this burden can be lowered with properly designed guidelines. It is considerably easier to start from a specific sector in developing countries than from a full-scale emission reduction program.

Global sectoral approaches include, almost by definition, a sector-wide exchange of confidential information, which has to be collected and managed by governments or some third party. Such an amount of confidential data may raise anti-trust concerns. Participating companies may suspect a leak of information or governments may suspect too close cooperation, even a cartel. Currently, the EU has the most experience of running a full-scale emission control system, but several other countries are also launching similar systems.

2.6 Global agreement on national policies

This chapter is short, but its message requires particular attention: Only governments have the legal right and means to force emitters to reduce greenhouse gas emissions. There is no intergovernmental body which could do this. Even in the EU, each directive has to be ratified by each member state before it becomes law.

Industrial installations are owned by companies who are not directly bound by international agreements. Every agreement requires national policies, which can be decided together or by each participating country alone. National policies may vary widely between participants or an agreement can be made to work together.

2.7 Issues related to sectoral approaches and EU ETS

Developed countries should adopt tougher commitments than developing countries, but, to avoid carbon leakage, climate policies should create an almost equal burden for globally competing companies in different regions. This can be achieved by increasing the burden of a globally competing industry in developing countries or lowering the burden in developed countries.

Potentially the strongest link between global sectoral approaches and EU policies would be the EU ETS. The Commission has made a proposal for revising the EU ETS and some rules for the third trading period are left open. The rules for setting the total cap has already been proposed, but the level of free allocation to industrial sectors is still under consideration. One major reason for this lies in the uncertainties in global policies. If sectoral approaches choose to measure benchmarks instead of total emissions, globally agreed benchmarks could be used to decide the amount of free allocation to installations within the EU ETS.

Currently the EU ETS uses a whole installation as a calculation boundary and does not define sectors. Despite this, sectoral approaches do not necessarily conflict with the EU ETS. If the definition of a sector is very narrow, it will create a boundary inside installations. The mass flows of this “island” would be monitored, reported, and verified separately and subtracted from the emissions of the rest of the installation for sectoral approaches. For the EU ETS, the installation could report in the same way as before the sectoral approach.

If the definition of a sector is very broad, legitimate responsibilities are difficult, because a sector could cover more than one company due to outsourcing. In this case, it could also be possible to break a broad sector definition into smaller pieces, e.g. main raw material and main product, but this would add a lot of complexity. It is possible, for an example, to buy raw materials outside the EU.

The EU ETS have developed well-defined calculation methods, but currently there is no data on mass flows inside an installation. If benchmarks are chosen, it is a minor expansion, because mass flows of each process are already measured by companies but not reported for the EU ETS.

Another issue in the EU, is article 81 (1) of EC treaty, which prohibits all agreements, decisions, and practices "which may affect trade between Member States and which have as their object or effect the prevention, restriction or distortion of competition within the common market". Whether the sharing of information violates Article 81 (1) EC depends on confidentiality of information. The Commission considers the 'hidden competition' as an important goal to protect and is concerned about 'artificial market transparency'. An exchange of information will be viewed more critically if products are homogenous and markets are highly concentrated, which is favorable in the case of sectoral approaches. It could be sufficient for a violation of Article 81 (1) EC if the global agreement has even potential anti-competitive effects. [CEPS 2008.]

However, in the Commission's view, the exchange of aggregated data is generally unobjectionable. In other words, the exchange of specific and individualized data will be acceptable only if data is old enough. The CEPS task force report states that 12 month old data is 'sufficiently historic'.

2.8 Brief literature review of proposed sectoral approaches

OECD published a sectoral approach for power generation in developing countries in 2006. The main idea was to create a CO_2 efficiency benchmark of electricity generation (tCO_2 / MWh) for different fuels, generation types, etc., and establish a baseline of future emissions. If countries or installations would reduce their emissions under this limit, they would be granted emission reduction units to be sold to developing countries. [Baron & Ellis 2006.]

This was one of the first proposals for the specific sectoral approaches and was merely planned to scale up the CDM mechanism with a sectoral dimension. The proposal intends to address vastly growing emissions from power generation in developing countries and admits to difficulties in statistical, administrative and political issues.

Later in 2006, CCAP proposed a "Sector-based Approach to the Post-2012 Climate Change Policy Architecture", which had similar elements as the previous OECD/IEA proposal. CCAP concluded that it would be easier and faster to start up the program with fewer participating countries. CCAP planned a sectoral approach for the ten biggest countries in six main industrial sectors: electricity, iron and steel, chemical and petrochemical, aluminum, cement and paper, and pulp and printing. Each sectoral agreement would have different participating countries, based on their production amounts. [CCAP.]

Within a sector, countries would define benchmarks (CO_2 / tonne of product) and establish a baseline for each developing country. Developed countries would have a nationwide obligatory target, like the Kyoto protocol. Developing countries would have sectoral no-lose targets, which are voluntary, but would grant emissions reduction units to sell to developed countries. Overall, the publication covers a wide range of sectors and does not go into great details. This allows shaping of the general idea, but lacks an analysis of possible barriers.

More recent proposals merely modify ideas presented in these two publications. The discussion slightly sifts towards technical details and difficulties involved in sectoral approaches. For example, WRI concluded already in 2005 that “the findings suggest that a ‘sector-by-sector’ approach to international cooperation on climate change is unlikely to be adequate or feasible” [WRI 2005].

More and more, sectoral approaches are seen only as an intermediary phase to gain some emission reductions on industry in developing countries to level the competitiveness concerns of developed countries.

3. An overview of the global iron and steel sector

3.1 The big picture

Steel is used widely in all sectors of modern society, which could not exist without steel. Steel is also a globally manufactured and traded commodity. Production levels have been quite stable in industrialized countries, but demand has increased massively in developing countries. Annual production of steel increased to more than 1000 million tonnes for the first time in 2004. The year 2004 was also noteworthy because, Chinese steel production and use surpassed production and use in the second biggest market, the EU.

Globally, the construction sector is the biggest steel user followed by other structural steelworks, mechanical engineering, car manufacturing and metal goods. The construction sector has a large share especially in urbanizing developing economies. Despite current global regression, most sectors using steel are still growing and the general market situation for the steel sector on a global scale is positive.

Approximately one-third of all manufactured steel is internationally traded, but transfer distances are usually not long due to relatively high transfer costs. Low value products are least profitable to transfer, but highly specified products can be traded across very long distances. This is why most of the new capacity is built near where there is new demand.

Steel production technology is mature and well-established. During the last decades, there have been no major innovations, and it is likely that the next generation of steel producing technologies will require more than 20 years of research. At the same time, other drivers have changed quickly. The most significant changes have been sharply increasing steel demand, the beginning of greenhouse gas emission regulation and soaring prices of both raw material and products.

Other materials can replace steel in certain products, e.g., aluminum in cars or wood in buildings, but currently these options are minor and the steel industry have replied to these challenges by designing specific steel alloys for these purposes. Overall, customer-specific steel quality and products are the competitive advantage of many western steel mills.

3.2 Steel manufacturing processes

Different parts of steel manufacturing processes are usually very closely integrated at a plant level. Every installation has a unique combination of process integrations, fuels, raw materials, etc. This intricate issue can again be simplified. To sum up, steel can be produced by two processes: basic oxygen furnace (BOF) or electric arc furnace (EAF).

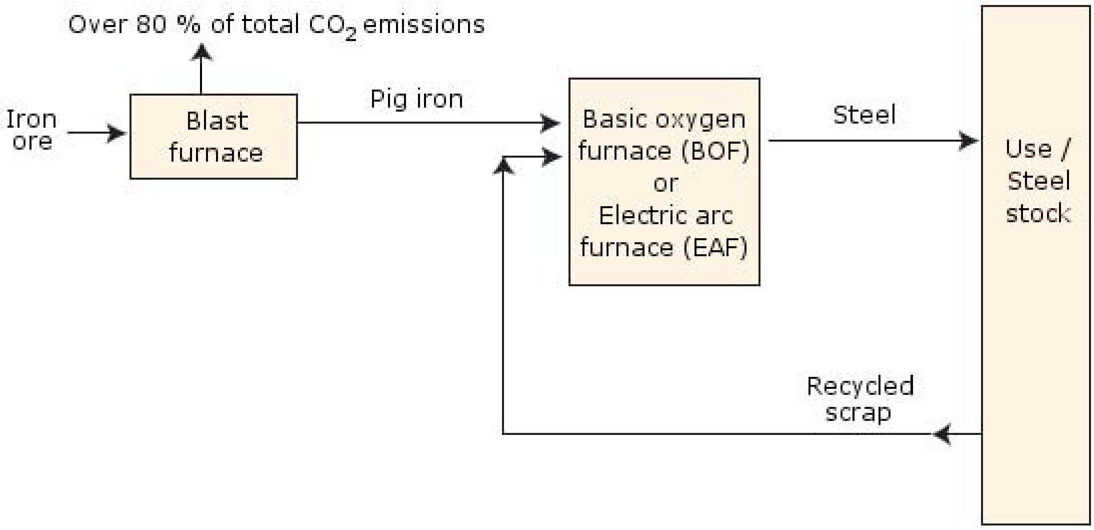

Figure 3.1. The most important processes and greenhouse gas emission source in steel production.

Both processes produce crude steel, which is cast, rolled, finished and used directly or processed into more sophisticated products. Steel in use has a product specific lifetime, which ranges from less than a year in cans to over 50 years in buildings. Steel products in use form a steel stock, which slowly becomes obsolete and is recycled. Steel scrap is so valuable a resource that over 90% is already recycled in Europe.

Steel scrap is fed to both electric steel and oxygen steel processes, but it can cover only a fraction of current demand. New steel has to be made from iron ore and iron ore has to be reduced before feeding it in steel converters. Blast furnace is the single dominant iron reduction technology where iron ore reacts with carbon monoxide from coke and coal. The amount of required carbon monoxide has a theoretical minimum and modern steel mills manage to get very close to this limit. Nevertheless, this limit is relatively high and blast furnaces produce over 80% of the total green house gas emissions in the whole iron and steel sector.

In reality, the process scheme is much more complex than shown in Figure 3.1, but the Figure condenses the most important aspects of modern steel dynamics. Sub-chapters 3.2.1 and 3.2.2 represent steel processes in more detail.

3.2.1 Oxygen steel process

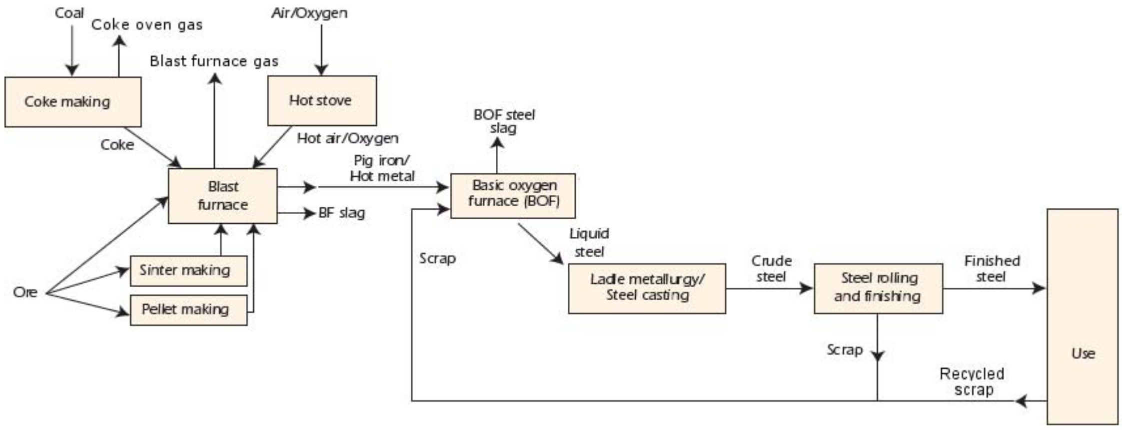

Figure 3.2. More detailed scheme of the oxygen steel process chain [modified from IEA 2007c].

The oxygen steel production chain starts from iron ore, which is pelletized or sintered and fed into the blast furnace with coke and air. Iron ore is a mixture of iron and oxygen, and the most common form of iron ore is hematite (Fe_2O_3). Taking the oxygen out of iron is called reducing. There is theoretical minimum for required reduction agents, but it can be made with fuels containing only carbon or hydrogen.

In modern technology, the reducing is done mostly with carbon monoxide (CO), which burns with oxygen from iron ore and forms carbon dioxide (CO_2). Electrowatt-Econo compiled a large number of studies regarding the need of reduction materials in 2005 [Electrowatt-Econo 2005]. One source of the study concluded that the theoretical minimum of CO_2 emissions from the reduction of iron ore without hydrogen is 1415 kgCO_2/ tonne of reduced iron. The emissions of the best available technology were around 1500 kgCO_2/ tonne of reduced iron.

Small amounts of carbon monoxide can be replaced with hydrogen from oil or natural gas. Hydrogen and oxygen from iron ore form only water, which allows smaller emissions than represented emission limits with only coal.

After a blast furnace, reduced iron (pig iron) is shifted to a basic oxygen furnace (BOF), where it is converted to steel. In order to change or improve the properties of steel, various additives are fed in alongside the hot metal. Stainless steel, for example, contains chromium at least 11.5% of its mass. Basic oxygen furnaces can use also scrap steel to replace some pig iron. After the steel converter, liquid steel is cast, rolled and finished for use.

In the oxygen steel process, the blast furnace is, by far, the largest CO_2 emitter. The reduction process of iron ore is a source of over 90% of oxygen steel greenhouse gas emissions. Future technologies will be more efficient, but existing blast furnaces will be the dominant technology for at least 20 or 30 years. There are also several other possibilities to decrease emissions below announced limits, for example natural gas or charcoal. These possibilities are discussed with in Chapters 3.2.3 and 3.7.

Figure 3.2 presents a more detailed scheme of the oxygen steel process, but it still lacks many processes, inputs and other details. Installations may include only a part of, or the entire, processes chain: for example, they may buy or produce the coke or iron pellets, and the installation may handle further processing itself or sell the crude steel. In addition, blast furnace gas and coke oven gas are burned to produce power and heat, but the power plant may be owned by the steel producer or other company, and the steel installation may use all or just a part of the produced power and heat. These variations create a multitude of installation boundaries and a problematic definition of a sector boundary in sectoral approaches.

3.2.2 Electric steel process

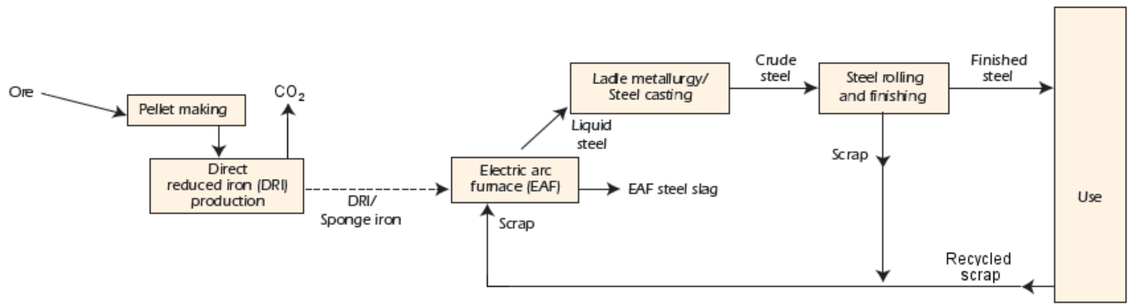

Figure 3.3. More detailed scheme of the electric steel process chain, including the production process of direct reduced iron. [Modified from IEA 2007c.]

Electric steel is produced in electric arc furnaces (EAF) from scrap metal feedstock, which avoids the emissions from iron ore reducing. Electric steel has much better energy efficiency than oxygen steel, because it uses recycled scrap instead of iron ore. The most important energy source in electric steel making is electricity, which does not produce CO_2 emissions on-site, but may have large indirect emissions depending on the energy source used for the electricity.

Electric arc furnaces may also add small amounts of pig iron from the blast furnace or direct reduced iron to steel scrap. DRI is favored in some developing countries due to its low capital costs in small installations, but less than 1% of world iron is DRI. Practically all direct reduced iron is fed to EAFs, but the specific CO_2 emissions of DRI-EAF route are not lower than in the BF-BOF route, because the DRI process was developed to gain a smaller capital cost of investments, not to lower the CO_2 emissions.

Figure 3.3 represents a schematic of the electric steel production chain, which is considerably simpler than the oxygen steel process. Some of the EAF installations have only the electric arc furnace, while others also cast, roll and finish the steel. Further processing of crude steel requires heat, which is usually produced with natural gas. This increases the otherwise minor emissions of an EAF installation.

Electric steel from scrap is an excellent way to reduce emissions, but it is limited by the availability of scrap. All available scrap is already recycled in developed countries and substantial improvements in the recycle rate, which is currently over 90% in Europe, are very improbable.

3.2.3 Future technologies

The steel sector has applied energy and process optimization programs over the last 50 years, driven by global competition. Significant CO_2 reductions in state-of-the-art installations cannot be achieved by increasing recycling, saving energy, or switching from coal to natural gas. Nevertheless, every installation has a certain energy-saving potential which is not utilized because the return on investment is too slow. And even the EU has many old installations which have not been refurbished as regularly as they should have.

Carbon capturing and storage technology is not going to nullify the CO_2 emissions of the steel industry, because a modern steel plant is a conglomerate of numerous sub-plants, which have their own combustion systems and stacks. Most of the CO_2 originates from the blast furnace, but blast furnace gas is used for heat in many other processes, and carbon capturing technology cannot be easily extended to each stack. CCS on a blast furnace would approximately yield a 25–30% reduction in CO_2 emissions, but with relatively high costs [Borlée 2007]. Further reductions of CO_2 emissions require the development of breakthrough technologies.

ULCOS is a consortium of 48 European companies and organizations from 15 countries, which include all major steel companies, engineering partners, research institutes and universities. ULCOS stands for Ultra-Low CO_2 Steelmaking. Its aim is to reduce the CO_2 emissions of the best available steel technologies by at least 50 per cent. (See www.ulcos.org.)

The main research theme of ULCOS is the in-process capture and recycling of carbon. With this method, the same carbon would encircle the process and the majority of CO_2 emissions would be avoided. The program also includes a research in biomass, hydrogen pre-reduction and electrolysis. ULCOS is considered to exhibit the fastest deployment potential of emerging technologies, but it requires a deep redesign of the blast furnace technology, which is a slow process. At best, the ULCOS project could result in commercial technology after 20 years.

3.3 Production, trade and use

World steel production has risen from 760 Mt to 1350 Mt between 1999 and 2007. Most of this growth located in China, which increased its steel production from 100 Mt/year to 490 Mt/year during these years. China's increase in production equals over 20% per year or three times the combined production of the US and Canada. All other regions combined had a much lower growth rate. Figure 3.4 shows the historical production amount from 1979 to 2006 [IISI 2007a]. A complete list of countries in each region is in Appendix A.

Production, trade, and end-use data are always aggregated data of different kinds of products and steel qualities. Table 3.1 shows statistics from eight regions, which all have different characteristics.

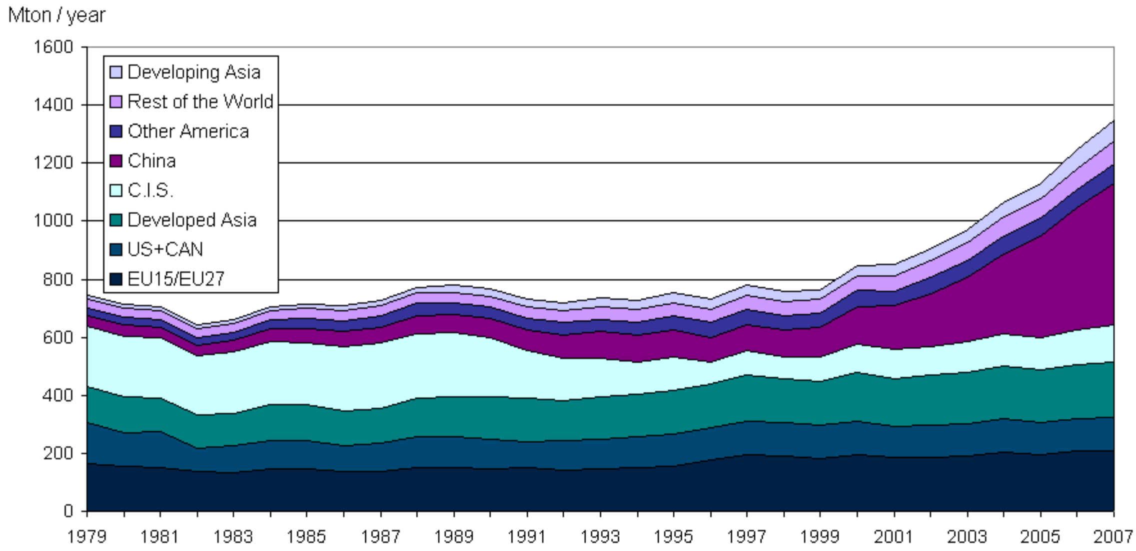

Figure 3.4. Yearly steel production in 8 regions from 1996 to 2006 [IISI 2007a].

China has increased steel production massively while having only 10% of electric steel production. For the last couple of years, China's production has increased more than demand, and it is the major exporter at the moment, but the Commonwealth of Independent States (C.I.S.) is an even bigger exporter. It has a major share of outdated open heart furnace technology, but also cheap natural gas. Other America, Developing Asia and Rest of the World are minor producers and major importers, but they still have very small per capita use. It is likely that steel demand is going to soar in these regions. The biggest per capita use is in developed Asia, almost twice the amount of steel per capita in the US or the EU.

Table 3.1. Production, trade and use of steel in eight regions [IISI 2007a]. Region's net export = export – import of semi-finished and finished steel products.

2006	Total production	Share of oxygen steel	Share of open heart furnaces	Share of electric steel	Net export	Apparent demand	Per capita use
	(Mt)	(%)	(%)	(%)	(Mt)	(Mt)	(kg / capita)
EU27	207	60	0	40	-0.8	208	418
US and Canada	114	45	0	55	-38	151	448
Other America	62	51	0	49	2.2	60	106
C.I.S.	119	59	24	17	54	65	234
China	421	90	0	10	33	388	293
Developed Asia	185	66	0	34	20	165	785
Developing Asia	67	32	1	66	-22	90	40
Rest of the World	71	35	0	65	-40	111	78

Table 3.2 contains information on sources and destinations of global steel trade in 2007. The EU is actually trading much more steel than Table 4.1 shows, but the majority of the trade was inside the region. The amount of steel net exports has remained quite the same as in 2006, but the EU seems to have imported slightly more steel than the year before. Based on Tables 3.1 and 3.2, roughly one-third of manufactured steel is traded globally.

Table 3.2. Regional steel trade in 2007 [IISI 2008].

million metric tons

Exporting Region / Destination	European Union (25)	Other Europe	CIS	NAFTA	Other America	Africa and Middle East	China	Japan	Other Asia	Oceania	Total imports	of which: extra-regional imports
European Union (25)	116.2	6.7	14.4	1.1	2.1	0.7	7.6	0.4	4.2	0.2	153.7	37.5
Other Europe	8.7	2.6	10.7	0.1	0.1	0.0	0.3	0.2	0.2	0.0	22.9	20.3
CIS	1.5	0.1	9.9	0.1	0.0	0.0	0.7	0.2	0.3	0.0	12.8	2.9
NAFTA	7.8	2.7	6.1	17.5	5.5	1.2	7.1	3.2	8.6	0.4	60.1	42.6
Other America	1.3	0.1	2.7	0.8	4.0	0.2	1.2	0.5	0.7	0.0	11.5	7.5
Africa	3.8	1.0	5.9	0.3	0.8	1.4	1.7	0.4	1.3	0.0	16.6	15.2
Middle East	3.9	3.6	9.0	0.3	0.4	1.6	3.0	1.3	4.0	0.0	27.1	25.5
China	1.4	0.0	2.9	0.1	0.1	0.1	-	6.8	7.3	0.2	19.1	19.1
Japan	0.1	0.0	0.0	0.0	0.0	0.0	0.8	-	3.5	0.0	4.4	4.4
Other Asia	3.1	0.3	6.5	0.5	1.8	0.7	29.4	21.7	14.7	0.3	79.0	64.3
Oceania	0.7	0.1	0.0	0.0	0.0	0.0	0.5	0.5	1.3	0.2	3.3	3.1
Total Exports	148.6	17.3	68.1	20.7	14.8	6.0	52.2	35.3	46.1	1.4	410.5	242.5
of which: extra-regional exports*	32.4	14.7	58.3	3.2	10.8	3.0	52.2	35.3	31.4	1.2	242.5	
Net Exports (exports - imports)	-5.1	-5.7	55.3	-39.4	3.3	-37.6	33.1	30.9	-32.9	-1.9		

The world's biggest steel producers are international companies producing steel all around the world. Many of these originate from the Europe, the U.S. or Japan, but are now owned internationally. Table 3.3 represents the biggest steel producers in 2007 and their production in 2006. Many Chinese and Indian steel companies have increased their production dramatically during only one year.

Table 3.3. 40 biggest steel producers in 2007 [IISI 2008].

2007		2006			2007		2006		
	Mt steel		Mt steel			Mt steel		Mt steel	
1	116	1	117	ArcelorMittal	21	13.3	21	12.5	Magnitogorsk
2	35.7	2	34.7	Nippon Steel	22	13.1	20	12.8	Techint
3	34	3	32	JFE	23	12.9	26	10.5	Shougang
4	31.1	4	30.1	POSCO	24	12.1	22	11.2	Jinan
5	28.6	6	22.5	Baosteel	25	11.7	24	10.8	Laiwu
6	26.5	45	6.4	Tata Steel1	26	11.1	27	9.9	Hunan Valin
7	23.6	5	22.6	Anshan-Benxi	27	10.9	25	10.7	China Steel
8	22.9	17	14.6	Jiangsu Shagang	28	10.1	28	9.8	IMIDRO
9	22.8	9	19.1	Tangshan	29	10	30	8.9	Hyundai
10	21.5	7	21.2	US Steel	30	9.7	29	9.1	Novolipetsk
11	20.2	16	15.1	Wuhan	31	9.3	47	6.3	Taiyuan
12	20	8	20.3	Nucor	32	9.1	32	8.7	Metinvest Holdings
13	18.6	15	15.6	Gerdau Group	33	9	39	7	Anyang
14	17.9	11	18.2	Riva	34	8.8	35	7.5	Baotou
15	17.3	12	17.5	Severstal	35	8.7	31	8.8	Sistema Usiminas
16	17	13	16.8	ThyssenKrupp2	36	8.3	33	7.9	Handan
17	16.2	14	16.1	Evraz	37	8.1	37	7.2	Celsa
18	14.2	23	10.9	Magang Group	38	8.1	34	7.7	Kobe Steel
19	13.9	19	13.5	SAIL	39	7.6	48	6	Tangshan Jianlong
20	13.8	18	13.6	Sumitomo	40	7.4	43	6.6	Jiuquan

3.4 Steel price

The vast increase in steel production was a response to even faster growth in the demand for steel in rising economies. The price of steel has multiplied since 2000 due to rising demand and costs of raw material. Figure 3.5 presents composite price information of flat & long carbon steel products from IEA and MEPS from Jan-2000 to Apr-2008. The first six series are export prices from various regions [IEA 2007c] and the latter four series are aggregated regional price [MEPS 2008]. The data ends in April 2008, but the price has increased since then.

In April 2008, EUROFER published a press release, where it states that the price of iron ore has risen 65% and, in addition, the price of coking coal has increased over

200% [EUROFER 2008b]. In June 2008, Chinese steel companies agreed to pay 96% more for iron ore coming from British-Australian Rio Tinto, greatly increasing the price pressure on iron ore [T&T 2008a]. All this has lead to fierce competition between steel companies who are trying to ensure the supply of raw material. Brazilian CSN was selling its iron ore producing daughter company Namisa in July 2008 and received a 50% higher bid than expected [T&T 2008b].

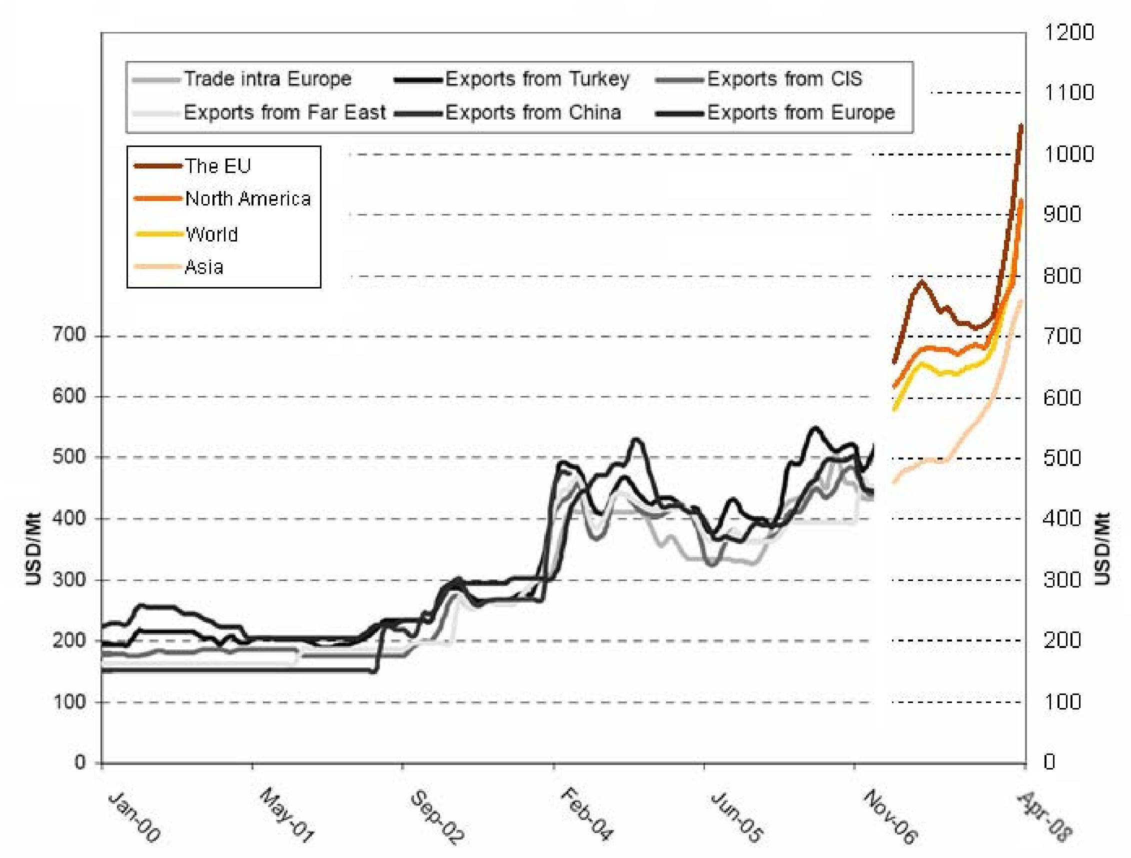

Figure 3.5. Price of flat & long carbon steel products [IEA2007c, MEPS 2008].

Operating costs have risen also for electric steel producers, which require two major raw materials: scrap and electricity. Figure 3.6 shows the development of the demolition scrap price [EUROFER 2008c]. The price is an index price (2001 = 100), which has been calculated on the basis of the average price in € for the following countries: France, Germany, Italy, Spain, and the UK. The price of electricity has also risen, due to tightened emission regulation and the increasing price of oil and natural gas.

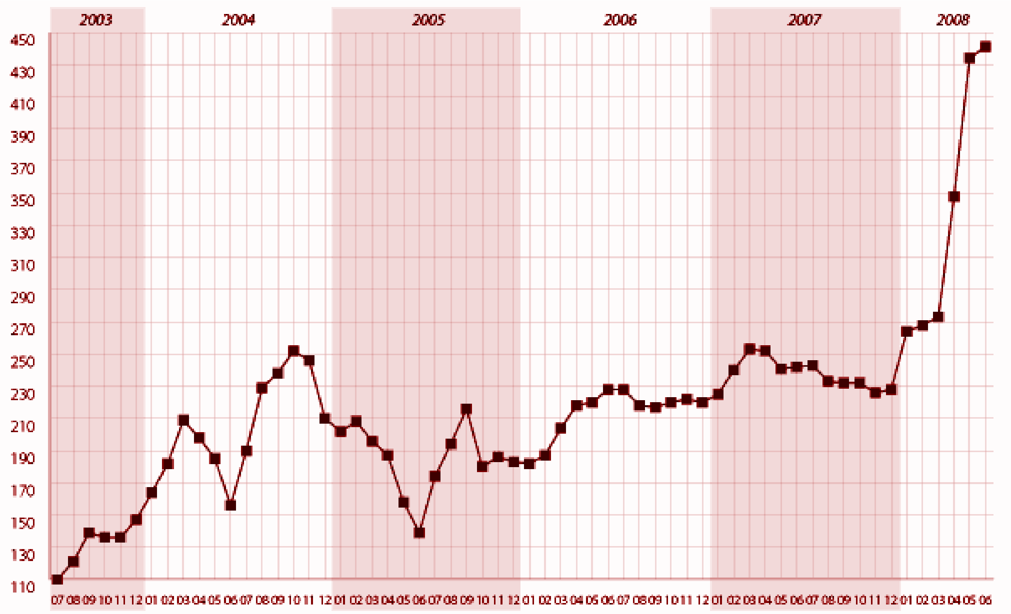

Figure 3.6. Price index of demolition scrap (2001 = 100) [EUROFER 2008c].

3.5 Energy use in steel and electricity sectors

In the oxygen steel process chain, a blast furnace uses the most of the energy, but the share depends on which subprocesses are included in the installation. Blast furnace gases still include a considerable amount of energy, and these are used in other sub processes or at the power plant. A coke oven also requires a lot of energy and produces coke oven gas, which is used as an energy source. After the blast furnace and the coke oven, rolling and further processing consumes the most energy.

In the electric steel chain, an electric arc furnace consumes slightly more energy than reheating and rolling. The energy needs for the whole electric steel chain is less than 50% of the energy needed for oxygen steel.

Process designers have some degrees of freedom when used fuels are decided upon, but choices are hard or impossible to change after the construction of the installation. The blast furnace has to be rebuilt after a lapse of approximately 10 years of use, due to heat and mechanical deterioration. Despite the reconstruction, the properties of the blast furnace have to be more or less same, if other parts of the integrated steel mill are also not rebuilt.

IEA has the most extensive public data of the energy use in the iron and steel sector. In IEA statistics, the iron and steel sector includes ISIC categories 271 and 2731, which includes the manufacture of basic iron and steel and the activities of iron and steel foundries. This definition excludes, for an example, power plants using blast furnace gas. Also coke ovens are in their own category, which cannot be mended to shown statistics. Due to these boundary reasons, the following figure of energy consumption is an indicative estimation. Figure 3.7 shows IEA statistics for energy use in the iron and steel sector in 1990, 2000, and 2005 [IEA 2007a]. The figure includes the amount of total energy in Mtoe and shares of different fuels.

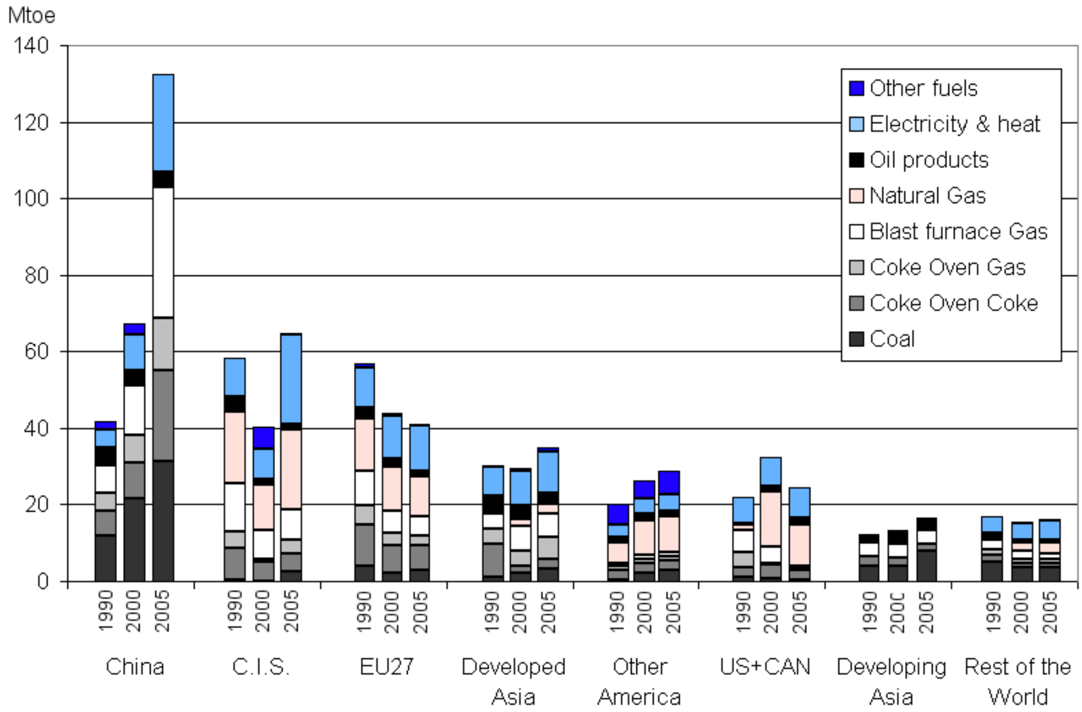

Figure 3.7. Energy use (Mtoe) in iron and steel sector in 1990, 2000, and 2005 [IEA 2007a].

Electricity generation sources are closely connected to discussion of sectoral approaches. Excluding coke ovens and industrial power and heat plants, the share of electricity as an energy source for the iron and steel industry was approximately 25% in 2005. This results in huge differences in the indirect greenhouse gas emissions between countries. Figure 3.8 shows the electricity by fuel type, but does not include the average efficiency of power plants, which also has a considerable effect on emissions. The more greenhouse gas emissions are produced, the more inefficient power plants are.

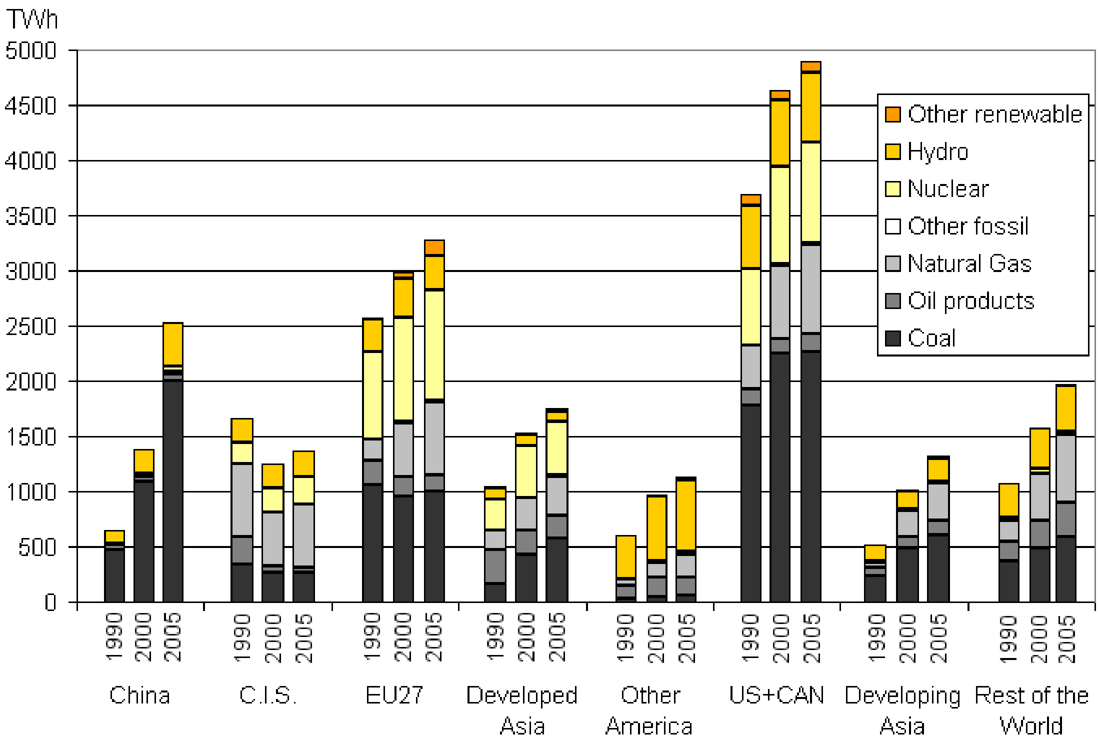

Figure 3.8. Generated electricity by fuel in 1990, 2000, and 2005 [IEA 2007a].

3.6 Energy efficiency

A comparison of the energy intensity of steel production based on existing and aggregated energy statistics is of limited value as the wide range of input values does not provide meaningful insights regarding actual technological and operational differences. In addition, existing energy use databases usually separate the coke ovens and power plants within steel installations. A proper comparison would require agreed upon data collection methods, sector boundaries and other parameters before the installation level-data would be gathered. After this, only similar processes would be compared to each other.

Old installations are modernized bit-by-bit or are replaced by new ones, which increases the average efficiency over time. Sometimes the development is very rapid. Investment speed has been high during the last decade, and this reflects the average efficiency of the sector. IEA published an estimate of the development in electrical energy use of electric arc furnaces. Figure 3.9 shows that a better-than-average EAF installation from 1990 would have belonged to the worst third in 1999.

From the point of view of emission regulation and sectoral approaches, the difference between the best and the worst installations in developing countries is especially interesting. Steel production capacity of China has grown very rapidly, which leads to slightly uncontrolled growth and many small and inefficient installations.

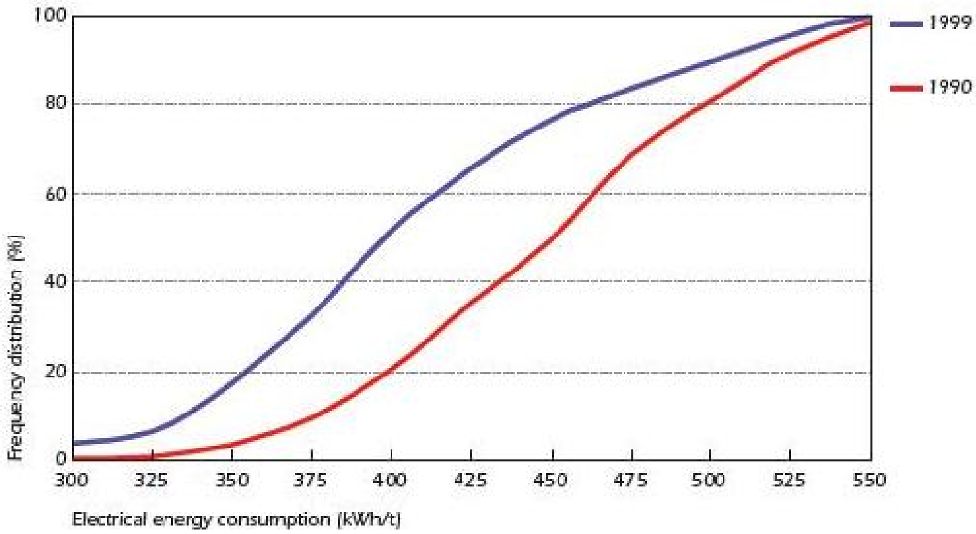

Figure 3.9. Efficiency distribution of world electric arc furnaces [IEA 2007c].

On average, OECD countries have more modern installations and effective processes than non-OECD countries, but the EU27, for example, includes inefficient Eastern Europe countries. On the other hand, new installations in developing countries are similar to up-to-date western technology. Table 3.4 shows the IEA estimate of the Chinese net energy use per tonne of product (primary energy equivalents) in the most important sub processes in steel making.

Table 3.4. Net energy use per tonne of product in the steel production chain [IEA 2007c].

			Sintering	**Coking**	**Blast furnace**	**Oxygen steel (BOF)**	**Electric steel (EAF)**	**Rolling**
			GJ/t	GJ/t	GJ/t	GJ/t	GJ/t	GJ/t
China	2002	Average	2.0	4.3	13.3	0.8	6.7	3
China	2003	Average	1.9	4.1	14.2	0.7	6.2	2.9
China	2004	Average	1.9	4.2	13.7	0.8	6.2	2.7
China	2004	Advanced	1.5	2.6	11.6	-0.1	4.3	1.6
China	2004	Laggard	3.2	6.7	17.3	2.2	9.5	8.4

3.7 GHG emissions and reduction potential

WRI estimated that the iron and steel sector produces approximately 3% of global emissions [Baumert et al. 2005], but WRI did not estimate the share of emissions between countries. UNFCCC keeps a record of global emissions, but the statistics lack sector-specific data in most non-Annex I countries. IEA keeps energy statistics where the emissions of iron and steel sector can be calculated, but the IEA's definition of the iron and steel sector excludes coke ovens and power plants. CCAP published estimates of sectoral emissions in 2000.

Table 3.5 presents the regional emissions calculated from IEA and CCAP statistics. All estimates are small as the reduction of 1 tonne of iron ore produces at least 1.5 tonnes of CO_2. Total emissions should be larger than this theoretical minimum.

Table 3.5. CO_2 from iron and steel sector [IEA 2007c] and [CCAP]. IEA data excludes coke ovens and industrial power plants.

	Production	**CO_2 emissions [IEA]**	**CO_2 emissions [CCAP]**
	2005	2005	2000
	(Mt)	(Mt CO_2)	(Mt CO_2)
EU27	196	129	172
US & Canada	110	50	199
Other America	62	63	52
C.I.S.	113	178	72
China	349	648	157
Developed Asia	180	115	67
Developing Asia	55	89	83
Rest of the World	67	47	116

The most important source of direct greenhouse gas emissions in iron and steel sector is the reduction process of iron ore in blast furnaces. Over 80% of the sector's total greenhouse gas emissions originate from blast furnaces as a blast furnace gas, which is a mixture of mainly carbon dioxide (CO_2) and carbon monoxide (CO). Blast furnace gas is combusted and emissions are emitted in other processes or in an interlinked power and heat plant. A part of the carbon from a blast furnace is also bound to pig iron, which contains ~4% of carbon, but most of this carbon is freed in a steel converter.

The remaining direct emissions come mainly from fossil fuels combusted for process heat in BOF and EAF routes. An electric arc furnace uses electricity, but possible casting and rolling requires the reheating of steel, which may be done with fossil fuels.

Figure 3.10 presents IEA estimates of the overall emissions of BOF with an average or advanced blast furnace and EAF. The product in estimations is crude steel and the figures exclude rolling and finishing. The red arrow describes the amount of emissions from the electricity, where the low-end and high-end indicate CO_2-free electricity and pure coal electricity. According to IEA estimates, the indirect emissions of used electricity are also minor compared to blast furnace emissions.

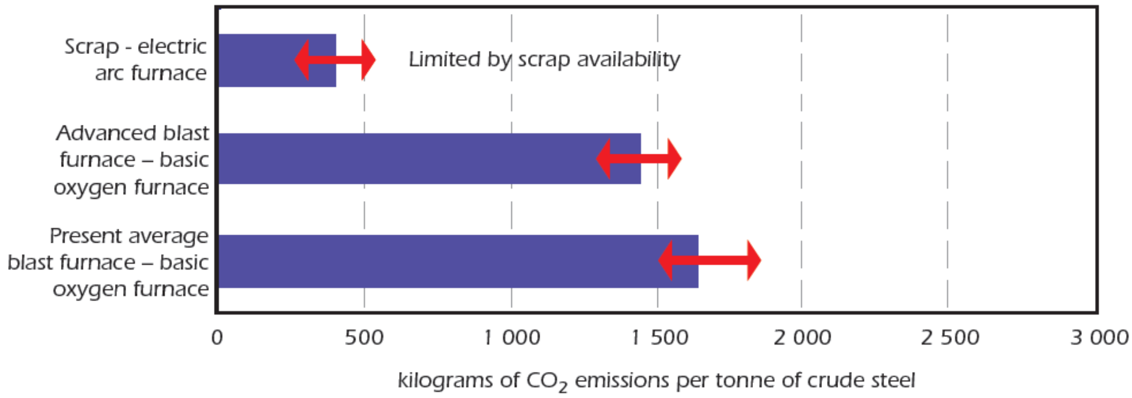

Figure 3.10. Total CO_2 emissions of EAF and BOF with advanced or average blast furnace. Red arrows indicate the range between CO_2-free and coal electricity. Figures exclude rolling and finishing. [IEA 2007c.]

IEA estimates should be compared to a theoretical minimum and the BAT level presented in Electrowatt-Econo's study. A theoretical minimum of CO_2 produced in the reduction of iron ore was 1415 kgCO_2/ tonne of reduced iron and the best available technology was 1489 kgCO_2/ tonne of reduced iron. IEA estimations seem to be slightly lower, but this may result from an assumed fuel mixture.

The biggest abatement potential lies in old installations, but every installation has some abatement potential, and even the most modern installations can improve their efficiency. Overall, the greenhouse gas reduction potential is hard to estimate. In the publication 'Worldwide Trends in Energy Use and Efficiency', the IEA carried out bottom-up estimates of the global abatement potential in the iron and steel sector if BAT would be applied worldwide. Results are presented in Figure 3.11 [IEA 2008].

Key findings were that most of the potential lies in blast furnaces and in China. The total amount of estimated abatement potential is under 350 MtCO_2, which is a sum of ~50 MtCO_2 from coke ovens, ~250 MtCO_2 from blast furnaces and remaining ~50 MtCO_2 from other sub processes and finishing. This is not the estimate of future potentials, only of the difference between current performance and BAT level. According to IEA, Western installations have only modest abatement potential with current technologies.

Theoretical model simulations exist from the future abatement potential. CCAP, for example, estimated that CO_2 emissions from the non-Annex I iron and steel sector would increase from 460 MtCO_2 to 1900 MtCO_2 in a baseline scenario by 2020 and only to 900 MtCO_2 if proposed sectoral approaches are adopted [CCAP].

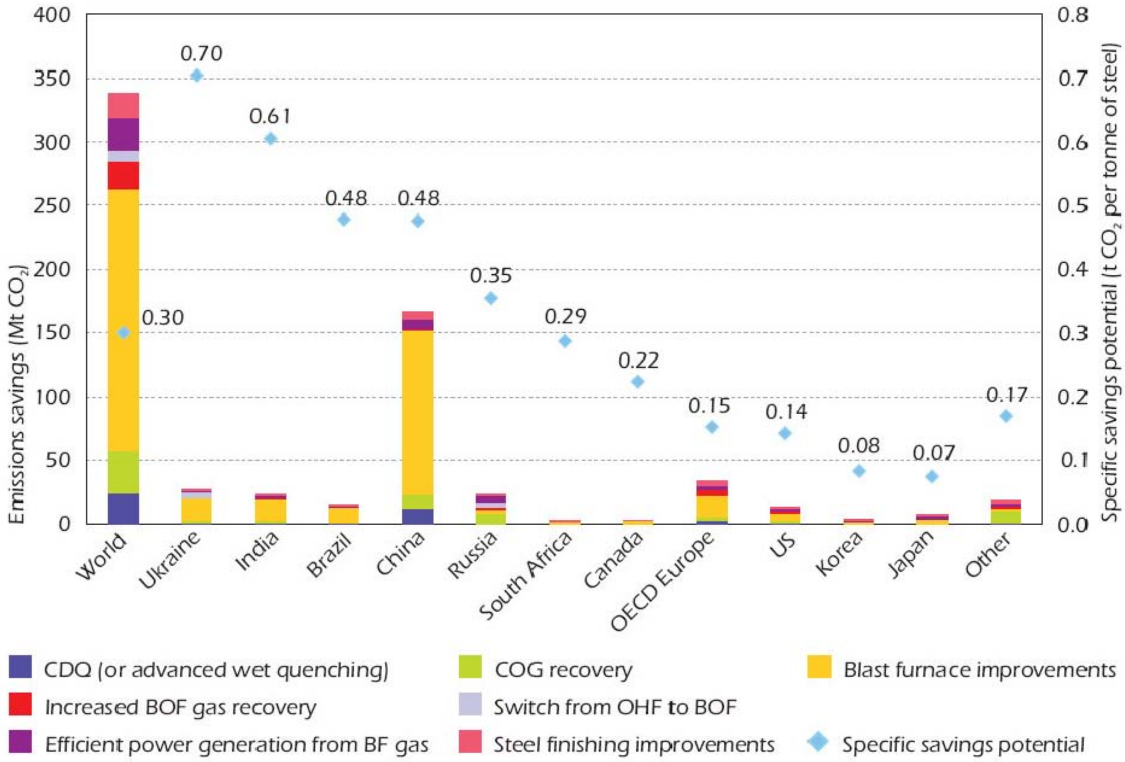

Figure 3.11. CO_2 reduction potentials in the iron and steel sector in 2005 based on the BAT (best available technology) [IEA 2008].

3.8 Existing work for sectoral approaches in the global steel sector

The iron and steel sector believes that a global sectoral approach is possible and aspired to despite the issued problems. The support is strongest in Japan and Europe. EUROFER suggested sectoral approaches already in 2006, but in the 2007 yearbook EUROFER admits that, "it became clear in the course of the year that EUROFER's baseline and credit proposal would not gain widespread political support" [EUROFER 2007b].

The Asia Pacific Partnership (APP), whose partner countries account for nearly 50% of the world's steel production, has a steel task force to develop sector relevant benchmarks and performance indicators, develop more efficient technology, facilitate the deployment of best practices, and increase collaboration between governments, industry and research institutes [APP 2008]. Unfortunately, the APP steel task force has published very little during 2008 and the development is difficult to follow.

Currently, the International Iron and Steel Institute (IISI) is developing the most comprehensive sectoral approach. There has been also several other suggestions from research institutes, but the IISI has already begun a practical work and has wide support in the industry. Also, the EUROFER has continued its work with IISI [EUROFER 2007b].

To sum up, IISI plans a sectoral approach based on intensity benchmarks (tCO_2 per tonne of steel), which would include indirect CO_2 emissions from the electricity generation. IISI's sectoral approach will include various intensity benchmarks, at least one for oxygen steel and another for electric steel. After the information-gathering period, the installations would be compared by calculated benchmarks. IISI's current proposals and presentations include only the data collection period and there is no final form or precise details about targets or policy instruments.

If the IISI's proposal will form the basis of a compulsory emission reduction scheme, asymmetry of knowledge between IISI and governments becomes a concern. Individual plant data would be confidential, but at least benchmark formulas and a large amount of aggregated data should be published.

4. A closer look at the European steel sector

4.1 Steel production and use in the EU

Europe has a long history of steel production and most installations are built near the sea coast, a river, an energy source or raw material resources. Table 4.1 presents the number of steel mills and steel produced in each EU member state in 2006. Electric arc furnaces have a 40% share in the EU and oxygen steel covers 60% of production. Only Latvian installations are still using old and inefficient open heart furnaces, but the total amount of OHF steel production is only 0.2% of the total EU production. Usually countries have both oxygen and electric steel production, but according to IISI statistics, Greece and Slovenia have only electric steel production.

Most European countries have domestic steel production. Germany, Italy, France, Spain and United Kingdoms are the five biggest producers, altogether producing 131 million tonnes of steel, which corresponds over 63% of EU production. The old EU15 still produces over 83% of European steel. Table 4.1 shows the number of installations, allocated emission allowances, steel production and net export of steel, population, and the apparent usage of steel in each member state.

Basically all European iron is produced in blast furnaces. The direct reduction technique of iron is used only in Germany and Sweden and it corresponds to just 0.6% of the total production of iron in the EU.

Despite the current slowdown in the economy, EUROFER presented a relatively good future prognosis for the European steel sector in the market report of July 2008. The growth of EU's steel sector was 5.5% from 2006 to 2007, but the growth is expected to slow down to 2.5% in 2008 and to 1.7% in 2009. EUROFER expects the growth in all steel using sectors to slow down, but the activity of all sectors should still keep growing. Table 4.2 shows the relative weight of each steel using sector in the EU and their expected growth in the next two years [EUROFER 2008a].

Table 4.1. Iron and steel production in the EU member countries in 2006 [IISI 2007a].

	Number of installations	**Allocated allowances for the 1st ETS period**	**Oxygen steel**	**Electric steel**	**Total steel**	**Net export ***	**Popu-lation**	**Apparent consumption**
		($MtCO_2$)	(Mt)	(Mt)	(Mt)	(Mt)	(million)	(kg/capita)
Austria	3	0.1	6.5	0.6	7.1	2.6	8.3	540
Belgium **	27	15.3	8.2	3.5	11.6	7.6	10.6	620
Bulgaria	0	-	1.2	1.0	2.1	0.1	7.6	260
Cyprus	0					-0.4	0.9	450
Czech Republic	7	5.8	6.3	0.6	6.9	0.2	10.4	640
Denmark	1	0				-2.1	5.5	380
Estonia	0					-0.6	1.3	430
Finland	4	7	3.5	1.6	5.1	2.3	5.3	520
France	24	28.6	12.2	7.6	19.9	1.9	64.5	280
Germany	34	33.7	32.6	14.7	47.2	4.9	82.2	520
Greece	5	0.7		2.4	2.4	-1.8	11.1	380
Hungary	8	2.2	1.7	0.4	2.1	-0.7	10.0	270
Ireland	0					-1.0	4.3	240
Italy	43	14.8	11.8	19.8	31.6	-6.9	59.6	645
Latvia ***	1	0.4		0.003	0.5	0.2	2.3	151
Lithuania	0					-0.6	3.4	190
Luxembourg	4	0.6	0.0	2.8	2.8	**	0.5	**
Malta	0					-0.1	0.4	160
Netherlands	2	10.4	6.2	0.2	6.4	2.0	16.4	270
Poland	9	13.3	5.8	4.2	10.0	-2.3	38.1	320
Portugal	2	0.3	0.0	1.4	1.4	-1.8	10.6	300
Romania	5	5.2	4.4	1.9	6.3	1.2	21.4	240
Slovakia	3	9.7	4.7	0.4	5.1	2.7	5.4	440
Slovenia	3	0.2		0.6	0.6	-0.6	2.0	620
Spain	27	11.2	3.6	14.8	18.4	-7.4	46.1	560
Sweden	13	7.2	3.6	1.9	5.5	0.3	9.2	570
United Kingdom	5	6.6	11.2	2.7	13.9	-0.4	60.6	240
EU	230	168.4	123.3	83.0	206.8	-0.8	498.2	420

* Net export of semi-finished and finished products
** Luxembourg's trade is included in Belgium's net export
*** Latvia's total steel includes 0.548 Mt of OHF steel

Table 4.2. Weight and expected growth of major steel using sectors [EUROFER 2008a].

	Weight in total steel consumption	**Growth rate**		
		2007 / 2006	**2008 / 2007**	**2009 / 2008**
	(%)	(%)	(%)	(%)
Construction	27	5.0	2.4	1.1
Structural steelwork	11	7.6	1.8	1.9
Mechanical engineering	14	8.9	4.8	2.2
Automotive	16	5.6	2.2	1.2
Domestic appliances	4	3.8	1.0	2.4
Shipyards	1	4.1	3.1	2.6
Tubes	12	1.9	0.6	1.4
Metal goods	12	6.0	3.3	3.2
Miscellaneous	3	2.5	2.1	1.7
TOTAL	100	5.5	2.5	1.7

Used steel forms a steel stock in society and returns slowly to recycling. Figure 4.1 presents a scheme of cycling steel in society. The general structure would be almost the same everywhere, but the width of the arrows is matched to data from EU15 in 2004 [EUROFER 2007a]. The figure illustrates clearly that very little amount of produced steel is lost, but the amount of recycled scrap depends on the life time of steel products. Constructions have the longest life time of steel products and the amount of steel stored in constructions is growing all the time. This will increase the amount of available scrap in the future, especially in developing countries.

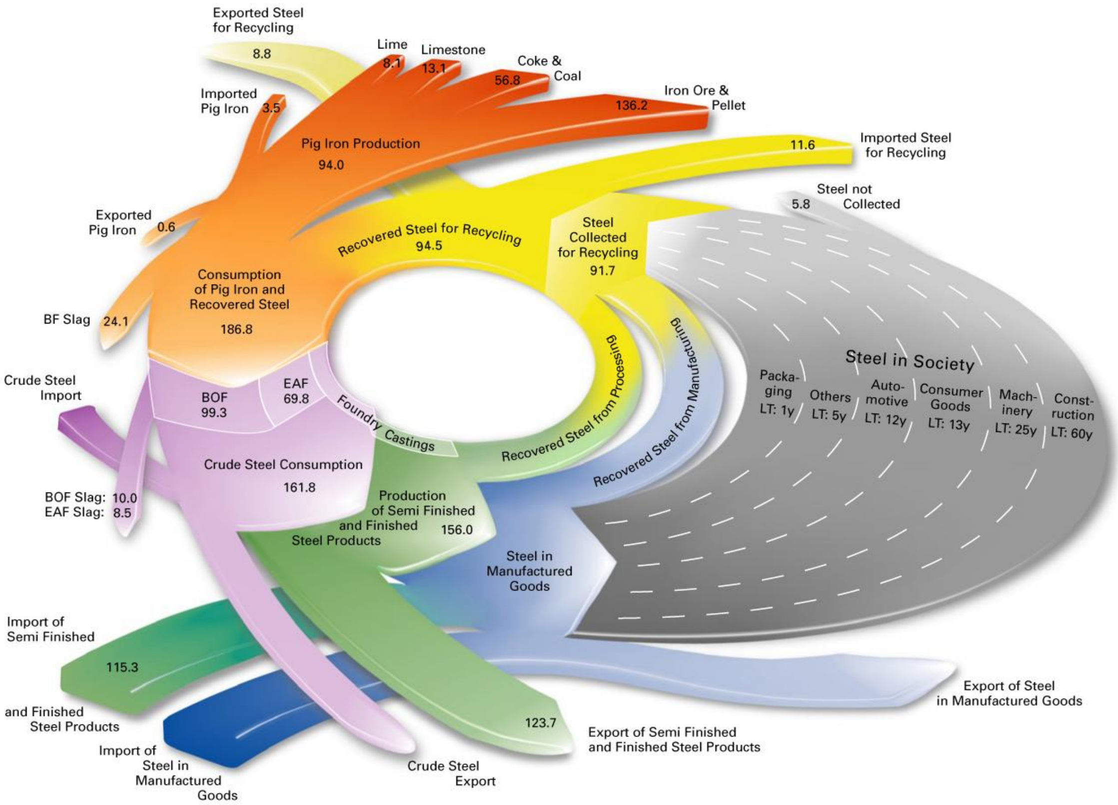

Figure 4.1. Illustration of cycling steel in the EU15 in 2004 [EUROFER 2007b]. New steel enters the circle from the top, and each phase of steel manufacturing has a different color. Steel in society is gray. The Average lifetime (LT) of products is shown under each category.

4.2 Electricity generation

The EU has a globally high share of renewable energy in electricity generation, but over 40% of produced electricity was still from coal in 2005. Figure 4.1 presents the share of each electricity source in EU member states in 2005. New renewable generation capacity is built on record high speed, but this won’t change the overall form of Figure 4.2 quickly, because the total amounts of generation capacity is high and construction times are relatively slow. According to IEA statistics, the EU15 had 590 GW of generation capacity in 2004.

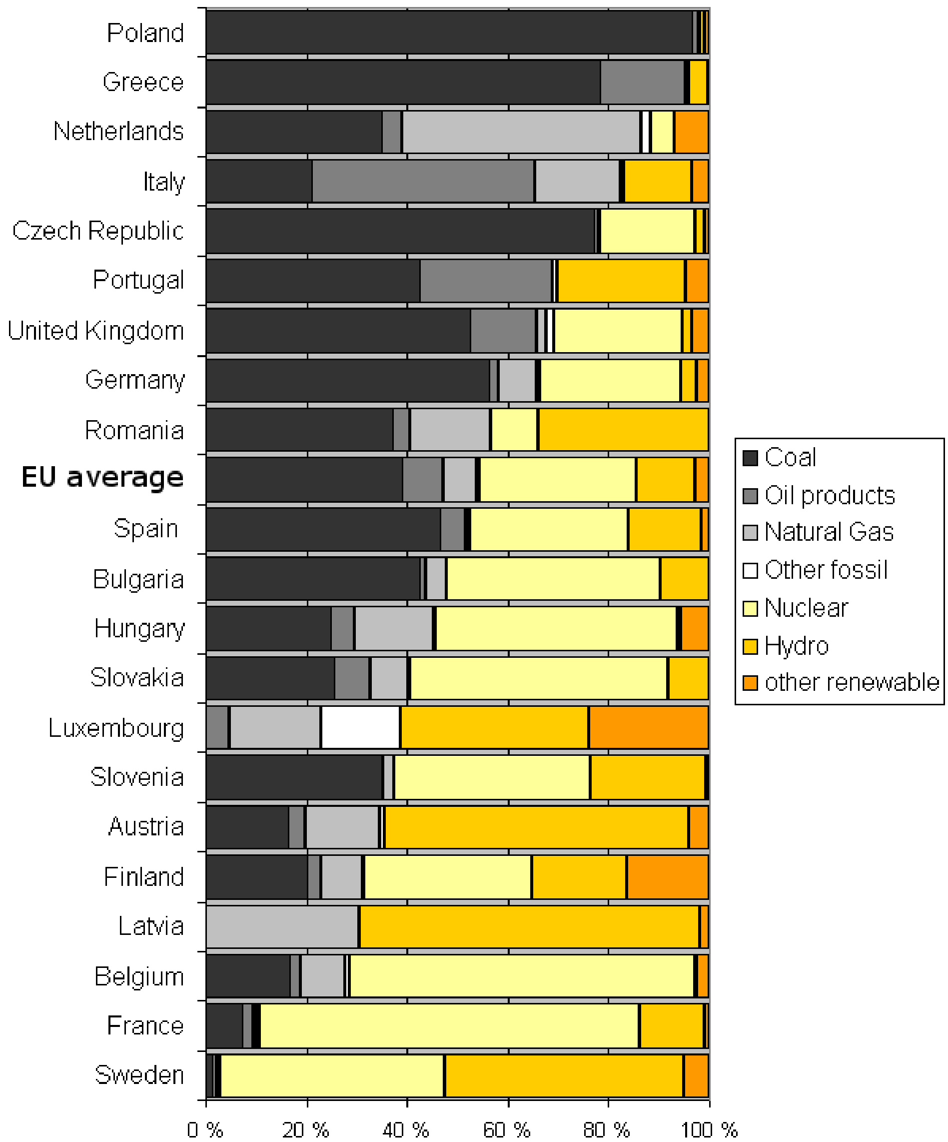

Figure 4.2. Share of electricity generation in the EU steel-producing countries by fuel [IEA 2007a].

4.3 Competitive issues of GHG reductions

A major new concern about competitiveness is the regulation of greenhouse gases and market imbalances brought by one-sided greenhouse gas reduction targets adopted by the EU. The EU has adopted a large number of environmental directives and multinational agreements. Two of the most important, in the case of greenhouse gas reductions in the steel industry, are the Kyoto protocol and the EU emission trading scheme (the EU ETS). The EU ETS has been active since 2005 and the Kyoto period started in 2008. The commission has planned that the EU ETS and additional national targets for other than ETS sector should be enough to fulfill the Kyoto commitments.

What is competitiveness?

(Summarized from the article of the Competitiveness Institute [TCI 2008])

For a company, competitiveness means an ability to deliver products or services as efficiently or more efficiently than the relevant competitors. Competitiveness may be artificially boosted by protective measures or subsidies, but the price of a product is not the only meaningful factor. Successful specialization, skilled salesmen with good networks, shorter transportation distances, long-term relationships with customers, etc. may sometimes have decisive power over price.

At the industry level, competitiveness means the capacity for the whole industry sector to succeed against foreign competitors. In this larger scale, the measures of competitiveness shift towards foreign trade balance, balance of outbound and inbound foreign investments and cost and quality at the industry level. Success of a single company may be due to company-specific factors, but the success of the whole industry is often evidence of the sector's competitive advantages.

For a nation, competitiveness is the capacity to achieve a high and rising quality of life for its citizens. These standards vary between nations, but it is usually thought that a continuously rising standard of living is achieved through continual improvements in productivity. Competitiveness on the national level could be measured by the purchasing power of its citizens, a balanced budget, productivity and standards of living, education and healthcare.

The effects of greenhouse gas regulations can be roughly divided into four categories: direct costs of GHG emissions, indirect costs of GHG emissions, increased administrative burden, and future uncertainties. The relative weight of these four categories depends, of course, on the regulation scheme but also on the size and type of installation. Small installations have similar administrative responsibilities as large ones, but much smaller emissions. Future uncertainty is most critical for international companies, especially if their competitors are not covered by regulation. According to the Commission proposal, small installations could be excluded from the EU ETS to maintain administrative efficiency, but the limit is too low for steel producers to fall below it.

Direct costs of regulated GHG emissions include process emissions from coke and combustible fuels, which is more crucial to oxygen steel manufacturers. In oxygen steel mills, blast furnaces are the source of the most of the emissions. A blast oxygen furnace and possible ferrochromium chain have a considerably lower overall effect.

Indirect costs come mostly from an increased electricity price, but also transportation fees are likely to rise as the EU starts to regulate the CO_2 emissions of transportation. These indirect costs do not have only negative aspects, because also foreign companies have to pay for increased transfer costs, which levels the playing field. On the other hand, the increase in transport costs should not be high because most of the global steel trade is by seas and railways. These two sectors are still not bound by greenhouse gas regulation, but it is likely that some measures will be also targeted at these sectors in the future.

The impact on the price of electricity depends on a country's electricity generation structure and transfer connections. The price of emission allowances is transferred directly to the price of electricity, but the generation costs of coal electricity is increased more than, e.g. electricity from oil. VTT has estimated that each euro in the price of emission allowances will increase the price of market electricity in the Nordic markets approximately by 0.75 Euro/MWh [Koljonen et al. 2004, Kara 2004]. Figure 4.1 shows that the Nordic electricity markets have a much higher share of CO_2-free electricity sources, and thus the price effect should be higher in most EU member states. The price impact is around 0.95 Euro/MWh for pure coal electricity and around 1.3 Euro/MWh for gas turbines, depending on the efficiency of power plants.

In addition, the soaring price of oil and gas increases the price of electricity. Because of the price mechanism of modern electricity markets, hydro power and nuclear power producers also gain profits from the EU ETS and rising oil and gas prices. Steel producers may try to avoid risks from the volatility of electricity prices by owning a share of a power plant or by making a long term delivery contract. Nevertheless, profitable long term electricity contracts are difficult or impossible to make, because power companies know the value of the electricity too.

The administrative burden from the EU ETS was highest in 2005 when the scheme started. During the first trading period, practices evolved, clarified and harmonized across the EU, which lowered the overall administrative burden of the EU ETS. Currently, the second trading period is underway with slightly revised rules, but the rules for the third trading period are under revision. The commission has decided on the total cap until 2020, but several important factors are left open, e.g., a possible free allocation method, creating extra uncertainty on greenhouse gas policies.

It is very difficult to estimate the overall effect of the EU ETS on the steel industry because a lot of other things changed in three years. For the first time in modern history, China produced more steel than it used in 2005. In 2006, China already exported over 30 million tonnes of steel, which equals 15% of the total production of EU27. Also the price of oil started to soar in 2006. These three factors combined with all other factors led to a large increase in imports for the EU27 and a slight decrease of EU27's exports in 2006. Figure 4.3 shows the amount of imports and exports in EU27 from 2002 to 2007 and EUROFER's estimates for 2008 and 2009 [EUROFER 2008a].

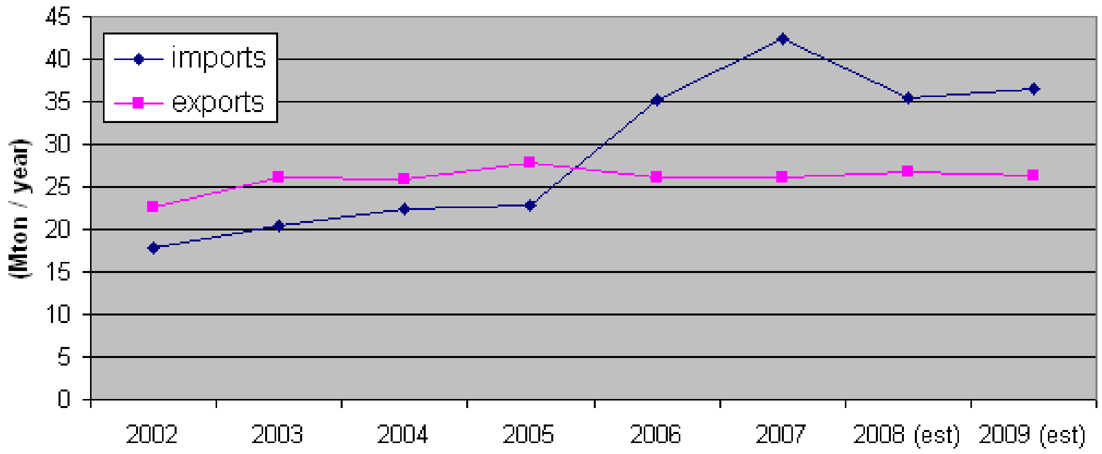

Figure 4.3. The yearly amount of imported and exported steel in the EU27 and future estimates [EUROFER 2008a].

The European commission decreased the overall cap for the second trading period 2008–2012 and markets have probably less emission allowances than they will need. The overall reduction will be 1.9% from the verified emissions in 2005 [COM IP/07/1614], which is likely to increase all the effects resulting from the EU ETS.

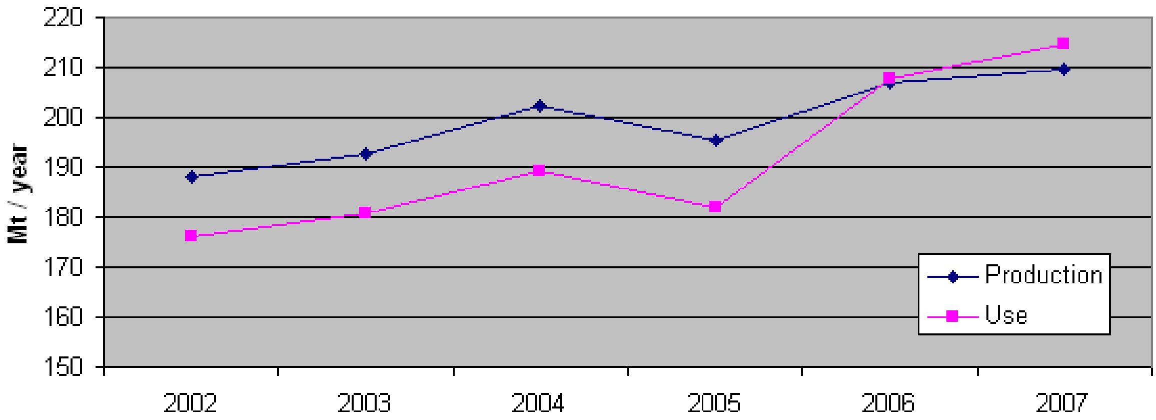

Figure 4.4. The yearly amount of produced and used steel in the EU27 [IISI 2007a].

The total use and production of steel decreased 7 million tonnes (3%) from 2004 to 2005. Figure 4.4 shows that, despite massively increased imports, the total production increased 11 million tonnes (5.8%) from 2005 to 2006 due to steel use increasing almost by 30 million tonnes. More than half of the increased steel use was satisfied by imports.

5. Assessment of selected sectoral approaches in the case of the iron and steel sector

5.1 Assessment options and criteria

As concluded in Chapter 2, every sectoral approach should include 1) selecting a sector, 2) defining a sector, 3) designing the approach and 4) amending it to national legislations. Scheme's trustworthiness also requires proper monitoring, reporting and verification. This chapter provides a discussion on parts 2) and 3) in the case of global iron and steel sector. Fourth part and monitoring, reporting, and verification (MRV) are assessed only briefly and generally in Chapter 2.

Deciding upon all possible definitions and designs is difficult while each alternative brings forward solutions and downsides. It is still possible to suggest several criteria to clarify the evaluation, but it is often impossible to give an answer to these difficult questions. Each option is discussed from the point of view of following criteria:

- overall greenhouse gas reduction potential
- cost effectiveness of GHG reductions
- competitiveness effects
- incentives for participation
- issues related to implementation.

5.2 Defining iron and steel sector

5.2.1 Boundary issues

Modern steel mills are highly integrated installations where process heat and gases from exothermic sub processes are used in multiple sub processes requiring energy. Wider integration increases efficiency but produces more emissions on site. And vice versa, it is possible to outsource energy consuming sub processes decreasing the level of integration and likely increasing the overall emissions of the whole process chain.

Both total emissions and benchmarks can be measured, but a crystal clear definition of a sector or a product is needed for a fair comparison.

In Tracking Industrial Energy Efficiency and CO_2 Emissions [IEA 2007b], the IEA listed effects that reduce steel installations' CO_2 emissions on site, but increase CO_2 emissions elsewhere:

- buying pellets
- buying coke
- more scrap for basic oxygen furnace (less scrap for electric arc furnaces)
- buying direct reduced iron
- buying oxygen
- buying lime
- buying steam and electricity.

In the case of global sectoral approaches, this issue gets even more complicated, because Annex I countries can buy these products from non-Annex I countries. In these cases, the total emission of a steel ton may rise, but overall costs may decrease because of unregulated part of the chain.

The steel sector also has several possible means that do not reduce CO_2 emissions at the site, but reduce them elsewhere:

- selling coke by-products
- selling granulated blast furnace slag as a cement clinker substitute
- selling steel slag as feedstock for cement kilns
- selling blast furnace gas to power producers
- selling coke oven gas to power producers
- selling electricity, steam, and low-temperature heat
- selling nitrogen (a by-product of oxygen production).

GHG regulation makes these measures more valuable, when other installations have the possibility to reduce their emissions.

Despite the difficulties involved in benchmarking, the steel sector generally believes that a reasonable amount of well covering benchmarks could be created for greenhouse gas mitigation. It is likely that extensive cooperation between the industry and governments is required to achieve widely accepted definition of a sector. The next two sub chapters discuss benefits and problems of narrow and broad sectoral definitions.

5.2.2 Only blast furnaces

Over 80% of global iron and steel sector's direct CO_2 emissions are produced when iron ore is reduced in blast furnaces. Based on IEA estimates presented in Chapter 3.7, blast furnaces also cover over 70% of current reduction potential.

Modern blast furnace is a mature technology and its structure is similar in all parts of the world. Narrowing the sector definition down to a blast furnace would reduce the boundary issues and complexity of sectoral approach dramatically and still cover most of sector's direct emissions and greenhouse gas reduction potential.

It is relatively easy to monitor the emissions of a blast furnace, because basically all of the coal in the process is emitted into the air after several intermediate phases: blast furnace gas contains most of the coal and it is burned in the power plant or in other sub processes, and the coal of pig iron is released into the air in the steel converter.

This definition would exclude nearly 20% of a sector's direct emissions and all indirect emissions from electricity. A narrow sectoral scheme is easier to administer, but it would not encourage saving energy in the rest of the installation.

Ultimately, the goal would be the whole steel production chain from iron ore and other raw materials to consumer. As a start, "only blast furnace" is an efficient definition of iron and steel sector and it can be broadened in the future. This definition is easier to understand and requires less administrative capacity in developing countries and relatively minimal data collection.

5.2.3 Broader sector definition including indirect emissions of electricity

It is easy to demand a broader sector definition, but it brings many problems with its better coverage. From the remaining sub processes, most of the energy is consumed in coke ovens, pelletizing/sintering, rolling and electric arc furnaces. The emissions from direct reduced iron could also be regulated, but currently its market share is minimal.

From this list, most of the emissions of coke are already included in the emissions of blast furnaces. Pellets and electricity could be products that can be defined clearly, but the finishing process varies depending on final products, steel quality, and installation boundaries. Coke, pellets, and electricity can be bought from subcontractors or manufactured within steel integrate. It is also common to buy these products from other countries, including non-Annex I countries which possibly have different targets and policy instruments than Annex I countries. From the point of the view of legal responsibilities, there should be clear rules for allocating emissions between subcontractors and steel installations.

The steel industry requires vast amounts of electricity. Regulating also the indirect emissions of electricity would level the playing field considerably. Currently, iron and steel companies in the EU also face the increased electricity prices due to greenhouse gas regulation and a global only blast furnace approach would not create an equal burden in other regions. On the other hand, this may conflict with other emission regulation schemes. In the EU, for example, emissions from electricity are already regulated, and electricity producers are responsible for the emissions of the electricity. If indirect emissions of electricity are included, legal aspects require clarification.

The sector definition could also be extended to other reduction processes, such as reduction of ferrochrome, which is one of the main ingredients of stainless steel. In the process chain of stainless steel, most of the emissions come from two reduction processes: blast furnace and forrechrome reduction, which could be assessed similarly.

A broader definition of a sector has greater greenhouse gas reduction potential, but this approach also requires more data collection and administrative capacity. This is likely to result into more laborious start-up and higher costs. On the other hand, this broadening of a sector definition should be done in the future anyway, and it could be easier to negotiate a more encompassing sector boundary immediately.

5.3 Designing an approach for developed and developing countries

5.3.1 An overview of possible options

Most important developed countries are likely to have their own national targets and emission trading schemes in near future. Even in the US, both presidential candidates supported cap and trade regimes and the US ETS bill is likely to be approved in the US senate during the next years.

The EU ETS and all other proposed cap and trade regimes would include iron and steel sectors. For the beginning, there would be no cooperation or linking between schemes. Linking could be possible afterwards, but according to Joanneum Research Institute, it currently seems very difficult [JR 2008]. Developed countries' ETSs are likely to be linked only indirectly trough CDM or similar mechanisms, which creates a well defined barrier for sectoral approaches.

After accepting this barrier, sectoral approaches can still be applied in both developed and developing countries. Table 5.1 lists these options and following chapters discuss each.

Table 5.1. Six possible options to utilize sectoral approaches in developed and developing countries.

	Target type	Target level	MRV level
Developed countries			
National allocation	benchmark	installation	installation
Performance comparison	benchmark	-	installation
Developing countries			
Option a	benchmark	installation	installation
Option b	benchmark	sector	installation
Option c	benchmark	sector	sector
Transfer of technology or practices	-	-	-

5.3.2 National allocation and performance comparison in developed countries

National iron and steel sectors will remain as a part of national trading schemes also in the future. There is not going to be sectoral trading where installations and companies within a sector would take part to their own emission trading scheme instead of national schemes. This kind of an approach has been suggested in publications, but both developed and developing countries have clearly refused such suggestions.

Sectoral approaches are, nevertheless, going to be included at least in the EU ETS, where the Commission would allocate emissions allowances for an energy intensive industry with some EU wide sectoral method in the third trading period. This change is proposed to prevent possible national subsidies.

Similar benchmarks as in the EU could be adopted in other emission trading schemes and acquired data could be used to compare the performance levels of industries. This kind of comparison would bring valuable insight on relative performances in each country and estimations of possible emission reduction potential. Nevertheless, these kinds of comparisons should be done with aggregated data to address competitiveness concerns.

5.3.3 Voluntary no-lose targets for developing countries

Large financial transfers are expected to be required if developing countries are wanted to join any emission reduction scheme. A portion of this money flow could be from emission reductions bought from companies in developing countries. Currently the only mechanism for developing countries to produce emission reduction units is the CDM mechanism, but it could be widened all the way to sectoral no-lose targets.

Sectoral no-lose targets are built from a baseline of future emissions and a voluntary target level of emissions, which allows selling emission reduction units if exceeded, but results in no penalty if not reached. A sectoral no-lose target could be designed for a single installation or for a whole sector. In the option a) from Table 5.1, an installation would receive credits, and in the options b) and c), credits would be earned by the government, which may direct them to energy efficiency investments.

In option a), each installation from a certain sector and a country could voluntarily adopt an installation level baseline, a no-lose target and MRV obligations. If the installation succeeds to reduce more emissions than the target requires, it would receive credits to be sold to developed countries. This option is otherwise very similar to existing CDM-mechanism, but it would have a sectoral scheme and benchmarks.

In option c), there would be a national benchmark target and sectoral MRV. In this case, credits would go to goverments. This approach requires much less administration as there would be only one baseline and aggregated MRV. Nevertheless, sector-level monitoring, reporting, and verification raise concerns as it cannot be done enough precisely and reliably. Otherwise this would be efficient option, but there is no apparent way to earn trustworthiness for this kind of approach.

Option (b) is the most complex one as there would be a sectoral baseline and target but an installation level MRV. This would require considerably greater administrative capacity as each installation would need to take part in proper emission surveillance before sector's performance could be calculated. It should not be an option that there would be a nationwide sectoral target with installations receiving credits. Sectoral targets are always averages and the best performing installations would earn money without any measures.

5.3.4 Evaluating design options

Overall greenhouse gas reduction potential

Even the simplest reasonable definition of a sector (only blast furnace) covers most of the emissions of the whole process chain, but the overall coverage depends on the amount of participating countries and installations.

- In 2007, total steel production of the EU, the US, Canada, Japan and South Korea was 495 Mt or 37% of world's total production. Solely China's production was 490 Mt or 37% of world's total production equaling all previous combined and growing fast. Russia (70 Mt, 5%), India (50 Mt, 4%), Ukraine (40 Mt, 3%) and Brazil (30 Mt, 2%) were the biggest producers from the remaining countries.
- The total production of non Annex I countries is more than 50% of the global sum. Good coverage requires that China participates to sectoral program.
- According to the IEA, China has also the biggest emissions reduction potential. By absolute measures, the biggest reduction potential after China lies in OECD Europe, Ukraine, Russia and India [IEA 2008].

Too tight targets are likely to reduce participating countries or installations and, thus, decrease the overall reduction potential. Too loose targets, on the other hand, decrease the price of an allowance unit and undermine the overall reduction potential.

Cost effectiveness of GHG reductions

All three options are market based instruments and, in theory, reductions are done where they are cheapest. In practice, reductions can be done only by those companies, which have enough knowledge, professionals and capital to invest. It is like current CDM mechanism, which is mostly utilized by larger and more skilled companies, which already have higher efficiency and, in theory, higher abatement costs.

Cost effectiveness also highly depends on set no-lose targets. If target is tight, massive reductions are required before any sellable unit. This would result to expensive and few CERs. If no-lose targets are too loose, the overall scheme is very cost effective, but does not yield considerable emission reductions.

Competitiveness concerns

In general, sectoral schemes would address competitiveness concerns better with as good coverage of scheme as possible. The more countries have commitments on greenhouse gas reduction the less competitiveness concerns should remain.

The biggest importers to the EU region are CIS countries, China and other Europe. World steel trade is presented in Table 3.2 in the page 26. On the point of the view of the European competitiveness, it is more important to get regulations for the iron and steel industry in these countries.

Alongside direct costs, greenhouse gas reduction schemes cause administrative burden and future uncertainties. If developing countries would adopt sectoral programs, also they would have these burdens. Burden due to reduction schemes is more than just direct costs. More equal overall burden would decrease the potential of carbon leakage and address the competitiveness concerns.

On the other hand, if developing countries make profit from sectoral approaches by selling emission reduction units, they may gain better competitiveness position than they had before sectoral programs. This would happen also in a case where governments would receive credits and invest them to energy efficiency of a sector.

Incentives for participation

Without a large demand and a reasonable price of reduction units, developing countries have little economic incentive to reduce emissions. It is likely that the EU will keep its ETS, which already creates global emission markets. But the demand for emission reduction units would grow greatly, if also other big Annex I countries would start their own emission reduction schemes.

Possible transfer of technology and practices would also create an incentive for participation, but these options are assessed in the following chapter.

Issues related to implementation

The first and biggest obstacle in the way of the sectoral no-lose targets is defining the baseline and target. The current quality of statistical data and trends from developing countries is so weak that such baselines would be mere guesses.

Another barrier is relatively poor administrative capacities in developing countries. Improving this capacity would require time, work and money, which could be aided through transfer of practices.

No-lose schemes also may raise general concerns of reliability, but these could be addressed with sufficient monitoring, reporting and verification.

5.3.5 From no-lose targets to binding targets

It is possible that some countries, which do not have binding national targets, could adopt binding sectoral targets instead of no-lose targets. Any of the presented options from a) to c) could be adopted also as binding target. The biggest difference between no-lose targets and binding targets is that latter is stronger promise to reduce emissions and may result to a situation where installations have to buy emission allowances.

It is not likely that a developing country would adopt a very ambitious binding target for a sector, but binding target could create sellers and buyers within a developing country. Depending on stringency of adopted targets, these countries would most likely remain net sellers and the global situation would remain more or less same for the rest of the countries. In the case of tight targets, no-lose targets could be thrown away, but binding target should be still fulfilled. This is why binding targets would also require more reliable monitoring, reporting, and verification.

As explained in Chapter 5.3.2, there would be no direct linking between national schemes. Also installations in a developing country would have to buy their allowances from their own country or from CDM markets. If a developing country would have only one sectoral scheme, there could be a situation where required allowance units are not available and adopted target could not be met.

Binding target also presumes that all installations within a sector would take part to scheme. In the case of the no-lose sectoral approaches, it is possible that some of the installations decide to take part and other do not. This should increase the greenhouse gas reduction potential of the scheme, but it would also increase the required administrative capacity.

5.3.6 Transfer of technology and practices

Technology transfers are often considered as an attractive incentive for developing countries to participate in global agreements or sectoral approaches. In the case of the iron and steel industry, it is crucial to ask: which companies would transfer technology to whom?

The biggest steel producers operate in dozens of countries in Europe, Asia, Africa and America; and the number one company produces over 10% of world steel. If one of these companies would build a new steel mill in Africa, should it get assistance or technology transfers from other companies?

One solution could be that any kind of aid should be limited to companies operating only in developing countries. This could result in a situation where subsidiary companies would be established in developing countries in order to gain benefits. On the other hand, this kind of statement would head off investments from developed countries as companies would not want to expand to developed countries.

If some kind of solution to this problem could be found, the main question still remains: what kind of technology could be transferred and who would do it? Advanced Chinese technology is already comparable to Western technology and detailed process characteristics are key information in global competition. Also, the best professionals work for companies, not for governments.

While developing countries already have modern steel making processes, they still lack of administrative capacity required for full-scale greenhouse gas mitigation. This could be one target of practices transfer.

Technology transfer could also be focused to on the poorest developing countries, which really lack of modern technology.

6. Summary and conclusions

Sectoral approaches have been proposed as one alternative for a post-2012 climate agreement, because they are considered to be able to enhance climate change mitigation in developing countries and address the competitiveness concerns of globally trading industry in developed countries.

Most developing countries have, so far, clearly rejected any kind of industry benchmarks and no-lose targets. On the other hand, developing countries demand technology transfers, which also are one kind of a sectoral approach. Developing countries may not take binding targets in Copenhagen, but according to IPCC, also developing countries have to reduce their emissions in long term if we want to reach 2 °C target. Sectoral no-lose or binding targets are considerably easier start than economy wide commitments.

These kinds of approaches are especially suitable for sectors with a small number of internationally traded uniform products, only a few manufacturing processes, and relatively few installations with high emissions. These are limiting conditions, but the global iron and steel sector seems to suit well.

The global iron and steel sector emits approximately 3% of total anthropogenic greenhouse gas emissions. Existing emission databases do not account for the share of different nations, and energy use databases are not designed for studying individual sectors. For example, in the IEA statistics, steel mills, coke ovens, and industrial power plants are allocated under different categories. Even in the EU ETS, different countries have different practices as to whether the emissions of an installation’s power plant are compiled to the iron and steel category or to the power plant category.

And the underlying confusion does not end with statistics. Sectoral approaches also mean different thing to different persons. This publication aspires to clarify the ongoing discussion and take a few practical examples in the case of the iron and steel industry. First of all, if the concept of a sectoral approach is broken down, it includes (1) selecting and (2) defining a sector, (3) designing sectoral approach and (4) applying it into national legislations.

A definition of a “sector” may, in theory, range from a single process (blast furnace) to a whole process chain from raw materials to consumers. Narrower sector definition as a start would exclude a part of the emissions, but it would also decrease the costs of building administrative capacities in developing countries. On the other hand, the broader the definition, the trickier boundary issues emerge. For example, coke is one of the main raw materials in steel-making, but its manufacturing can be outsourced and coke can also be bought from non-Annex I countries. From a legal point of view, it is crucial that the chosen sectoral approaches clearly allocate emissions from every sub process to manufacturer or buyer.

The “Approach” part includes a variety of options for measuring emissions, setting targets and choosing policy instruments. In principle, all policy instruments can be designed to suit each definition of sector and both methods to measure emissions (total emissions and benchmarks). Policy instruments may be designed as national measures or agreed to be similar or interlinked between nations.

The general reliability and trustworthiness of a sectoral approach or any other global agreement require monitoring, reporting, and verification. This is especially important if emission reductions are worth of money. Any global agreement requires a huge amount of data collecting, but properly designed sectoral approaches can lower this burden remarkably.

Why developing countries would adopt any commitments is one of the key questions. They may (1) receive funds in exchange for GHG reductions; or there can be (2) technology transfers and (3) training of professionals. In a general discussion, these options may sound reasonable, but they include many difficult questions.

If companies in developing countries benefit from a sectoral approach, it may actually enhance competitiveness concerns more than address them while they receive subsidies resulting from sectoral policies. Another puzzling issue is multinational companies, which already have production in both developed and developing countries. In the current agreement, they can also receive CDM credits if they improve their own installations. Also this could encourage increasing investments in developing countries.

Presented methods to analyze sectoral approaches can also be applied to other sectors if their unique process chain is considered thoroughly. Different sectors may require different steering mechanisms and a similar sectoral study for other sectors could bring forward underlying barriers and possible solutions. This study’s Appendices B and C present key statistics for the cement and paper sectors. Based on WRI analyses, cement sector is rather suitable for sectoral approaches [WRI 2005]. Pulp and paper was not assessed in the WRI’s publication and would require more study.

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Appendix A: Country list of regions

EU	EU15 before 1995 and EU27 after 1995
US & Canada	
Other America	Mexico, Central America and Latin America
C.I.S.	Commonwealth of Independent States consists nine of fifteen former Soviet Republics: Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan and Uzbekistan
China	
Developed Asia	Japan, South Korea, Hong Kong, Singapore and Taiwan
Developing Asia	Bangladesh, D.P.R. Korea, India, Indonesia, Malaysia, Myanmar, Pakistan, Philippines, Sri Lanka, Thailand and Viet Nam
Rest of the world	This group includes many developed and developing nations, but all are rather small players in the global steel markets

Appendix B: Key statistics for cement sector

Global production and trade

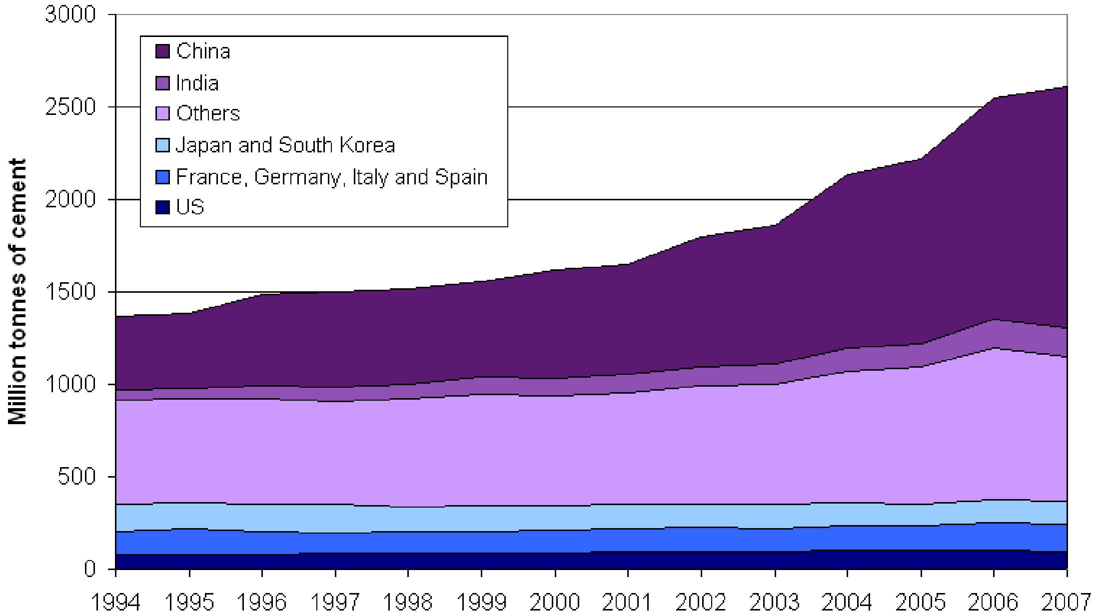

Figure B1. Cement production in biggest producing countries. Others have large share due to very limited amount of countries in USGS statistics in early 90's. [USGS.]

Appendix B: Key statistics for cement sector

Table B1. Global trade of cement in 2003. Units are in million tonnes. [IEA 2007.]

Exporting: \ Importing:	Africa	Aus/NZ	Canada	China	East Europe	West Europe	FSU	India	Japan	Korea	Latin America	Middle East	S&E Asia	USA	Total exports	Extra-reg. exports	Net exports
Africa	1.5	0.0	0.0	0.0	0.0	0.4	-	-	0.0	-	0.0	-	0.0	0.0	1.9	0.4	-8.3
Aus/NZ	0.0	0.0	-	-	0.0	0.0	-	-	0.0	0.0	0.0	0.0	0.8	0.0	0.8	0.8	-0.4
Canada	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	-	0.0	0.0	0.0	5.7	5.7	5.7	4.8
China	0.3	0.0	-	1.2	0.0	0.0	0.0	0.0	0.0	1.1	0.1	0.0	0.3	1.9	5.7	4.5	-0.2
East Europe	1.4	0.0	-	-	2.8	2.7	0.0	-		-	0.0	0.0	0.0	0.2	7.0	4.3	1.7
West Europe	3.7	0.0	0.0	0.0	1.8	19.3	0.1	0.0	0.0	0.0	0.0	1.6	0.0	3.3	31.5	12.2	6.2
FSU	0.0	-	-	0.1	0.6	1.3	1.6	-	-	-	-	0.0	0.0	0.0	3.7	2.0	1.7
India	0.3	0.1	-	0.0	0.0	0.6	0.0	-	-	-	0.0	3.3	2.5	0.0	6.9	6.9	6.9
Japan	1.0	0.8	-	4.3	-	0.0	0.0	0.0	0.0	0.9	0.1	-	2.3	0.0	9.7	9.7	8.9
Korea	0.4	0.0	-	0.0	-	0.0	0.0	-	0.8	-	0.0	0.0	0.1	1.7	3.1	3.1	1.2
Latin America	0.0	-	0.0	-	-	0.3	-	-	-	-	2.0	0.0	-	5.3	7.7	5.6	4.8
Middle East	0.4	-	-	-	0.2	0.4	0.2	0.0	-	-	-	2.7	0.2	-	4.2	1.6	-3.4
S&E Asia	1.0	0.2	-	0.2	0.0	0.4	-	0.0	0.0	0.0	0.5	0.1	9.7	3.3	15.6	5.9	-0.3
USA	0.0	0.0	0.8	0.0	0.0	0.0	0.0	-	0.0	0.0	0.1	0.0	0.0	-	0.9	0.9	-20.5
Total imports	10.1	1.2	0.8	5.9	5.3	25.3	1.9	0.0	0.9	1.9	2.9	7.7	15.9	21.4	104†		
Extra-reg. imports	8.6	1.1	0.8	4.7	2.6	6.0	0.3	0.0	0.9	1.9	0.8	5.0	6.3	21.4		64†	

Table B2. Production statistics from 2007 and 2003 [USGS] combined with CO_2 emissions statistics of cement production in 2003 [WRI].

	Production, 2007	**Share**	**Cum. share**	**Production, 2003**	**CO_2 emissions, 2003**	**Share of emissions**	**Cum. share**
	[USGS]			[USGS]	[WRI]		
	(Mt)	(%)	(%)	(Mt)	($MtCO_2$)	(%)	(%)
China	1300	50	50	750	430	43	43
India	160	6.1	56	110	61	6.1	49
US	96	3.7	60	93	46	4.6	53
Japan	70	2.7	62	72	34	3.4	57
Russia	59	2.3	65	40	20	2.0	59
Korea, rep. of	55	2.1	67	56	29	2.9	62
Spain	50	1.9	69	40	22	2.2	64
Turkey	48	1.8	71	33	17	1.7	66
Italy	44	1.7	72	40	19	1.9	68
Mexico	41	1.6	74	32	17	1.7	69
Thailand	40	1.5	75	35	16	1.6	71
Brazil	40	1.5	77	40	17	1.7	72
Indonesia	35	1.3	78	34	17	1.7	74
Iran	34	1.3	80	31	15	1.5	76
Germany	34	1.3	81	28	16	1.6	77
Vietnam	32	1.2	82	0	12	1.2	78
Egypt	29	1.1	83	26	13	1.3	80
Saudi Arabia	28	1.1	84	23	11	1.1	81
France	21	0.8	85	20	10	1.0	82
others	390	15	100	360	183	18	100
total	2600			1860	1008	100	

European details

Table B3. Number of cement and clinker installations in EU member states and allocated emission allowances in the first trading period. [CITL viewer.]

	Number of installations	Allocated emissions, average 05–07
		(Mt)
Austria	19	3.6
Belgium	11	9.2
Bulgaria	0	0.0
Cyprus	2	1.6
Czech Republic	11	4.4
Denmark	1	2.8
Estonia	1	0.1
Finland	8	2.0
France	50	17.4
Germany	121	32.1
Greece	25	11.7
Hungary	7	2.9
Ireland	6	3.9
Italy	89	28.9
Latvia	1	0.3
Lithuania	2	1.3
Luxembourg	1	0.8
Malta	0	0.0
Netherlands	2	0.8
Poland	66	14.2
Portugal	12	7.1
Romania	12	1.0
Slovakia	10	3.5
Slovenia	5	0.9
Spain	58	29.8
Sweden	5	2.3
United Kingdom	27	7.5
EU	552	190.2

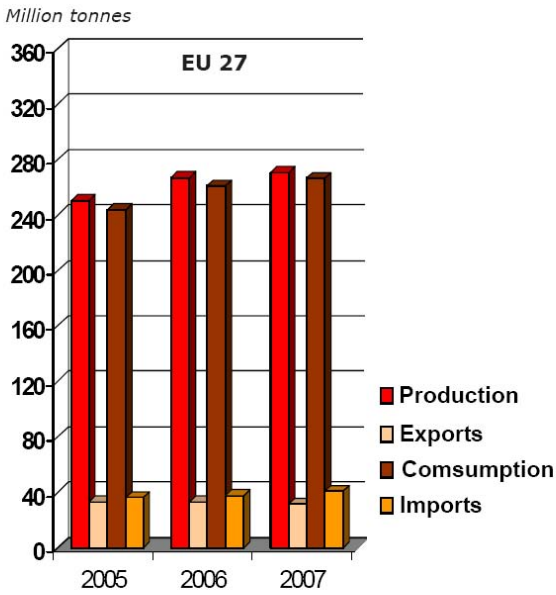

Figure B2. Aggregated production, consumption, imports and exports of EU27 [CEMBUREAU].

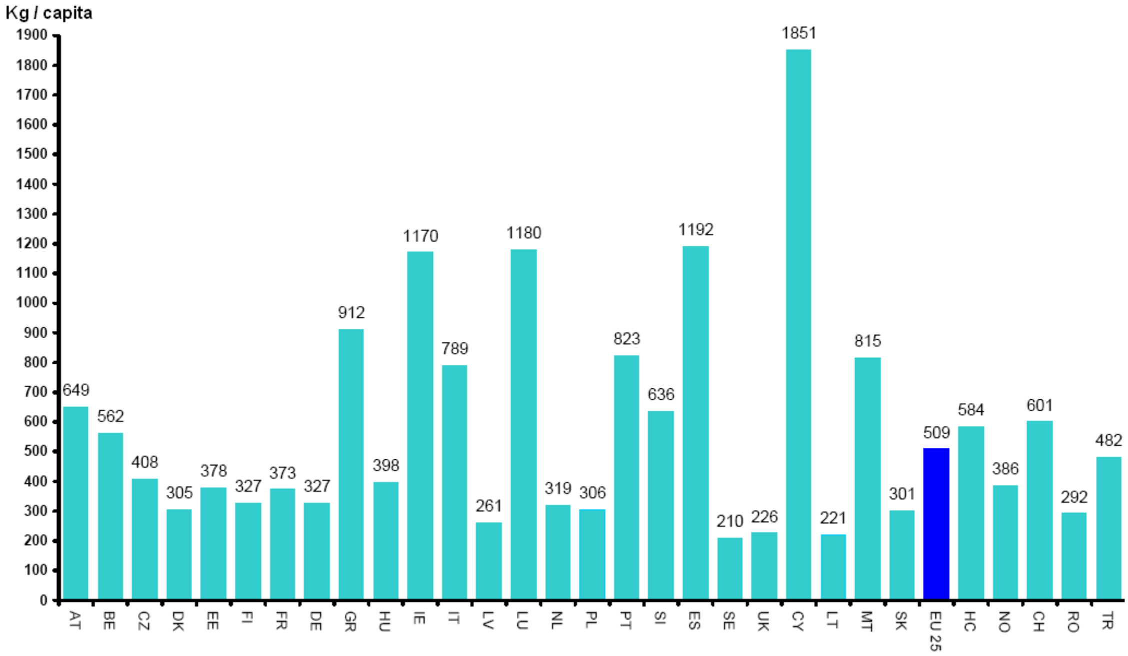

Figure B3. Per capita consumption of cement in EU member states in 2005 [CEMBUREAU].

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Appendix C: Key statistics for paper sector

Global production and trade

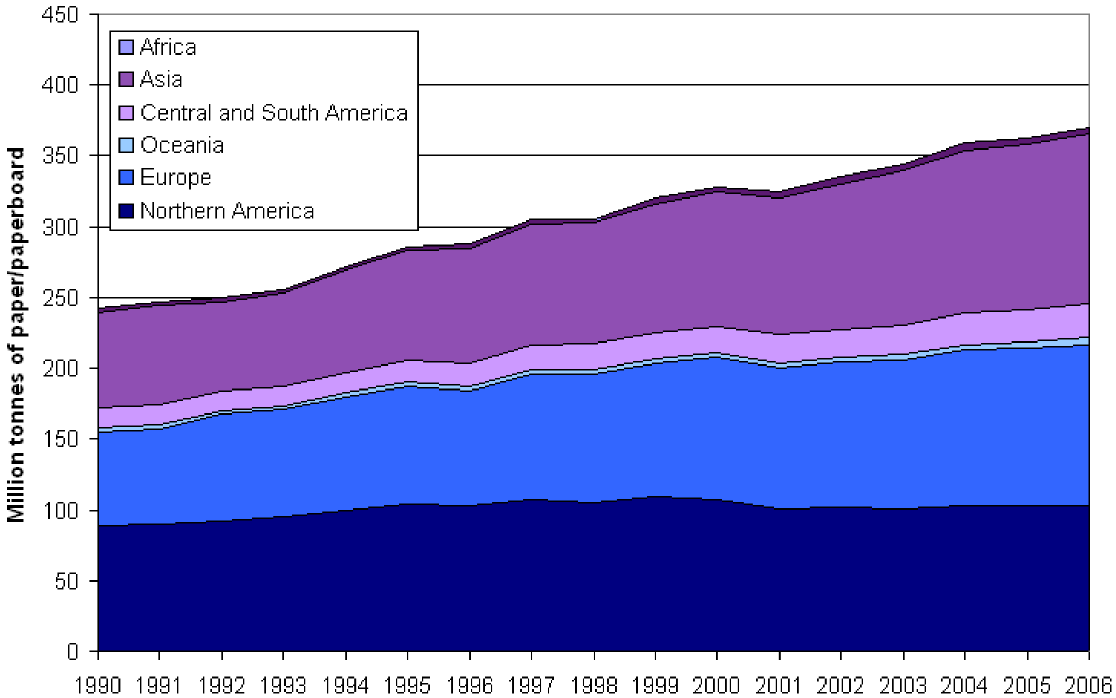

Figure C1. Global production of paper and paperboard [FAOSTAT].

Appendix C: Key statistics for paper sector

Table C1. Biggest producers of paper and paperboard [FAOSTAT].

	Production quantity	**Share**	**Cum. share**
	(Mt)	(%)	(%)
US	84	23	23
China	53	15	38
Japan	29	8.1	46
Germany	23	6.2	52
Canada	18	5.0	57
Finland	14	3.9	61
Sweden	12	3.3	64
Korea, Rep. Of	11	3.0	67
Italy	10	2.7	70
France	10	2.7	73
Brazil	9	2.3	75
Russia	7	2.0	77
Indonesia	7	2.0	79
Spain	6	1.7	81
United Kingdom	6	1.6	82
Austria	5	1.4	84
Mexico	5	1.3	85
Others	54	15	100
Total	365	100	

European Details

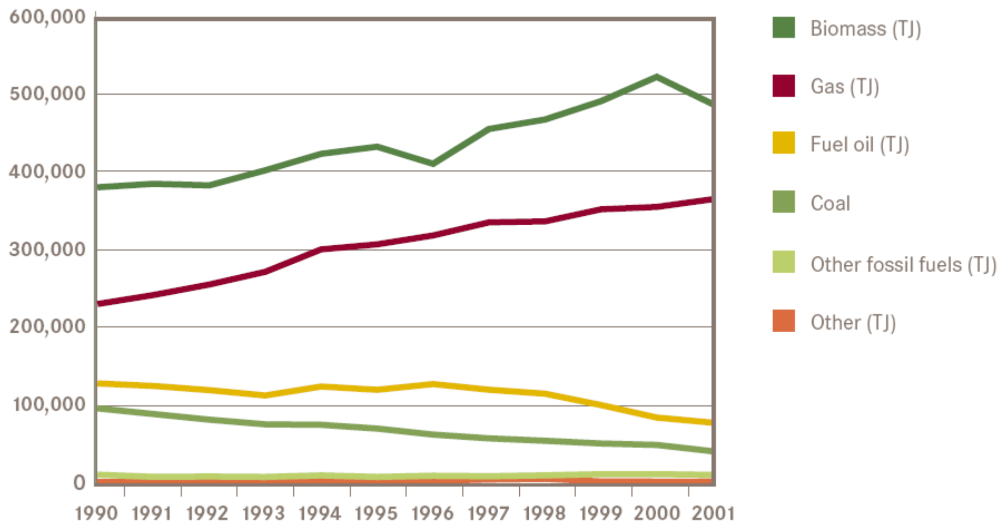

Figure C2. Primary energy consumption of the European pulp and paper industry from 1990 to 2001. Data cover 94% of the production. [CEPI.]

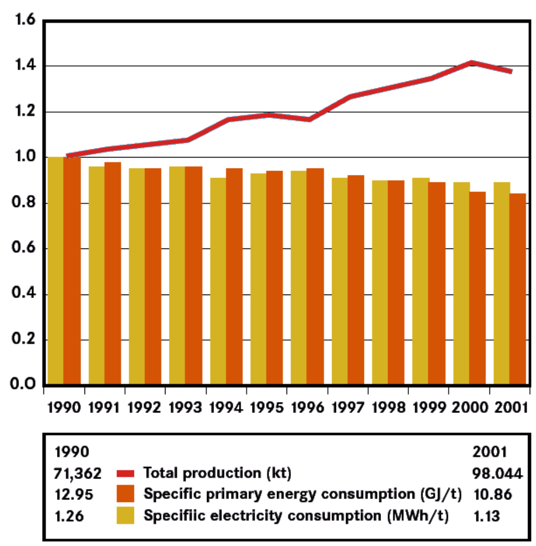

Figure C3a. Indexed specific primary energy and electricity consumption of the European pulp and paper industry from 1990 to 2001. Data cover 94% of the production. [CEPI.]

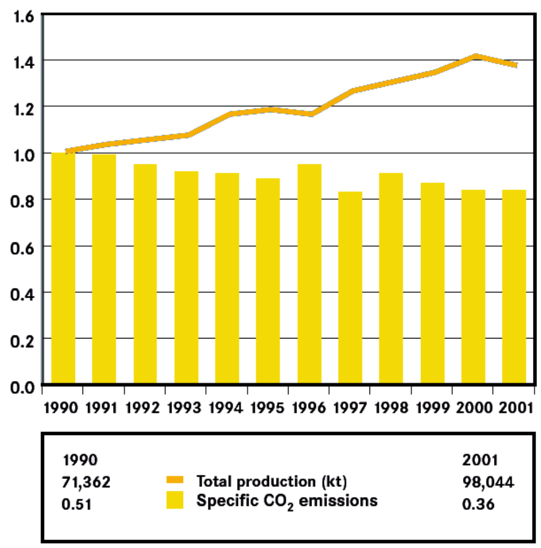

Figure C3b. Indexed specific CO_2 emissions of the European pulp and paper industry from 1990 to 2001. Data cover 94% of the production. [CEPI.]

Table C2. Number of paper and pulp installations in the EU ETS and their average allocated emissions in the first trading period [CITL viewer].

	Number of installations	**Allocated emissions, average 05–07**
		(Mt)
Austria	24	2.3
Belgium	13	1.0
Bulgaria	0	0.0
Cyprus	0	0.0
Czech Republic	10	0.4
Denmark	3	0.0
Estonia	2	0.1
Finland	49	4.6
France	122	5.2
Germany	138	7.1
Greece	15	0.2
Hungary	6	0.2
Ireland	1	0.0
Italy	170	4.9
Latvia	1	0.0
Lithuania	2	0.1
Luxembourg	0	0.0
Malta	0	0.0
Netherlands	21	2.1
Poland	24	0.3
Portugal	29	0.4
Romania	11	0.2
Slovakia	2	0.2
Slovenia	9	0.5
Spain	112	4.7
Sweden	57	2.6
United Kingdom	54	0.3
EU	875	37.4

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